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Options Contracts for Contingent Takings

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Abstract

Disasters are low-probability situations with high potential losses. Shortly before and during some disasters, government use of private property may reduce losses to others that strongly outweigh the costs imposed on the property owner, implying significant net benefits. Coercive takings or attempts to contract at the time of the emergency will frequently be defeated by transactions costs. We propose a policy tool to realize the available net benefits: options contracts for contingent takings. Such contracts between the government and private parties allow the government to take property in the event of a low-probability event that would make the property much more valuable in government hands. In exchange for such use, the property owner is compensated, in part up front and in part when the option is exercised. Setting the exercise payment equal to the cost of losses promotes efficiency in both risk spreading and the incentives for exercise. Options contracts of this form will be valuable in a range of settings, from improving disaster response by guaranteeing a flow of needed supplies, to reducing potential damages by diverting floodwaters to low-value lands, or even to helping ensure the survival of some endangered species. The moral hazard and hold-out problems that may afflict such contracts can be controlled.

KEYWORDS: option, takings, contingent taking, eminent domain, disaster, exercise price, government contracting, floods, land assembly, holdup problem

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In emergencies – low-probability situations with high potential losses – government use of private property may be highly desirable although it ordinarily would not be. In ordinary eminent domain, by contrast, uncertainty plays no major role and time is not of the essence. In emergencies, normal-length legal proceedings, or even the haggle-time expected with everyday eminent domain, would sacrifice most or all of the value from having the government take control of the resource. To prevent losses, the government must move quickly.

Readers familiar with the hit T.V. series *24* will remember a gripping episode from season four. During a blackout, Jack, the heroic counter-terrorism agent, needs to use a sporting goods store both to hide from terrorists and as a source of guns, ammunition, and flashlights. The owners of the store oblige, giving him free rein of their store and its contents. This example richly illustrates that there are times when government use or confiscation of private property can help avert disaster. In this case, the use of the store and its supplies allowed Jack to keep critical information for fighting terrorism out of the hands of the terrorists themselves. The nation was lucky that the store owners were not only patriotic and brave, but also generous, since they offered resources to protect the public without asking for compensation.

But such public-spiritedness and generosity cannot be assumed in a vast range of situations where the public use of private property, whether for a short or long time, can offer great benefits. This is especially true when the takings are more significant than a broken-up store and the use of some equipment. While the government does sometimes forcibly commandeer property even if the owner is unwilling to oblige – as in the case of a foot patrolman taking a car to catch a criminal – usually the government leaves the private property undisturbed, even when using it would offer social benefits, because it lacks the authority to take or use it, or judges that the follow-on economic or political costs will be too high.

We explore one policy tool for realizing the potential benefits of government use of private property in situations that are uncommon but foreseeable. That tool is options contracts for contingent takings. These are contracts between the government and private parties that allow the government to take property if a low-probability event occurs that would make the property much more valuable in government hands. In exchange for use of their property, the individual or firm is compensated, in part up front and in part if and when the uncertain circumstances arise. This combination of up-front payment and payment at time of exercise is the norm for purchasing most options. While Jack told the store owners he would get them help to clean their store after the shooting, we envision cash payments at the level of direct damages plus opportunity costs from lost business.

In this paper we focus much of our discussion on the use of contracts for minimizing flood damage. The principles we outline are general, however, and

would apply just as well if the government were commandeering (or destroying) property to fight terrorism or crime, carving a fire break in a forest to stop a fire from spreading, or requiring cattle owners to destroy their herd if it might be infected with a disease with a long incubation period. Furthermore, although we focus on the use of contingent takings and mutually agreeable compensation in disaster response, this type of contracting could be used more broadly to achieve other social aims.

The first section of this paper provides an overview of options contracts for contingent takings and introduces our prime case study of contracts for reducing flood damage. The next section argues why ex ante, voluntary contracts are likely to be preferable either to contracting at the time of the event or to a coercive approach. The third section discusses the structure of such contracts, including the timing of payments, how to award contracts, compensation amounts, and how payments are financed. The fourth section addresses two possible complications: moral hazard and land assembly problems. Section five concludes.

1. WHY OPTIONS CONTRACTS?

Some might say that having one's property taken during an emergency is simply a risk one takes when living in an interdependent society. However, arguments of risk spreading and equity would suggest that compensation is desirable. Moreover, given the likely high value-to-cost ratio from the taking, it makes practical sense to compensate if only to avoid litigation by relying on voluntary exchange.[1] Contracts for compensation must be negotiated in advance; in emergencies, there is rarely time to bargain and contract, a point elaborated below.

We focus on unlikely but predictable situations within which the right to use private property would provide benefits well in excess of costs. For example, after a hurricane, the government may want to commandeer the use of boats or other supplies for rescue operations. If avian flu proves to be pandemic, it will be essential to take over major facilities, for example, sports arenas and hotels, to treat and quarantine the sufferers. If a major drought strikes a region, the government may want to compensate farmers to refrain from exercising their water rights.

The 1993 flood on the Missouri and Mississippi Rivers illustrates the potential value of options contracts. Damages from the flood are estimated at $12 to $16 billion, but easily could have been far higher. The floodwalls protecting

[1] As we explain briefly in part 2.1, the application of the Just Compensation requirement to government use or destruction of private property in emergencies is difficult to predict and hence ripe for costly litigation.

St. Louis and Kansas City were not overtopped in part because agricultural levees upstream failed, creating storage for floodwaters on agricultural land.[2] When agricultural levees are breached, the costs in lost crops from flooded fields can be important. However, they are quite modest relative to the losses (both property and human) that would be incurred if densely populated areas were flooded, even to relatively low levels.

