PROPERTY LAW

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DEAN LUECK AND THOMAS J. MICELI*

Abstract. This chapter examines the economics of property rights and property law. It shows how the economics of property rights can be used to understand fundamental features of property law and related extra-legal institutions. The chapter examines both the rationale for legal doctrine, and the effects of legal doctrine regarding the exercise, enforcement, and transfer of rights. It also examines various property rights regimes including open access, private ownership, common property, and state property. The guiding questions are: How are property rights established? What explains the variation in the types of property rights? What governs the use and transfer of rights? How are property rights enforced?

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1. Introduction

This chapter examines the economics of property rights and property law.   The purpose of this chapter is to show how the economics of property rights can be used to understand fundamental features of property law and related extra-legal institutions.   The chapter will both examine the rationale for legal doctrine and the effects of legal doctrine. The guiding questions are: How are property rights established? What explains the variation in the types of property rights? What governs the use and transfer of rights? How are property rights enforced?

1.1. Property Rights and Property Law

Property rights have been a subject of discussion among philosophers as well as political and legal scholars long before economists began to examine their origins and consequences. We define property rights as the ability (or expected ability) of an economic agent to use an asset (Allen 1999, Barzel 1997, Shavell 2002). As Demsetz (1967) notes in one of the classic early economic analyses, property rights represent a social institution that creates incentives to efficiently use assets, and to maintain and invest in assets. They may or may not be enforced by courts and because the actions of courts are costly, legal rights are but a subset of economic property rights. In addition to law (and statutorily-based regulations enforced by administrative agencies), property rights may be enforced by custom and norms (e.g., Ellickson 1991), and by markets through repeated transactions.

Property law is the body of court enforced rules governing the establishment, use and transfer of rights to land and those assets attached to it such as air, minerals, water, and wildlife. Property law is thus a subset of the law governing property rights applied to land and related assets. Intellectual property law similarly details the conditions under which the courts enforce rights to intellectual assets. In this framework, virtually all, if not all, branches of law are 'property rights law.' Labor law defines the court's role in enforcing rights to one's labor; contract law defines the rights of contracting parties, and so on.   Because the economics of property rights originated with a focus on rights to land and associated natural resources (e.g. fisheries, pastures, water) the link between "property law" and "property rights" is firmly established. This chapter will develop this link by examining property rights generally and property law in particular. Yet, much of the analysis in this chapter is applicable to topics elsewhere in the handbook, though in many cases (e.g., contracts, torts) the literature has become so specialized that the connection to the economics of property rights might seem faint.

The economic analysis of property law is substantially less well developed than the economic analysis of contract law or tort law (for example, there is no generally applicable model), and this chapter reflects this state of the discipline. The economics of property rights, however, is well developed but mostly without a focus on property law.[1] The disconnection between the economics of property rights and the law and economics of property law is longstanding. Demsetz' (1998) recent entry "Property Rights" in the *The New Palgrave Dictionary of Economics and the Law* makes absolutely no mention of property law, and much of the economics of property rights literature remains ignorant of property law.[2] Similarly,

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[1] The main exception to this is a deep theoretical literature on takings which is examined in section 8.
[2] Merrill and Smith (2001) note this also.

property law scholarship often is ignorant of economics. This is not to say there has not been important work in property law with strong economic underpinnings (e.g., Ellickson 1993, Epstein 1985, Heller 1998, Merrill 1986, Rose 1990), but it is clear that economics has not yet penetrated property law as it has penetrated contract and tort law. While it is common for courses in contract law and tort law to be taught using economics as the guiding framework, an economics-based course in property law is almost unheard of. In part, this chapter seeks to break down this division by bringing the two literatures together.

1.2. Property Rights, Transaction Costs, and the Coase Theorem

The economics of property law begins with Coase (1960), who provides a property rights perspective on the problem of externalities, or 'social cost.'[3] Prior to Coase, economists viewed externalities as a source of market failure requiring government intervention to force the responsible party to curtail the harmful activity. Consider Coase's famous example of the rancher and the farmer with adjacent plots of land. The rancher's cattle stray onto the farmer's land causing crop damage. If the rancher's profit, $\pi(h)$, and the amount of crop damage, $d(h)$, are functions of the rancher's herd size, h, then the first-best optimal herd size, h^*, maximizes $\pi(h)-d(h)$. That is, h^* solves $\pi'(h)=d'(h)$.[4] This is also the choice that would be made a single party were both the farmer and the rancher, Coase's 'sole owner' solution. First-best then is synonymous with the zero transaction cost outcome. With separate parties, however, and the absence of a contract between the farmer and the rancher or some type of government intervention (a tax, fine, or regulation), the rancher would choose the herd size to maximize $\pi(h)$. This results in too many cattle because the rancher adds cattle until $\pi'(h)=0$, which implies $h^r > h^*$. Thus, the rancher must pay a tax (or face liability) for the damage from straying cattle or he will expand his herd beyond the efficient size.

Note that this solution to the externality problem embodies a particular assignment of property rights--namely, that the farmer has the right to be free from crop damage. Another way to say this is that the farmer is labeled as the "cause" of the harm and therefore must face liability. And if the property right (or the legal liability rule) is structured properly, the rancher will purchase the right to impose crop damage up to the point where the marginal profit from the last steer just equals the marginal damage, yielding an efficient herd size.