The upstream levee failures in 1993 provide an object lesson: What happened then by chance could be made a deliberate policy. For example, levees could be broken when necessary (or built so that the pressure of a certain size flood would likely break them on its own[3]), or farmers could agree to build levees to a certain maximum height, so that severe floods would undoubtedly top them. This could substantially reduce the overall costs of a major flood. In 1994, the noted hydrologist Luna Leopold proposed the purchase of easements in floodplains to allow for temporary storage of floodwaters.[4] He predicted this would reduce disaster costs by directing waters onto areas where damage would be the lowest. Andrew Manale has researched the possibility of a voluntary program of water storage on private, agricultural lands.[5] Examining eight watersheds in Iowa, he found that under plausible assumptions, the benefits of compensating farmers for floodwater storage exceed the costs. We employ this example of options contracts for floodwater storage throughout the paper.[6]

Options contracts would also be immediately applicable to proposals that have already been made for dealing with other situations. For example, James Titus has proposed the idea of rolling easements to protect public shores from sea level rise caused by global warming.[7] As sea levels rise, coastal property owners might choose to erect walls and other structures to prevent the water from

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[2] *See* National Research Council, Flood Risk Management and the American River Basin: An Evaluation (1995).

[3] Already in use on the Mississippi is a floodway that runs parallel to the river, which the river would enter during a flood through a fuse-plug levee. A fuse plug levee is "a levee lower than those surrounding it that is designed to blow out in a great flood. (If it holds, the Corps will dynamite it.)" JOHN M. BARRY, RISING TIDE: THE GREAT MISSISSIPPI FLOOD OF 1927 AND HOW IT CHANGED AMERICA (1997).

[4] Luna B. Leopold, *Flood Hydrology and the Floodplain*, 96 WATER RESOURCES UPDATE 11 (Spring).

[5] *See* Andrew Manale, *Flood and Water Quality Management Through Targeted, Temporary Restoration of Landscape Functions: Paying Upland Farmers to Control Runoff*, 55 J. SOIL & WATER CONSERVATION 285-295 (2000).

[6] While not using contracts, The Netherlands is considering a similar approach to floodwater storage through the use of emergency flood areas. *See* Aaron Gray-Block, *The Dutch v. the Water*, EXPATICA (2005); Hein T.C. van Stokkom et al., *Flood Defense in The Netherlands: A New Era, a New Approach*, 30 WATER INT'L 76 (2005).

[7] James G. Titus, *Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting PropertyOwners*, 57 MD. L. REV. 1279 (1998).

reaching their property. If they do, the country would lose its tidal lands – beaches and shorelines that are largely public – since as the sea rose, it would inundate the shore until being constrained by the wall. Titus proposes the use of rolling easements, whereby property owners would be prevented from hardening the shore, and when the sea encroaches the property would revert back to the state as public shoreline. There is sure to be fierce opposition to such a policy. If options contracts were used instead, the government would compensate landowners for turning their property over to the government when the sea begins to threaten or wash over their property line, with perhaps some payment initially for signing the contract.

The reintroduction of endangered wolf species provides another intriguing environmental example of an implicit option contract. Many ranchers are opposed to the reintroduction of wolves, which sometimes kill livestock. To protect their animals, most ranchers have no qualms about shooting wolves that enter their property. To protect the ranchers' livelihoods and wolves' lives, in the late 1980s, Defenders of Wildlife established a fund in the northern Rockies to compensate farmers for livestock losses due to wolves, eliminating most opposition to reintroduction of the endangered species. Once it is verified that a death was due to a wolf, the fund compensates farmers the full value of the livestock lost.[8] An ex ante understanding is necessary, as the group cannot negotiate with the rancher when the wolf is about to attack livestock. Similar programs exist in several other countries, some of which are run by governments and some by NGOs.[9] Unfortunately, little empirical evidence evaluating these programs is available.

Although options contracts for contingent takings could be formed between private parties, as the Defenders of Wildlife wolf fund illustrates, such arrangements will rarely succeed. The Defenders of Wildlife effectively represented all beneficiaries – an unusual situation for a private party. In most cases there are many beneficiaries, e.g., all the residents of St. Louis, so that free riding by beneficiaries would scuttle any potential deal. Therefore, we focus on the use of such contracts by a government entity that serves both those giving up property and those then protected.

Still, these examples indicate that contingent takings and options contracts can be useful in a wide variety of situations where significant losses threaten, and time is of the essence. The cases we are interested in can be distinguished from traditional takings cases on three dimensions. First, our cases deal with *voluntary* transactions. Second, they examine *temporary* use of private property. And,

[8] The fund has since been expanded to other regions and to include losses due to grizzly bears. *See* http://www.defenders.org/wildlife/new/facts/faq.html.

[9] *See* Philip Nyhus, et al., *Taking the Bite out of Wildlife Damage: The Challenge of Wildlife Compensation Schemes*, 4(2) CONSERVATION IN PRACTICE (2003).

third, they look at situations in which only some of a person's property rights are taken, namely the right to interfere with designated government uses.

These situations are very different from ordinary eminent domain proceedings, where government compensates owners to take, say, property that is in the path of a highway. For such takings, there is no emergency condition, and there is no contingency. The government wants the property no matter what, and usually wants it fully and permanently. They also differ from cases like the taking of a car to catch a criminal, in which a clear emergency exists to justify the commandeering of property, but the probability of any one car being taken for such a purpose is exceedingly close to zero, which would make prior contracting much too costly to pursue.[10]

2. Reasons for Contracting in Advance

In addition to paid rescue workers and first responders, many heroes without uniforms helped rescue people during Hurricane Katrina, and many of them worked without compensation. They donated their time and their property, such as trucks and boats, for temporary use during the initial response to the disaster. However, reliance on volunteerism generally will not guarantee that property is used in a way that maximizes social benefits. While there will be some Good Samaritans, there will be others, perhaps ordinary businessmen and women, who will look out for their own interests and will find they cannot recover payments for the use of their supplies during the disaster. Consider the owner of a boat that could be used to rescue people after a hurricane. She is far more likely to commit her boat on the 1 chance in 1000 it will be needed, which is a modest charitable gesture, rather than giving it when she knows it will be used and significant costs may be incurred.[11] Or consider a farmer for whom drowning an entire season's crops would represent a major loss. He could not be expected to merely accept that loss to promote social well-being, yet this private loss may be much less than the damages avoided by using the cropland to store floodwaters. This suggests substantial gains from trade, but absent compensation it is unlikely the farmer would flood his land to avoid far greater damages to the downstream city.

One option is for the government to seek out private entities once a threat is known – when the floodwaters are rising or the hurricane is approaching – whose property is needed for disaster prevention or response, and contract with them for such use. Under this scenario, only contracts actually needed would be

[10] The government could, of course, pass provisions of how consumers would be compensated in such circumstances, but there would be no sense of contractual agreement.

[11] Bone marrow registries work on this principle. It is hard to deny giving your blood for testing – say if someone in your ethnic group makes an appeal – when there is only a tiny chance that you subsequently will be called for the painful process of donating marrow.

drawn, and the contracts would be simpler. For example, the private entity with whom the government is contracting need estimate neither the probability that the contingent event will occur nor future opportunity costs. They may negotiate simply with reference to the cost of the taking at the present moment, reducing information costs and uncertainty. Yet such contracting at the moment of the crisis is likely untenable; such contracts would be particularly difficult to negotiate, and likely impossible in a crisis.

Negotiations over possible takings may be especially prolonged if each party attempts to extract the highest amount of the available surplus. Farmer Jones, for example, recognizes that flooding his fields would cost him $100,000 in lost crops but save $2 million down river. In negotiating compensation for use of his fields, he will look for a number near $2 million. Jones and the government may not be able to reach agreement before the flood crest comes down the river. Similarly, an opportunistic firm that could provide facilities or equipment following a disaster might try to take advantage of the higher willingness-to-pay of the moment. For example, in summer 2006, taxi drivers in Lebanon charged up to forty times their usual price to individuals trying to flee the violence between Hezbollah and Israel.[12] If the government hangs tough, eager to avoid overpaying – both for the money entailed and for the precedent – the likely outcome is no agreement, and great inefficiency. The larger the surplus, the more difficult the negotiations might be, since there is more for each side to gain. When disaster looms, there will hardly be time to bargain, particularly since governments at all levels will be overburdened.

Wal-Mart's efforts during Katrina provide an example of the potential difficulties of striking agreements at the time of a crisis. Following the storm, there was a shortage of emergency supplies in the region. At the outset, Wal-Mart provided many supplies to affected areas and let the government commandeer trucks, for example, when needed. After a while, senior executives began to worry that merchandise might never be paid for, but it was extremely difficult to establish purchase orders.[13] Ex ante contracts would have helped. If there were standing contracts for the state or federal government to purchase certain amounts of particular goods given a certain scale disaster, commodities could have been mobilized by Wal-Mart much more effectively and extensively. Many Wal-Mart trucks rolled during the crisis, but more would have if the company had not

[12] *See* Sam F. Ghattas, *Israel Calls Up Reserves, Warns South Lebanon Residents to Flee*, ASSOCIATED PRESS (July 21, 2006).

[13] *See* Speech, Ray Bracy, [Wal-Mart Vice President of Corporate Affairs], Spanning and Crossing the Business and Government Boundaries, (John F. Kennedy School of Government, Harvard University, December 14, 2005). For example, Bracy noted that there were times when Wal-Mart was told there was not a purchasing agent in some location and so supplies could not be accepted. Bracy concluded: "We still haven't solved that problem."

worried that it might not receive a fair price for the merchandise provided. This likely also would have kept federal costs down during the crisis. During the response to Katrina some people purchased goods from Wal-Mart and sold them to the federal government at an elevated price. A standing contract would avoid such middlemen and the transaction costs and antagonisms they entail. Furthermore, contracts in advance would induce Wal-Mart to keep extra "disaster merchandise" in their distribution centers, and to dispatch it when appropriate.

Ex ante contracts would also help lock in socially beneficial decisions. Many catastrophes create opportunities for triage, for example flooding A's land to keep B's safe, or saving C before D. Absent prior arrangements, such decisions would have to be made in the spur of the moment as a disaster unfolds. In a pinch, the government may feel it has to allocate evenly, when an uneven allocation would be much more efficient. This will tend to create errors of omission. For example, if River City's levee is going to break and flood the city, the federal government is unlikely to intentionally breach a levee upstream to flood River Village and relieve the downstream pressure, even though the damage there would be much lower. However, if the government had arranged ex ante for certain lands to be flooded and the owners agreed to such action in exchange for some payment, possibly some at the time of the contract as well as some when action is taken, much damage could be avoided.

In some situations it will be uncertain whether property will be needed. Perhaps a flood threatens a levee in a downstream city, but there is some uncertainty about whether it will survive, and if not, how severe damages will be. Before the crest of the floodwaters reaches the city, the government must decided whether to divert floodwaters onto farm fields, and thereby lower the risk. Without contracts negotiated in advance, the government could be entangled in costly litigation if it flooded a farmer's lands and after the fact it became clear that this was unnecessary.

In sum, signing options contracts for contingent contracts before threats are known can help ensure that beneficial deals are reached as well as contribute to reducing potential damages or improving disaster response.

2.1 Inefficiencies That Result From a Reliance on Coercive Means

If public use of private property can sometimes reduce damages, why should the government bother with contracts at all? For example, in flooding low-value land to preserve high-value land, the government could act coercively – giving the landowner notice of its intentions but not asking permission.[14] Such coercive

[14] There is no question that the government has the *power* to destroy private property to prevent or mitigate a catastrophic harm. Under the Fifth and Fourteenth Amendments, the government may take private property so long as it is for a "public use." In *Kelo v. City of New London*, 125 S. Ct.

measures might improve welfare when the government is caught unprepared, but as a matter of policy, reliance on coercive measures entails three serious drawbacks.