Coase's critique of this conventional, or "Pigovian," perspective on externalities is not that it is wrong, but that it is incomplete.[5] To illustrate, suppose that the rancher initially has the economic (and legal) right to impose crop damage without penalty. According to the Pigovian view, this would result in an excessive herd size because the rancher would expand the herd to h^r. But note that the farmer would be willing to pay up to $d'(h)$, his marginal damage, for each steer that the farmer removes from the herd in order to avoid crop damage, while the rancher would accept any amount greater than his marginal profit, $\pi'(h)$. Thus, if transaction costs are zero, the parties will contract too reduce the herd to the efficient size. In other words, the farmer will purchase the rights to the straying cattle, the reverse of what happened under the Pigovian solution. The outcome in both cases, however, is efficient. This conclusion has become known

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[3] Another important, though little known early property rights contribution is that of Alchian (1965).
[4] We assume that $\pi''<0$ and $d''>0$, ensuring a unique optimum.
[5] This tradition is attributed to A.C. Pigou's *The Economics of Welfare* (###).

as the Coase Theorem[6], which can be stated in general terms as follows: *When transaction costs are zero, the allocation of resources will be efficient regardless of the initial assignment of property rights.*[7]

In reaching this conclusion, Coase challenged two assumptions implicit in the Pigovian view: first, that there is a unique cause of the harm, and second, that government intervention is necessary to internalize the externality. The Coase Theorem shows that neither is necessarily true. First, both ranching and farming are simultaneously causes of the harm--that is, causation is "reciprocal" in the sense that if either party is removed, the harm disappears. [8] Second, if private contracting is possible, a government-imposed remedy is not necessary to achieve an efficient outcome. The role of the government can be limited to assigning property rights and enforcing whatever deals the parties make.[9] These insights are important because they suggest an expanded set of remedies for externalities as compared to the Pigovian taxation approach, a point that we elaborate on below (see section 7).

1.3. The Impact of Transaction Costs: When Does Law Matter?

Although there has been debate among economists and legal scholars on the significance of the Coase Theorem and its implications, Coase (1960, 1988) has been clear on this issue. Economic and legal institutions are important and have impacts because transaction costs are *not zero* and thus property rights are *not perfectly defined* (Allen 1999, Barzel 1997). The Coase Theorem is merely an analytical benchmark that puts the focus on property rights. The Coasian approach thus stresses the role of transaction costs in determining the allocation of resources and the role of institutions, including law, in determining these allocations.[10] Seen as the costs of defining and enforcing property rights, transaction costs include enforcement costs, measurement costs, moral hazard costs, and related costs (Allen 1998).

Not only will the law matter for efficiency, as Demsetz (1972) explicitly points out, but the law itself is an economic choice, also expected to be driven by economic forces.[11] Indeed, Coase's (1960) discussion of nuisance law suggests an economic logic to the law in its assignment of property rights among various parties to these disputes. Coase, then, is not only the fountainhead

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[6] Stigler (1987) takes credit for calling this proposition the "Coase Theorem." Stilger also recounts a famous dinner at the home of Milton Friedman where Coase convinced a formidable group of scholars (including Friedman and Stigler) that his analysis was indeed correct.

[7] Typically economists have argued that the Coase Theorem is conditioned on the size of wealth effects. Barzel (1997), however, argues that wealth effects are likely to be trivial and not a condition of the Coase Theorem. He notes that the standard example of rights shifting without compensation itself violates the assumption of zero transaction costs since such a transfer would have to be compensated to meet this condition.

[8] In technical terms Coase points out that most interesting actions (Y) depend on the actions of both parties (a,b); that is, $Y = f(a,b)$.

[9] Ellickson, in his study of landowners and straying cattle in rural California, found that such contracting does occur, though the parties do not seem to rely on established legal rules as their starting point. Rather, they proceed by "developing and enforcing adaptive norms of neighborliness that trump legal entitlements" (Ellickson, 1991, p.4).

[10] Many scholars have called a case of zero transaction costs a "Coasian world" [get cites], but in making his case that the real world is full of transaction costs, Coase (1988) claims "I am not a Coasian" [full cite].

[11] In another path breaking article, Coase (1937) used a similar transaction cost argument to define the boundary between markets and firms. Barzel and Kochin (1992) note the link between Coase's property rights and transaction costs theories.

for the economics of property rights but also for the economics of law. Yet, Coase's focus on nuisance doctrine is a limited view of property law. Nuisance and trespass law concern the resolution of disputes that are not solved in the market, so here property law can be viewed as a substitute for market allocation.[12] The law of property, however, is much more that trespass and nuisance; it is concerned with the establishment of property rights, the types of property rights regimes that are allowed, and the rules that govern the use and transfer of property rights. In this sense, property law is a complement to markets. If there is an overarching theme to the chapter, this is it.

1.4. Outline of Chapter

The remainder of the chapter is organized as follows. Section 2 develops a taxonomy of property rights to illustrate the basic economic models. Section 3 examines the origin of rights. Section 4 follows with an analysis of the changes in property rights, or what has become known as the evolution of rights. Section 5 then examines various forms of voluntary exchange, including markets, leases, and inheritance. Section 6 examines involuntary transfers of title by adverse possession and theft. Section 7 examines various means of internalizing externalities. Section 8 considers issues related to state (collective) ownership, as opposed to private ownership, of property, including the optimal scale of ownership and takings. Finally Section 9 concludes. Each section is a mix of formal and informal theory and application to law and related institutions. Throughout we try to make clear that the goal of the chapter is to use economics to illuminate the rationale for and effects of property law doctrine. Where possible we summarize the empirical literature or explain empirical applications. The sections are not symmetric because the literature is not symmetric.