First, when the government relies on coercion it loses the opportunity that negotiations provide to form an accurate estimate of the property owner's private valuation of her property. That is, the private owner's willingness to accept the damage cannot be known accurately where there is no actual acceptance. Thus, in an emergency, the government will be forced to guess as to which private owner has the lowest private costs or, perhaps more cynically, to guess which owner is likely to impose the lowest political costs on the responsible officials. By contrast, bargaining between the government and the private property owners – either through direct negotiations or through an auction system where some property gets taken for flooding and some does not – allows the government to obtain authentic information on the private costs of burdening the private property and, when possible, to first use the property with the lowest private valuation.

A second drawback of coercion is its likely significant political costs for the government officials responsible, which implies that some efficient uses of private property will not be undertaken. Government officials may reasonably fear that, by deliberately taking and possibly destroying private property, they will make themselves appear to be the proximate cause of the harm even though an external force created the underlying emergency. Further, in such cases the harm imposed by government officials will be concrete and directly attributable to their actions, whereas the harm averted by the government officials (such as levees not broken, flood waters that remain lower) will be speculative and attributable to a host of factors. By contrast, when there is an agreement with the property owner, the political costs of using that property are likely to be substantially reduced if not eliminated altogether.

A third drawback to the coercive approach is that it entails uncertain duties to compensate the property owners and produces the risk of litigation, both of which may deter officials from efficient uses of private property. When government officials burden or injure private property, the government may be liable for compensation under either a state tort theory, or the takings clause of the applicable state constitution or the federal constitution. In many situations, governments have successfully cleared all three hurdles by arguing that emergency circumstances excuse any tort liability and render the destruction of private property a legitimate use of police power rather than a taking. For example, when the police seize or destroy private property in the course of apprehending a criminal subject, most jurisdictions do not force the responsible

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2655 (2005), the Supreme Court held that a municipality's use of eminent domain to aid a private residential and commercial development constituted a "public use." It follows *a fortiori* that destroying private property to prevent a catastrophic harm would also constitute a public use.

government entity to pay compensation.[15] Similarly, courts have typically refused to mandate compensation when private property is destroyed to prevent the spread of plant diseases, fires, or when it could be used by the enemy in war time.[16]

The government's luck runs out, however, when courts determine that the situation was not an emergency either because the need to destroy the property was not so immediate or because the circumstances creating the emergency were foreseeable by the government.[17] The latter line of reasoning has played a key role in the few cases in which private landowners have brought takings claims against the government for intentionally flooding their land. In two cases from California, the state appeals court confronted situations in which a local government intentionally flooded low-value land – a ranch and a campground – to prevent flooding on high-value commercial land.[18] The court did not award compensation in one case but did in the other on the grounds that, in the former, the local government had longstanding notice of the weak levee system, whereas the latter case was truly an emergency since it was the result of an extraordinary event for which the government was not on notice.[19]

Thus, governments deciding whether to flood low-value land face substantial ambiguity as to whether they will have to pay compensation. It is uncertain what constitutes an emergency exception to the just compensation requirement; it is uncertain whether the flooding will effect a permanent or a temporary taking,[20] and it is uncertain as to what amount of damages the plaintiff is likely to be awarded, if any. Thus, prospect of uncertain compensation and litigation costs would deter some coercive albeit efficient uses of private property.

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[15] *See* C. Wayne Owen, Jr., Note, *Everyone Benefits, Everyone Pays: Does the Fifth Amendment Mandate Compensation when Property Is Damaged During the Course of Police Activities?*, 9 WM. & MARY BILL RTS. J. 277, 278 & n.5 (2000) (collecting cases).

[16] *See e.g.*, Miller v. Schoene, 276 U.S. 272, 279 – 80 (1928) (holding that no compensation was required when a state government destroyed infected cedar trees); Teresi v. State of California, 180 Cal.App.3d 239 (1986) (denying compensation for destruction of diseased crops). On the destruction of private property during war, see *United States v. Caltex*, 344 U.S. 149 (1952); *United States v. Pacific Railroad*, 120 U.S. 227 (1887).

[17] *See e.g.*, Rose v. Coalinga, 190 Cal.App.3d 1627, 1635 (1987) (holding that the emergency exception to the just compensation requirement did not extend to the demolition of a building rendered unsafe by earthquake damage when the demolition occurred 57 days after the earthquake).

[18] *See* Thousand Trails v. California Reclamation District Number 17, 124 Cal.App.4th 450 (2004); Odello Brothers v. County of Monterey, 63 Cal.App.4th 778 (1998).

[19] *Compare Odello Brothers*, 63 Cal.App.4th at 791 (awarding compensation) *with Thousand Trails*, 124 Cal.App.4th at 463 (denying compensation).

[20] Ambiguity arises because of the courts' unwillingness to require compensation for takings that are temporally limited or which do not burden the entire property interest and because it is unclear whether floodwaters ought to be thought of as a 'physical invasion.' *See generally*, Alan Romero, *Takings By Floodwaters*, 76 N.D. L. REV. 785 (2000) (arguing that, despite some contrary precedent, the Constitution requires compensation for flooding caused by the government).

Finally, it is worth noting an additional inefficiency in relying on courts to award "just compensation" after the fact: it fails to properly align incentives for both private investment and government use of private property. When the government can take private property without compensating the private landowner all of her costs, it may do so too often because it incurs no financial cost. In that situation, the private landowner will likely under-invest due to the risk of a government taking. When the landowner is guaranteed full compensation, the private landowner may fail to internalize the chance that the government will need her property and thus is likely to over-invest. This inefficiency can also be corrected through the use of options contracts.[21]

3. HOW TO STRUCTURE THE OPTIONS CONTRACTS

Having already discussed the benefits of signing contracts in advance of a known threat, this still leaves open many questions regarding the way these contracts should be structured, such as how payments should be timed, how much private entities should be compensated, and how any payments should be financed. We examine these issues in this section, and then turn to the critical problems of moral hazard and land assembly in section four.

3.1 TIMING OF PAYMENTS AND COMPENSATION AMOUNTS

The contracts we are discussing here are call options.[22] A call option is a contract between two parties – here the government and a private entity, but usually referred to as the holder and the writer – that gives the holder (the government) the right, but not the obligation, to purchase a particular asset from the writer (private entity) at a particular price. This is the strike price or the exercise price. In order to have this right, the holder pays some amount for the option. In options contracts for contingent takings, the government would make some payment when the contract is signed and some payment if and when the option is exercised. In the example of flood contracts, assuming an optimal contract form, the amount and structure of payments the government makes will depend at a minimum on the farmer's degree of risk aversion.

A simple model can illustrate these points. For several reasons, it seems realistic to assume the government is risk neutral: It can spread losses over many

[21] *See* Robert Cooter, *Unity in Tort, Contract, and Property: The Model of Precaution*, 73 CAL. L. REV. 1, 19-25 (1985) (noting the inability of the just compensation system to align government and private incentives properly and suggesting the government purchase of options as a solution).

[22] There is an immense amount written on options in the financial world. One good text on this topic is OPTIONS: ESSENTIAL CONCEPTS AND TRADING STRATEGIES (The Options Institute: The Educational Division of the Chicago Board Options Exchange ed., 1999).

independent contingencies, it can spread its risks over time, and the disasters under study are not too large relative to the government's resources, which include the power to tax. Let's first posit that the landowner is also risk neutral, with a utility function given by v(W) = W, where W is total terminal wealth. Let w be the farmer's wealth assuming that his fields are not flooded and absent any payments from the government. Posit further that the farmer will escape any damage, unless the government exercises the option to flood his fields. Terminal wealth will be w plus any payments he receives from the government minus any losses he may incur. Let π be the upfront payment, ε denote the exercise price, and L the farmer's loss if his fields are flooded. Then the farmer's terminal wealth, W, will equal $w + \pi + \varepsilon - L$ should his field be flooded, and $w + \pi$ otherwise. To keep the analysis simple, we assume contracts are for one year, although multi-year contracts are actually more desirable given the small probability of most contingencies, and the costs of drawing contracts. Let p be the probability that the contract is exercised. In this risk-neutral case, the farmer's expected utility from a contract is:

(1) $E(v) = p*(w+\pi+\varepsilon-L)+(1-p)*(w+\pi) = w+\pi+p(\varepsilon-L)$.

The farmer's expected utility without a contract is simply w, as his terminal wealth will then always equal w. To make a risk-neutral farmer prefer entering into the contract, it is sufficient that $\varepsilon \geq L$, with $\pi \geq 0$, since in that case his terminal wealth never falls below w. (Prefer in this analysis means strict preference or indifference.) More generally, the required condition is that:

(2) $\pi + p\varepsilon \geq pL$.

In this risk-neutral case, payments upfront can be traded off in linear fashion against a lower exercise price, as long as the farmer's expected wealth with the contract is greater than it is without it.

However, the farmer is almost certainly risk averse. The options contract should be structured to reflect this fact. Let the farmer's utility function be u(W) with derivatives $u' > 0$ and $u'' < 0$, which imply risk aversion. The farmer's expected utility is now given by:

(3) $E(u) = p*u(w+\pi+\varepsilon-L)+(1-p)*u(w+\pi)$.

For the farmer to be made whole in both cases (flooded and not flooded),[23] it is sufficient that we have $\varepsilon \geq L$ and $\pi \geq 0$. If in addition, the government's expected budget, B, is such that

(4) $\pi + p\,\varepsilon = B$,

then there is a potential bargain to be struck. The optimal contract will maximize (3) subject to (4). Positing risk aversion, this gives:

(5) $\varepsilon = L$,

since that payment equalizes the farmer's wealth across the two conditions when there is and is not flooding. That is, the exercise price should exactly equal the loss.[24] Essentially, the farmer is provided with full insurance, as efficiency requires since he is risk averse and the government is not.

Any surplus going to the farmer – as there will be if the left side of (2) exceeds the right side or in other words the budget B exceeds expected losses – is paid to the farmer up front, so that it is spread evenly across all states of the world.[25] The pattern of payments matters to a risk-averse farmer, not merely their expected value.

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[23] It is not necessary that the farmer be made whole in both cases, since a loss in utility for one could be offset by a gain for the other. However, efficiency requires him to be made whole; hence we employ the simpler sufficient condition.

[24] To maximize the farmer's expected utility subject to the government's budget constraint, we first solve equation (4) for π and substitute this into equation (3). This gives:
$E(u) = p*u(w + B - p\varepsilon + \varepsilon - L) + (1 - p)*u(w + B - \varepsilon)$.
Taking the derivative of this equation with respect to ε and setting the result equal to 0 gives the equation:
$(1 - p)p*u'(w + B - p\,\varepsilon + \varepsilon - L) - (1 - p)p*u'(w + B - p\,\varepsilon) = 0$.
If $\varepsilon = L$, the positive (left) and negative (right) terms are identical, indicating that the total value will be 0. Thus, expected utility is maximized by setting $\varepsilon = L$, which implies that $\pi = B - pL$.

[25] It is difficult to determine in advance the outcome of negotiations over π (or equivalently B), as it depends on the negotiation skills of both parties and their ability to offer credible threats. It is also possible that there are non-observable benefits for the private party entering into the contract, which may make it possible for the government to reduce the amount of π. For instance, if farmers are worried that a great flood may damage part of their crop even if they do not contract with the government, signing a contract to store floodwaters ensures them of full compensation should their lands be inundated. Or, in the case of the Wal-Mart contracts mentioned earlier, the contract to provide certain goods at a certain price may guarantee the store that third-parties will not profit by selling their goods at a higher price to the government and will also ensure a certain degree of sales in the event of a catastrophe. Some contracts may also involve upfront costs, such as storing an extra amount of bottled water in warehouses in the event of a catastrophe. Such costs optimally would be paid up front as well.