2. A Taxonomy of Property Rights

Before examining property law doctrine it is appropriate to first examine the predominant types of property rights regimes. With this basic understanding, the economics of property law can be pursued. The economics of property rights began with Frank Knight's (1924) analysis of public and private roads. Knight showed that a public road with no charge for access would be overused compared to the private road because users would not face the full cost of their actions. Gordon (1954) further developed Knight's preliminary model – establishing the now famous 'average product rule' for input use -- in the context of an open ocean fishery where no one could be excluded.[13] Gordon's model was completed with Cheung's (1970) paper, which fully characterized the Nash equilibrium for an open access resource.

Our analysis of various property rights regimes will use a common set of notation in which a fixed asset (e.g., plot of land) is used in conjunction with a variable input (x) in order to produce a market output ($Y = f(x)$). If the input is available at a market wage of w, then the first-best use of the input ($x^*(w)$) must maximize $R = f(x) – wx$ and satisfy the first-order necessary condition $f'(x) = w$. The first-best value of the land is thus $V^* = \int_0^\infty R^*(x^*,t)e^{-rt}dt$, where r is the discount

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[12] But see section 7.4 where we argue that trespass law can be seen as promoting voluntary resolution of certain property rights disputes.
[13] Scott (1955) similarly shows the dissipation under open access and the private property solution.

rate.[14] We start with open access, or a complete lack of property rights, and then, in turn, examine private property rights, common property, and mixed property rights regimes.

2.1. Open Access

Assume there are *n* individuals who have unrestricted assess to a resource such as a piece of land, and that output from the land (i.e., beef from grazing animals) is given by $Y = f(\sum_{i=1}^{n} x_i)$ where x_i is the effort of the ith individual, $f'(\cdot) > 0$ and $f''(\cdot) < 0$, and the opportunity cost of effort is the market wage, w_i.[15] Each person's objective is to maximize his own rent subject to the constraint of open access, which means that each user can only capture (and own) the output in proportion to his share of effort.[16] This means each person must solve the following constrained maximization problem:

$$\max_{x_i} R_i = f^i(x_i) - w_i x_i$$

$$\text{subject to } f^i = \left[x_i \Big/ \sum_{i=1}^{n} x_i \right] f(\sum_{i=1}^{n} x_i) \tag{2.1}$$

Assuming that all users are homogeneous[17] ($w_i = w_j$, for all $i \neq j$), the Nash open access equilibrium is $x = x^{oa}(n, w_1, ..., w_n)$, which must satisfy the first-order necessary condition

$$\left(n - 1 \Big/ n \right) \left(f(\sum_{i=1}^{n} x_i) \Big/ \sum_{i=1}^{n} x_i \right) = \left(1 \Big/ n \right) f'(\sum_{i=1}^{n} x_i) = w_i, \quad i = 1, ..., n. \tag{2.2}$$

Equation (2.2), as Cheung shows, is indeed identical to Gordon's asserted average product equilibrium, but only in the limiting case of an infinite number of users with unrestricted access.[18] Thus, in the limit as $n \to \infty$, (2.2) becomes

$$\left(f(\sum_{i=1}^{n} x_i) \Big/ \sum_{i=1}^{n} x_i \right) = w, \tag{2.3}$$

which states that the open access equilibrium level of effort occurs where the average product equals the wage. More importantly, this limiting case also implies that rents are completely

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[14] Each period's rent can be viewed as a steady state outcome.

[15] This production function captures the effect of competing users of the open access asset and is standard in the literature. Also, note that while ownership of the land is absent each person is assumed to have perfect ownership of themselves, their labor, and the product derived from the open access asset.

[16] This is a standard assumption but might be modified to explicitly distinguish use effort from violence effort.

[17] This has been the starting point with Knight, Gordon and Cheung,

[18] Equation (2.2) is actually a weighted average of average and marginal products. Brooks et al. (1999) show that Cheung's(1970) equilibrium holds in a dynamic setting.

dissipated; or that, $\sum_{i=1}^{n} R_i = \sum_{i=1}^{n} \left[f^i(x^{oa}) - wx^{oa} \right] = 0$. Similarly, the present value of the asset is also zero; that is, $V^{oa} = \int_0^{\infty} R(x^{oa}, t)e^{-rt}dt = 0.$

In this framework, the absence of property rights leads to overuse of the asset and complete dissipation of its value.[19] Complete dissipation is a limiting result, however, of the assumption of homogeneous users. If users are heterogeneous, dissipation under open access will be incomplete, and infra-marginal (low cost) users will earn rents (Libecap 1989). The presence of rent under open access may be an important factor in preventing the establishment of rights to the open access resource because those earning rents will have incentives to maintain the open access regime.

2.2 Private Property Rights

Private ownership, as Knight first noted is the straightforward solution to the open access problem.[20] Under the conditions of the Coase Theorem, the owner faces the full value and opportunity cost of asset use, he chooses the first-best level of use ($x^* < x^{oa}$), and generates $V^* > V^{oa} = 0$. The Coase Theorem also implies that, as long as property rights are well defined the organization of the asset's use will not matter: the owner may use the land himself, he may hire inputs owned by others, input owners may hire (or rent) the asset, or there may be a sharing arrangement between the asset owner and the input owners. In fact, under the conditions of zero transaction costs, any property regime (e.g., common property, state ownership) would generate the first-best use of the asset.

Not only does private ownership create incentives for optimal resource use, it also creates incentives for optimal asset maintenance and investment. With open access, no user has any incentive to use inputs that have a future payoff.[21] To see the effect on investment, consider a slightly modified version of the model above.[22] Let future output be $Y_{t+1} = f(x_t)$, where x_t is current investment, available at a market wage of w, and the interest rate is r. The first-best use of the input (x_t^*) must maximize $R = f(x_t)/(1+r) - w_t x_t$ and satisfy the first-order necessary condition $f'(x_t)/(1+r) = w_t$. This outcome is generated under perfect private ownership. Now let π be the probability of expropriation (because of imperfect property rights) of the future output, so that ($1-\pi$) is the probability the investor's output remains intact. The solution to the investment problem (x_t^{π}) is now to maximize $R = f(x_t) [(1-\pi)/(1+r)] - w_t x_t$ which must satisfy $f'(x_t) [(1-\pi)/(1+r)] = w_t$. This clearly implies less investment ($x_t^{\pi} < x_t^*$). Pure open access means that no investor could claim future output ($\pi = 1$), so $x_t^{oa} = 0$, and the rent from investment also equals zero.

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[19] Hardin's (1968) famously named "tragedy of the commons" is a popularized version of this literature.

[20] This was well understood by Hobbs, Bentham, Locke and Blackstone long ago.

[21] Writing before Adam Smith, Wm. Blackstone (Book II, Chapter 1, 1765) recognized this and wrote: "And the art of agriculture, by a regular connexion and consequence, introduced and established the idea of a more permanent property in the soil, than had hitherto been received and adopted. It was clear that the earth would not produce her fruits in sufficient quantities, without the assistance of tillage: but who would be at the pains of tilling it, if another might watch an opportunity to seize upon and enjoy the product of his industry, art, and labor?"

[22] This is based on the detailed analysis of Bohn and Deacon (2000).

In a recent article, Heller (1998) identifies a situation in which a large number of uncoordinated individuals have the right to exclude users, thus creating a regime in which assets are under-used because each rights holder can exercise a 'veto' over use. Because of the incentive to under use rather than over use the asset, Heller labeled this the anti-commons and argues that many of the development problems in post-communist Europe are plagued with this problem of 'too many owners.' Buchanan and Yoon (2000) formalized Heller's idea and gave it application in cases where competing bureaucracies can stifle development by exercising veto rights. De Soto's (2000) documentation of the difficulties of operating in an economy heavily laden with overlapping bureaucracies is a similar application (as discussed in Section 5.1.2). In a similar application, Anderson and Lueck (1992) study 'fractionated'ownership of land on American Indian reservations. Anderson and Lueck found that divided ownership of agricultural land led to dramatic reductions in the value of agricultural output. While the anti-commons phenomenon clearly is real, it can be regarded as an open access investment problem rather than as a distinct regime.

The empirical literature on private property rights is of two types. First, there is a literature that attempts to measure the dissipation from open access and compare resource use to that under private property. This literature is dominated by studies on natural resources and especially of fisheries where open access regimes have been common (e.g., Agnello and Donnelly 1975, Bottomley 1963). These studies have estimated the deadweight losses from open access use and compared levels of asset use in open access regimes with those of private property and other limited access regimes. Second, there is a recent and growing literature on the effects of property rights security on resource use and investment. Much of this literature has focused on the investment effects of differences in legal title to land. In his survey article Besley (1998) notes that the econometric evidence for positive investment effects in developing countries is quite limited. These limits arise from data limitations (on both measures of investment and measures of property rights security) and from potential property rights endogeneity. We expect more investment with better defined rights, but as we discuss in section 4, the choice of property rights regime can itself be influenced by investment levels or other correlated variables. Thus the econometric issue is how to find an instrument for property rights variables to isolate the effect of rights on investment.

2.3. Common Property Rights

In modern social science the term 'commons' or 'common property' originated in the analysis of what is now called open access. Yet, in law and custom common property has long meant, in stark contrast to open access, exclusive ownership by a group.[23] Common property regimes have been well documented, especially for natural resource stocks in less developed economies (Bailey 1992, McKay and Acheson 1987, Ostrom 1990), and their details have been studied in many settings (e.g., Dahlman 1980, Eggertson 1992, Stevenson 1991). Many writers on common property have noted the gains from group enforcement of rights to the resource (Ellickson 1993,

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[23] Indeed Hardin's (1968) famous paper incorrectly characterizes the common pastures of English villages as open access resources when the historical record shows clearly that they were common property (e.g., Dahlman 1980, Smith 2000).

McKay and Acheson 1987, Ostrom 1990, and Stevenson 1991), and we model common ownership to take this empirical feature into account.