Having the exercise price equal the loss provides additional benefits. The most important is that it provides appropriate incentives to the government to not exercise the contract too readily. Consider a situation in which the government is more beholden to downstream interests, perhaps because they have more political or economic clout, and it is uncertain whether floodwater storage on farms will be needed. If the government has already made payments to the farmers upfront and is obligated to pay an amount less than losses when they occur, it might flood their land when it should not have.[26] Or it may flood land when the farmer does not think it should have, causing the farmer to contest whether the conditions necessitated that his property be used. This could lead to stalemates, injunctions, and expensive legal battles. When the exercise price is set equal to the loss, the government will be just appropriately cautious about when to exercise the option.

A difficulty arises, however, when losses are uncertain and their magnitude cannot be observed or verified by the government. In some cases, the government may be able to estimate losses reasonably well using an easily measured proxy. For example, if it cannot determine exact crop losses, the government could use the average yield of the crop in the specific county from preceding years and multiply that by the acreage flooded and the going market price of the commodity. As long as such proxies do not substantially misestimate the loss, they will not impede contracting, and the risk imposed on the farmer – which entails an inefficiency – will not be great.

With flood contracts, though, damages vary with the time of year at which the option is exercised and how high floodwaters are on the farmer's land when it is flooded.[27] Similarly, the value of livestock varies with age, weight, and possibly other factors. Given the farmer's risk aversion, optimal compensation will be higher if an entire crop is destroyed and smaller if the flooding occurs at a time that say, only delays planting, or if stored waters are low enough or transient enough not to fully destroy a crop, suggesting an exercise price that varies over the year. As negotiating a payment schedule with each farmer would likely be prohibitively costly, the government could offer a take-it-or-leave-it amount of compensation that varies over the time of year when the option is exercised and is standardized on factors that determine water-storage potential. These would

[26] During the 1927 flood of the Mississippi and its tributaries, after significant lobbying, the powerful elite of New Orleans were able to convince the relevant state and federal officials to allow them to dynamite a levee protecting St. Bernard and Plaquemines Parishes. With no legal obligation to repay all losses, those individuals were likely too quick to act. After the dynamiting, upstream levee failures proved the action unnecessary; had the dynamiting been postponed one day, it would have been clear it was unnecessary and the property of the residents of those parishes would not have been sacrificed to protect property in the more affluent and politically powerful sectors of New Orleans. *See* JOHN M. BARRY, RISING TIDE: THE GREAT MISSISSIPPI FLOOD OF 1927 AND HOW IT CHANGED AMERICA (1997).

[27] *See* Manale, *supra* note 5.

include acreage, topography and location.[28] For livestock compensation, the amount would vary with properties of the animal killed.

In many circumstances, the assumption of a full loss may well overestimate losses. If the farm is flooded shortly before harvest, then the farmer loses the potential revenue from crop sales, but avoids the costs of harvest and getting the crop to market. Thus, the farmer should receive compensation below the market value of the crops. Also, it is possible that the flooded field could be used for something ex post, such as grazing or hay production, which should further reduce both losses and optimal compensation.[29]

3.2 AUCTIONS TO SECURE CAPACITY

Given the inevitable information asymmetry – the farmer knows his true expected losses but the government does not – the government might want to use a form of auction to secure flood capacity. A "reverse auction," where the government raises its standardized price until enough farmers, or more precisely, enough flood capacity, participates, is well suited for such purposes. Under such an auction, a farmer would submit a bid that indicated the amount he would need to be compensated to allow the government to store floodwaters on his land should pre-specified conditions come to pass. The government would find a price just high enough to get its required acreage, and all participating farmers would get that price. The bidding could be over π (the up-front payment), or ε (the exercise price), or both. With such an auction, barring collusion among farmers, a rational farmer will honestly reveal his reservation price. Contracts that last longer than a year may need to include a provision for changes in commodity prices or other stochastic factors. Such auctions have been used by the state of Georgia to compensate farmers to suspend irrigation during extreme droughts and in Australia to increase the extent of native vegetation on private lands.[30]

When submitting a bid to such a reverse auction, each farmer's bid will depend on his estimate of the likelihood that the government would exercise the option, namely that there would be a flood exceeding some magnitude. If the farmer thought the probability were lower than it actually was, he would offer a bid lower than the true expected losses because he (mistakenly) thought he would

[28] There is a further complicating factor. Relative storage potential will depend on the total quantity of floodwaters across all farms. The larger the flood, the greater the relative storage of a farm at a higher elevation.

[29] *See* Manale, *supra* note 5.

[30] *See* Ronald G. Cummings at al., Using Laboratory Experiments for Policy Making: An Example from the Georgia Irrigation Reduction Auction, Andrew Young School of Policy Studies Research Paper Series No. 06-14 (2002); Gary Stoneham et al., *Auctions for Conservation Contracts: An Empirical Examination of Victoria's BushTender Trial*, 47 AUS. J. AGRIC. & RESOURCE ECON. 477 (2003).

be getting a good deal. Essentially, farmers would likely suffer from a "probabilistic winner's curse."[31] By underestimating the probability, the winner is likely to face expected losses.

If the government's objective were merely to minimize its own financial costs and it only needed one or a few farmers to accept its offer, it could save money by capitalizing on the probabilistic winner's curse, whereby the farmers who had the lowest estimates would offer excessively low prices. In many cases, however, the government would have more to lose than to gain by making the exercise price depend on farmers' probability assessments. It might be seen as inequitable or unjust; government is supposed to help its citizens, not exploit their ignorance.

More generally, there are many reasons to suspect that private entities are likely to make relatively inaccurate estimates of the probability and severity of disasters. First, landowners might not have access to all the information needed to estimate probabilities correctly. Second, even if the landowners had the information they needed, cognitive biases would likely lead them to misestimate probabilities.[32] For instance, there is strong evidence that people tend to rely too heavily on events from the recent past in predicting future outcomes. In the years immediately post-Katrina, private actors will likely overestimate the probability of apparently similar disasters, such as storm-induced floods, and so demand contract prices that well exceed their true expected marginal costs. This proclivity is called the availability heuristic, a behavioral process by which we base estimates on what comes readily to mind rather than using unbiased data.[33] Basing estimates only on the recent past is akin to what Tversky and Kahneman call belief in the law of small numbers, that is, viewing a small sample as representative of the population, thus failing to recognize that larger disasters may occur even if they have not occurred recently.[34]

Prospect Theory, the leading model in economics and psychology describing how people actually make decisions, finds that people tend to homogenize the likelihood of low-probability events; hence those that are extremely low probability get substantially overestimated, and those at medium

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[31] The "winner's curse" is a phenomenon observed in common-value auctions where bidders do not know the true value of the object for which they are bidding. If each bidder makes his bid depend solely on his own information, the winner of the auction will be an individual who has overestimated the value. He will thus incur a loss. Dozens of experiments show that in practice individuals fail to understand the strategic context, and overbid in such situations. *See* Richard Thaler, *Anomolies: The Winner's Curse*, J. ECON. PERSPECTIVES 191 (1988).

[32] DANIEL KAHNEMAN ET AL., JUDGMENT UNDER UNCERTAINTY: HEURISTICS AND BIASES (1982).

[33] Amos Tversky & Daniel Kahneman, *Availability: A Heuristic for Judging Frequency and Probability*, 5 COGNITIVE PSYCH. 207 (1973).

[34] Amos Tversky & Daniel Kahneman, *Belief in the Law of Small Numbers*, *in id*. at 23; *see also* Matthew Rabin, *Inference by Believers in the Law of Small Numbers*, 117 Q. J. ECON. 775 (2002).

low levels are underestimated. In addition, decision makers put an added value on certainty, on probabilities of 0 and 1. Thus, living with a very small risk of suffering a contingent taking without full compensation would be perceived as costly. Prospect Theory also addresses how individuals make judgments about payoffs. Losses, even small losses, get weighted roughly twice as much as gains, producing implicit levels of risk aversion well beyond what traditional decision theory would think reasonable.[35] Loss aversion and a tendency to isolate each risky choice rather than consider one's whole portfolio of risk assets, leads to many departures in behavior from the predictions of expected utility theory.[36]

The problem of under- or overestimation of the probability of a taking would be largely eliminated if, as recommended in section 3.1, the exercise price ε were set equal to losses, L. Then, an auction would merely determine what magnitude of surplus farmers would receive for participating.[37] Lest the reader jump to Pollyannish conclusions, we should stress that estimating losses may be difficult, certainly before a catastrophe, and probably after one.

3.3 WHO PAYS FOR THE CONTRACTS?

Most often the increased protection, reduced damages, or other benefits contingent takings would provide are at least to some extent public goods benefiting a large group. In our flooding example, the group would be residents and asset owners downstream. These beneficiaries are diffuse and would face collective action problems in organizing to fund such contracts. Free riding would rule out the use of any mechanisms that tried to raise funds voluntarily. Thus, we expect the government to step in and fund such contracts through tax revenues, probably raised from a much broader constituency than the beneficiaries. We leave aside here the difficult political economy questions this may raise. Even so, some mechanism would be needed to guarantee landholders they would actually be compensated should disaster strike and the option be exercised. One strategy would be to endow a "disaster contract fund" from which payments would be made as needed.

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[35] Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk*, 47 ECONOMETRICA 263 (1979).

[36] Matthew Rabin & Richard H. Thaler, *Anomalies: Risk Aversion*, 15 J. ECON. PERSPECTIVES 219 (2001).

[37] This amount would be zero if there were a sufficiently large number of similarly situated farmers to ensure a competitive outcome. It would be positive, except for the marginal farmer, if farmers had different losses per acre flooded or different degrees of risk aversion.

4. TWO COMPLICATIONS

Options contracts for contingent takings will face unique challenges that will vary with the circumstances in which they are employed. Here, we discuss two problems that are likely to be widespread: moral hazard and land assembly problems.

4.1 MORAL HAZARD

Moral hazard is likely to plague some options contracts for contingent takings. Consider the livestock contracts in which a rancher receives compensation should a wolf eat his animals. If compensation amounts were equal to the full value of the livestock (as efficiency in risk spreading requires) and if there were few transaction costs entailed to receive payment, ranchers would not adequately protect their animals, since they would have nothing to lose. In effect, such an arrangement would invite the wolves to prey on the livestock.[38] Similarly, when a flood crest is heading down the river, at certain times of the year a farmer might be able to take some action to reduce losses from flooded fields, such as emergency harvesting of some crops, or moving machinery to an alternative location. However, there is little incentive for him to do so if he will be compensated for the crops or machinery lost in a flood.

Building on the model above, losses from exercising the contract are now a function of effort the farmer could take at a cost given by a. The risk-averse farmer's expected utility (or the rancher's for wolf contracts) is now given by:

(6) $E(u) = p * u(w + \pi - a - L(a) + \varepsilon) + (1 - p) * u(w + \pi)$.

Maximizing this, subject to the same government constraint in equation (4), gives:

(7) $\varepsilon = a + L(a)$.

So, as before, the optimal exercise price is to compensate for the losses, including effort.[39] Efficiency also requires that the farmer undertake actions to reduce losses until one unit of effort reduces losses by one unit, namely

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[38] Philip J. Nyhus, et al., *Bearing the costs of human-wildlife conflict: The challenges of compensation schemes*, *in* PEOPLE AND WILDLIFE: CONFLICT OR COEXISTENCE? 107 – 121 (Rosie Woodroffe et al. eds., 2005).

[39] This result requires that effort be effectively a financial cost. If it were merely hard and furious physical work, it would be a separable term in the utility function, and different efficiency conditions would apply.

(8) L'(a) = -1.