Common property is best viewed as an intermediate case between open access and private ownership. Common property may arise out of explicit private contracting (*e.g.*, unitized oil reservoirs, groundwater districts) or out of custom (*e.g.*, common pastures and forests); it may have legal (*e.g.*, riparian water rights) or regulatory (*e.g.*, hunting and fishing regulations) bases that have implicit contractual origins. Contracting to form common property effectively creates a group that has exclusive rights to the resource (Eggertsson 1992, Lueck 1994). Acting together individuals can realize economies of enforcing exclusive rights to the asset. Equation (2.2) implies that waste can be reduced simply by restricting access to the asset.

A contracting model can illustrate how common property can limit waste from the rule of capture.[24] Contracting to form common property effectively creates a group that has exclusive rights to the resource. We assume that (contractual) agreement among group members pertains only to the group's size and the joint effort to exclude outsiders. In this setting, individuals acting together can realize economies of enforcing exclusive rights to the asset, so we also assume the costs of excluding (or policing) non-members can be represented as *p(n)*, where *p'(n)* < 0 and *p''(n)* > 0.

A simple and customary method of allocating use of common property is a rule that grants equal access to all members of the group (Ostrom 1990). Equal sharing of the asset avoids the explicit costs of measuring and enforcing individual effort (or use) but still creates an incentive for over use.[25] Effort is not explicitly part of the common property 'contract' so each member chooses his own effort (x_i) as he captures his share of the asset's output ($Y = f(x)$ again) in competition with other group members. The size of the group is chosen to maximize the wealth of the group subject to the constraint of aggregate effort (X^c) by members operating in a common property regime, and in recognition of the costs of excluding outsiders. Optimal group size is a tradeoff between increased resource use with a larger group and increased enforcement costs associated with a smaller group. Formally the problem is

$$\max_n R = f(\sum_{i=1}^n x_i^c(n)) - \sum_{i=1}^n (w_i x_i^c(n)) - p(n), \tag{2.4}$$

where x_i^c is the individual's solution to the problem in equation (2.1). The optimal group size, n^c determines total effort[26] and must satisfy the first-order necessary condition

$$\frac{\partial R}{\partial n} = \sum_{i=1}^n \left[\left(f'\left(\sum_{i=1}^n x_i \right) - w_i \right) \right] \frac{dx_i^c}{dn} - p'(n) = 0. \tag{2.5}$$

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[24] The model is based on Lueck (1994). Also see Caputo and Lueck (1994) and Wagner (1995).

[25] Common property might also be viewed as an output sharing contract with moral hazard. In this framework group members shirk as in a principal-agent model (see Lueck 1994). Both types of common property – asset sharing and output sharing – are found in the empirical literature.

[26] Total effort is given by $X^c = \sum_{i=1}^{n^c} x_i^c$.

Equation (2.5) states that the gain from an additional member in terms of a marginal reduction in policing costs must equal the marginal reduction in aggregate rent from overuse of the resource. The net present value of the common property resource is thus $V^c = \int_0^\infty R(x^c, t)e^{-rt}dt > 0$, where $V^* > V^c > V^{oa} = 0$. While the value of an asset governed by common property is less than its first-best value, it could clearly have greater value than private property depending on the magnitude of the policing cost and overuse effects.

Dissipation from internal capture can be limited by maintaining a homogeneous membership. With equal sharing rules, a homogeneous membership maximizes the present value of a common property resource (Lueck 1994, 1995). Once a group chooses an equal sharing rule there is an incentive to maintain homogeneity. With heterogeneous members and equal shares, highly productive individuals will supply too little effort and the less productive will supply too much, so dissipation will increase. In effect, equal-sharing rules increase group wealth with homogeneity among group members. This provides an economic rationale for preserving homogeneity by screening potential members, by indoctrination, or by restricting the transfer of memberships.

There are other potential limits on the capture behavior of individual common property owners that are not considered by the above model. For example, if group members expect to interact over long periods the incentive to overuse the resource may be limited by the desire to maintain the productive relationship. Accordingly, customary rules can evolve that restrict members, for instance, by limiting the size of private herds on a common pasture (Rose 1986, Smith 2000). For common resources that are attached to land such as oil, game, and water, ownership of the land can limit access to the resource. In effect, the group is the set of private landowners who have access to the common resource. In this case, private contracting to consolidate land holdings is a possible solution to the ownership problem for the attached resource (Libecap and Wiggins 1984, Lueck 1989).[27]

It is difficult to know how important common property regimes are in modern economies. Certainly families and other 'close knit' groups use common property rights to govern resources. The 'lobster gangs' of Maine are perhaps the most famous such case. In modern businesses they seem to be less typical, perhaps because group ownership leads to costly transfers of rights that must ultimately be governed by political decision making. It may also be true that large-scale enforcement by the state (i.e., courts, police) has usurped the major advantage of common property. In law, riparian water rights and the public trust doctrine (as we show in Section 8.2.1 below) still contain important elements of a common property regime.

2.4. State Property Rights

A third, and increasingly important, category of property rights are those held by the state. Vast amounts of land, buildings, and capital equipment are owned by governments (local, state and

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[27] On the other hand, there are problems when resource rights are tied to land ownership. For example, further parcelization of land can exacerbate the rule of capture as it has done with oil discovered in urban areas. In addition, linking rights can create incentives for further parcelization. For instance, under riparian doctrine linking water to land sometimes yields long, narrow "bowling alley" parcels designed to extend water rights to many users (Dukeminier and Krier 2002).

federal). Local governments own schools, road ways and fleets of police cars. States own vast tracts of land, especially in the west, where statehood grants established state trust lands to be managed to finance schools. States own universities and administrative buildings. The federal government owns over one-third of the total land area in the United States, again with a much larger presence in the western states. It owns the Outer Continental Shelf from the shore to the 200-mile international border and thus own billions of dollars worth of oil-gas and other resources. The federal government also has vast holdings of urban real estate (e.g., The White House, federal buildings throughout the country) and billions of dollars of capital equipment ranging from fighter jets and aircraft carriers to personal computers and desks.

The specific set of property rights than govern these state assets varies widely and has not been systematically analyzed by economists.[28] All are under the control of some administrative agency be it the US Army, the state highway department, or the Bureau of Land Management. The statutes and regulations and political forces that govern these agencies varies widely and thus lead to a range of outcomes. Many federal lands are managed passively and are thus open access for many uses, especially for outdoor recreation such as cycling, fishing, hiking, hunting, and rafting. This is true for the bulk of land administered by the Bureau of Land Management, the Forest Service, and the Fish and Wildlife Service.[29] Other lands and uses are governed by a combination of price and non-price (lottery, waiting lists) mechanisms, but open to virtually all citizens in principle. Commercially valuable natural resources, such as coal, oil-gas, and timber, are routinely leased to private firms, who essentially have private rights over certain attributes of the land (Nelson 1995). Ski resorts have long term leases to operate on federal lands, and commercial businesses such as hotels tend to have similarly long term agreements to operate in national parks. Moveable property like desks, planes and rifles are governed differently as well. In some cases state assets are assigned to individual users and thus become an almost exclusive usufruct right. It is well known that a soldier's rifle is 'his rifle' and no one else's. What seems to be common to all of these regimes is a severe limit on transferability of rights.

Given the great variation in property rights, the analysis of state property not only requires a detailed knowledge of the asset and the relevant administrative agency but also a workable theory of bureaucracy. The limited applicable literature is found in the analysis on natural resource agencies, especially those governing federal lands. An early study by Stroup and Baden (1973) examined the behavior of the Forest Service and the management of national forests. They pointed out the different incentives faced by Forest Service managers compared to those of private forest owners and how interest groups influence agency behavior. Since that time there has developed a literature that has examines the economic efficiency of public land management, mostly concluding that federal lands are not particularly well managed, and that these inefficiencies often are coupled with lower environmental quality.

The relevant law for state property has origins in common law (e.g., mining on federal land in a first possession rule) but is primarily governed by statutes and regulations, all shaped by bureaucrats, interest groups and politicians. These legal constraints shape the objective of agencies. For example, managers of state school trust lands in the west are typically mandated to

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[28] Nelson (1995), however, notes the underlying and variable system of property rights in federal lands.
[29] For these assets the typical rhetoric is that open access is good since 'they belong to all of us' yet no one would make the same claim for an F-18 fighter jet.

maximize financial returns and are used under a system of leases to private parties for uses ranging from farming to hunting to logging. National forests, however, are governed by federal 'multiple use' statutes which very often limit the ability of managers to generate revenue from forest use. These statutory constraints, in turn, shape the property rights that develop.

2.5. *Mixed property rights and complex assets*

Real property regimes are more complex than the open access, private property, common property, and state property discussions suggest.   Real property rights regimes, in fact, are mixtures of these basic types. A rancher's land may seem to be private but this is only a partial description. The right to the grass for grazing is private but the streams running through the property may be open access for fishing or recreation; or the grass may be a lease from a federal agency with mineral rights held by yet another private party. The underlying oil reservoir may be governed by a unitization contract (subject to oversight by an state oil conservation agency) among many neighboring ranchers, essentially mimicking common property. Predator control for coyotes that roam across many ranches may likewise be governed by a common property regime. Similar scenarios are found in residential and commercial real estate, and Bailey (1992) found a mixture of ownership regimes among aboriginal peoples. This suggests a mixture of rights. Because assets are a complex collection of valuable attributes, ownership is also a complex collection of rights (Barzel 1982, 1997, Eggertssonn 1990, Ellickson 1993, Rose 1998), comprised of the four fundamental types.

Little work has been done to understand the forces that determine the optimal complexity of property rights. This area thus remains an important area for future work. Smith's (2000) study of the common field system of medieval Europe is one of the few to examine the economic logic of a mixed property regime. Smith notes that for crops the land in the typical village was private, but that for grazing the land was common property.[30] He notes how private property for crops provides incentives for investment and husbandry and how a larger scale of land ownership is optimal for grazing (of private herds). Lueck's (1989) study of wildlife law focuses on the variation in ownership of wildlife but recognizes that wildlife is but one of many valuable attributes of the land and that the dominate property regime is linked to agricultural use. Ellickson (1993) similarly notes a wide range of mixed regimes, including legal and customary rights. These studies are important in furthering our understanding of the complexity of rights but are lacking a cohesive (and ultimately formalized) framework. The modern principal-agent literature on contracts, especially that on moral hazard, may be a starting point as our discussion of land leases in Section 5 suggests. The major question is to what extent each individual attribute of asset can be treated as an independent asset whose ownership is independently determined.