If effort were perfectly observable, the contract could specify this optimal effort level. Some of the programs that compensate landowners when livestock are eaten have requirements landowners must follow before they can receive compensation, such as enclosing the animals at night.[40] One difficulty is that often landowners know better than program managers about what actions are most effective in protecting their livestock.[41]

A larger problem is that often effort is not observable. In this case, the preferred solution would require that the farmer bear some risk so that he will have the incentive to take loss-reducing action. For example, compensation might not cover all the losses. Unfortunately, this solution sacrifices some efficiency in risk spreading to secure better incentives.[42]

An alternative approach bases compensation on a measure over which the farmer or rancher has no control. For example, compensation for animals eaten by wolves could depend on total losses in an area. It would be slightly better to base rancher A's compensation on the losses of all other ranchers in the area, but not his. This arrangement makes a rancher's compensation independent of his actual losses, but highly correlated with his losses. The rancher would then have every incentive to scare away the wolf entering his property, or to properly fence his sheep in at night. Another possible solution is to base payments to landowners (or communities) residing in areas where the wolf (or other endangered species) lives contingent on its abundance – if this is verifiable – as opposed to the damage it does. Similarly, landowners could be compensated if a wolf makes a den on their property, for example.[43] This would encourage both protective measures being taken for livestock and discourage killings of the wolves.

Clearly, when effort is unobservable and private actors are risk averse, optimal contracts will force some risk on the agent and will not fully align incentives.

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[40] Our formulation in (7) and (8) has effort required only when the threat is imminent. Thus, the farmer might have to move equipment outside the flood zone when the waters are beginning to rise. In other cases, such as enclosing the animals, the action is required in all circumstances. Then a will reduce p as opposed to L, and a will be part of both terms in the revised version of (7). Obviously, other optimality conditions would emerge.

[41] *See* Nyhus, et al., *supra* note 38.

[42] *See* Richard J. Zeckhauser, *Medical Insurance: A Case Study of the Tradeoff between Risk Spreading and Appropriate Incentives,* 20 J.ECON. THEORY. 10 (1970).

[43] *Nyhus et al.*, *supra* note 38.

4.2 THE LAND-ASSEMBLY AND HOLDOUT PROBLEMS

To make effective use of contingent contracts to store floodwaters, the government may have to secure participation from a number of farmers with contiguous properties, for two reasons. First, the amount of damages prevented by exercising the option contracts will depend on the amount of farmland contracted for flooding relative to the intensity of the flood. If the government can flood the fields of only a few farmers, it need not bother, for example, because the downstream levee would still fail. (That is, there may be increasing returns to scale to acreage flooded over some range.) Second, unless costly levees or floodwalls are built between parcels of land, if one landowner is flooded by the government, his or her neighbors will likely be flooded as well. (Such parcel dividers will make sense if some adjacent properties have such valuable assets as the town center.) Thus, the government needs to enter into contracts with specified groups of landowners in critical locations along the river and its tributaries.

Since we are assuming that the government will only receive benefits once it has entered into contracts with a critical group of landowners, the difference between their losses should the contract be exercised and the government's gain is the surplus available. When voluntary participation is needed from an entire group of landowners, there will be an incentive for each individual to 'hold out' and demand a higher payment for participating so as to extract the largest percentage of the surplus possible.[44] Such demands can deadlock negotiations.

The land-assembly and holdout problems may also be an issue for contracts outside of disaster response, such as creating habitat for an endangered species. In this case, fortunately, there may be more variety in the groups of landowners that could create the critical land area. When the government can simply turn to another landowner when one demands higher payment, the incentive to hold out is diminished. Whereas in the flood contracts, landowners near the river were essential and perhaps landowners in particular low-lying areas, when creating habitat for an endangered species, there might be a wider variety of properties that could provide the benefit. And for certain species, such as birds, it may not be necessary to have contiguous landowners participating; the key would be protecting a critical amount of designated land in a given area.

If the government could credibly threaten to abandon negotiations, one possibility to overcome the holdout problem may be mutually contingent contracts.[45] The government would offer a certain payment, in excess of the

[44] As mentioned in the section above, the efficient solution is for any surplus payments to be made upfront and the exercise payment be made to cover losses. Thus, any surplus a farmer receives should not be dependent on his or her loss.

[45] Lloyd Cohen, *Holdouts and Free Riders,* 20 J. L. STUD. 351 (1991).

opportunity costs of each landowner, contingent on all the landowners agreeing to enter the contracts. This might work if the government would leave the negotiations if any holdouts emerged, and if contracts were better than the status quo for all the landowners.

More likely, however, legislation would be needed to coerce any holdouts to accede to a contract once a certain percentage of the landowners agree to it. This type of solution is invoked to overcome holdout problems in oil production. When many firms are extracting from a common pool of oil, all firms race to extract as much as possible before the others do. The commonly proposed solution is unitization in which one firm extracts from the pool of oil and shares the profits with the others.[46] In this way, the oil would be extracted in a profit-maximizing fashion, instead of all firms racing to extract as much as they can as quickly as possible. Each firm has an incentive, however, to holdout and not agree to unitization unless it receives a higher portion of the profits. Due to this holdout problem, some states have a form of a compulsory unitization rule. For example, in Okalahoma, once 63% of the oil companies in a field agree, they can coerce the rest to agree to the unitization.[47] This model could be used for options contracts for contingent takings as well.

5. CONCLUSION

In certain low probability events, government use of private property could generate benefits that would more than make up for the cost to the property owner. To obtain these benefits, we propose the use of options contracts for contingent takings. With such contracts, the government would make a payment up front and a second payment should the option be exercised. Setting the exercise payment equal to the cost of losses promotes efficiency in both risk spreading and the incentives for exercise.

The use of such options contracts would allow beneficial transactions to occur that otherwise might not. Options contracts for contingent takings are applicable to a range of situations, from improving disaster response by guaranteeing a flow of needed supplies, to reducing potential damages by diverting floodwaters to low-value lands, to helping ensure the survival of an endangered species.

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[46] Gary D. Libecap, *Contracting for Property Rights, in* TERRY L. ANDERSON & FRED S. MCCHESNEY, COOPERATION, CONFLICT, AND LAW 142 – 167 (2002).

[47] Gary D. Libecap & Steven N. Wiggins, *The Influence of Private Contractual Failure on Regulation" The Case of Oil Field Utilization*, 93 J. POL. ECON. 690 (1985).