The common law of property begins with the *ad coelum* doctrine's mandate that ownership of land includes all attributes in an infinite projection above and below the earth's surface.[31] In this system the only ownership question is the size of the surface boundaries. The *ad coelum* framework ultimately breaks down because various attributes (as the rancher example shows)

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[30] Smith labels this regime a "semi-commons."
[31] The complete Latin phrase is *"cujus est solum ejus est usque ad coelum,"* which translates "to whomsoever the soil belongs, he owns also to the sky and to the depths" (Dukeminier and Krier 2002, p.141).

have different surface projections. Thus the optimal ownership of land for a home may be one acre, but for an oil reservoir it may be ten thousand acres and for an airshed it may be much larger still. The law has long recognized the limits of *ad coelum* doctrine and has developed to accommodate the demand of different attributes of land. The law of servitudes and the law of separate estates in water and minerals are clear examples. Modern public administration of environmental resources is a recent application (e.g. Rose 1998). The law of nuisance and trespass, the focus of Coase's analysis, has to do with conflicts that ultimately arise between the owners of adjacent parcels, which derive from complex assets with various dimensions of use. The doctrine of private necessity, for example, is an exception to the law of trespass, which actually allows one to use another's property in an emergency.[32] Thus emerges the traditional legal concept of property rights as a "bundle of sticks;" an idea that accurately meshes with the complexity and mixed ownership of real assets. As Ellickson (1993) notes, the common law allows a wide variety of subdivision of rights in time, use, space.

3. The Origin of Property Rights

This section examines the origin of property rights. In both custom and law first possession has been the dominant method of establishing rights, and the rationale for and the effects of this mechanism will be examined closely. It will be clear that the manner by which possession is defined and enforced will be crucial in the type of rights that are created. Alternatives to first possession are also examined including auctions, lotteries, and administrative assignments.

3.1. *First Possession*

First possession rules can operate on different margins. For instance, the rule can grant ownership of a single bison to the first person that kills it under the so-called rule of capture, or it can grant ownership of the entire herd to the first person that claims ownership of the entire living herd. The behavior of the possessor and the use of the bison resource will obviously differ in the two cases. In the initial case, first possession applies to the *flow* of output from the *stock* of living bison, while in the second case the rule applies to the stock itself. In the bison example, the rule of capture is expected to emerge --and in fact did -- because the cost of enforcing possession to the live herd is prohibitive (Lueck 2002).

Figure 1 illustrates the effects of a first possession rule, beginning with an unowned asset. As the left branch of the figure shows, if applied to a stock, private property rights are established directly through possession. On the right branch, if only a flow (or a portion of the stock) can be possessed, the rule of capture ensues. Thus both paths have the potential for dissipation, either from a race to claim the stock or from open access exploitation. In a race, dissipation takes the form of excessive investment prior to ownership, but the resource is unaltered. In contrast, under the rule of capture, dissipation manifests as damage to the resource from excessive use. The stock-flow distinction also illuminates the temporal dimensions of ownership. First possession rules often vary as to the duration of the granted ownership right. For example, possession could grant ownership of a pasture in perpetuity or it could simply grant ownership of the grass

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[32] *Ploof v. Putnam* 81 Vt. 471, 71 A 188 (Supreme Court of Vermont, 1908). Here a person was allowed to tie-down a boat at a private dock during a severe storm without permission. The court ordered the user to pay for the use of the asset.

currently being grazed by one's livestock. Perpetual ownership means ownership of the stock, while a shorter term of ownership means ownership of some flows. Granting rights to stocks also confers ownership to the future stream of flows, so the formal economic model is inter-temporal. Granting rights to flows, on the other hand, means ownership is a one-time event, so the formal economic model examines just one period.[33]

[Figure 1 here]

Consider an asset (e.g., a plot of land) that yields an instantaneous (net) flow of benefits *R(x(t))*, where *x(t)* is the amount of a variable input supplied by private owners at time *t*.[34] Let *r* be the interest rate, and assume the flow value, *R(t)*, grows over time at the continuous rate *g < r*, so that the value of the asset grows over time. Also assume that each period's return is independent of past returns.[35] The term *g* can be thought to measure increases in the demand for the asset, perhaps because of population growth. This formulation also recognizes the usual case that during early periods assets are not sufficiently valuable to cover the costs of establishing ownership. The first-best, full-information outcome is

$$V^{FB} = \int_{t=0}^{\infty} R(x^*(t))e^{-(r-g)t}dt, \tag{3.1}$$

where *x***(t)* is the optimal input level in period *t*. In general, V^{FB} is not attainable because of the costs of both establishing and enforcing rights that efficiently allocate use of the resource.

3.2. *Claiming the Asset*

The left-hand side of Figure 1 shows the case when ownership of the asset is granted to the first person to obtain possession of the entire stock. To simplify, we assume that the method of possession does not damage other resources. The first claimant thus obtains exclusive rights, into the indefinite future, to the flow of rents, $\int_0^\infty R*(t)dt$, generated by the asset. Since establishing a bona fide claim will be costly and because *g < r*, rights may not be worth enforcing. Under these conditions, property rights to the asset will emerge, after an initial period without ownership, as the value of the asset increases (Demsetz 1967). Maximizing resource value is, in effect, a problem of optimally timing the establishment of rights under first possession.

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[33] Of course, there can be ownership rights of intermediate term (e.g., patents, copyrights) but this simple dichotomy covers most of the important cases and serves to clarify the model.

[34] The model here is derived from Lueck (1995, 1998).

[35] One can think of *R(t)* as the steady-state flow of benefits. Note, if *g > r* the present value of the asset would be infinity.

Now assume there are one-time costs, *C*, of establishing enforceable rights or demonstrating possession which grant the owner the exclusive right to the stream of production for all time. If there is a single potential claimant, the flow from the asset (and the rents) is available after rights to the stock are established. The decision to claim the stock is the result of private maximization which, in this case, means the net present value of the asset is

$$V^S = \int_{t^S}^{\infty} [R(x^*(t))e^{-(r-g)t}dt] - Ce^{-rt^S}, \qquad (3.2)$$

where t^S is the time at which ownership of the stock (and the flow of output) is established under first possession. The optimal time to establish ownership is when the marginal return from waiting, the present value of the asset's flow at t^S, equals the marginal cost of waiting, the present value of the opportunity cost of establishing rights also at t^S, or $R^*e^{-(r-g)t^S} = rCe^{-rt^S}$. Inspection of (3.1) and (3.2) shows that the value of the asset clearly falls short of first-best, or $V^* < V^{FB}$. This is because the net value of the asset must now account for the costs of establishing ownership, and the fact that these costs delay ownership and production to t^S from $t = 0$.

A first possession rule can dissipate value when there is unconstrained competition among potential claimants.[36] In the simplest case with homogeneous competitors, potential claimants gain ownership by establishing possession just before their competitors. A claim is worth staking as long as the net value of the asset is positive, so a competitive rush to claim rights causes ownership to be established at exactly the time, t^R, when the present value of the rental flow at t^R equals the present value of the entire costs of establishing ownership at t^R, or when $R^*e^{-(r-g)t^R} = Ce^{-rtR}$. In such a race, rights are established prematurely at t^R, where $t^R < t^S$.[37] More important, the race equilibrium implies that the rental stream is fully dissipated; that is,

$$V^R = \int_{t^R}^{\infty} [R(x^*(t))e^{-(r-g)t}dt] - Ce^{-rt^R} = 0. \qquad (3.2)$$

Heterogeneity among potential claimants can reduce, or even eliminate, the dissipation of wealth (Barzel 1994, Lueck 1995). Assume there are just two competitors (*i* and *j*) for ownership of the asset with possession costs $C_i < C_j$. Also assume that neither party knows each other's costs. In a race, person *i* gains ownership just before the closest competitor makes a claim, at time, $t^i = t^R - \varepsilon$, and earns rent equal to the present discounted value of his cost advantage, V^{R_i}. The key implication is that as the heterogeneity of claimants ($C_j - C_i$) increases, the level of dissipation will decrease. The analysis remains the same with rental value differentials such as $R_i \neq R_j$ or different expectations about the rate of growth of the flow value, $g_i \neq g_j$. In the extreme case, where just one person has costs less than the net present value of the asset's flows, the first-best outcome is achieved. Since only one person enters the race, there is no dissipation.

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[36] This phenomenon was first studied by Barzel (1968) in the context of research and technological development. Also see Mortensen (1982).

[37] The single claimant solution yields $t^S = (lnr+lnC-lnR)/g$ while the race model gives $t^R = (ln(r-g)+lnC-lnR)/g$. Inspection reveals $t^R < t^S$.

Altering the assumption about information can alter the racing equilibrium. Fudenberg et al. (1983) and Harris and Vickers (1985) show that if competitors have complete information about each other's talents a race will not ensue because only the low-cost individual will have a positive expected payoff of entering the race; that is, V^S is achieved *if $C_i < C_j$, $i \neq j = 1, ... n$.*

Even though claimant heterogeneity can limit or eliminate racing dissipation, there arises the possibility that a claimant can gain a cost advantage by expending resources, thereby altering the margins of dissipation (McFetridge and Smith 1980). For example, if competing claimants can acquire the technology to achieve the minimum costs (C_i), then homogeneity and the full dissipation equilibrium is re-established. This extreme result, however, relies on the assumption that homogeneity can be attained easily by investing in the low cost claimant's technology. The more likely reality is that claiming costs depend not only on endogenous investment decisions but also on exogenous forces that generate and preserve heterogeneity. Consider two possibilities. First, if the distribution of talent across individuals is not equal, some people will have innate advantages that will be difficult or impossible, to overcome with investment. Second, if there is random variability in opportunities, then some individuals will be in the position of being the low cost claimant; again, investment is unlikely to destroy the random advantage.

Because first possession is a rule that restricts competition to a time dimension, there is another reason why investment cannot routinely eliminate heterogeneity. Cost advantages, no matter how they were gained initially, are expected to diminish over time because potential investors ultimately will gain information that allows them to mimic the behavior of the low cost person (Kitch 1977, Suen 1989). As long as costs depend on exogenous factors, dissipation will be incomplete. In the worst-case race equilibrium, the first claimant will own just the value of his exogenous advantage; in the best-case, extreme heterogeneity or the full information game theory equilibrium, the first claimant will own the full potential value, V^S, of the asset.

3.3 *The Rule of Capture for Asset Flows*

When the costs of enforcing a claim to the asset are prohibitive, ownership can be established only by capturing or "reducing to possession" a flow from the asset. (See the right side of Figure 1.) The rule of capture -- simply a derivation of the rule of first possession -- will occur when enforcing possession of the flow is cheaper than enforcing possession of the stock. Wildlife and crude oil are the classic examples: ownership is established only when a hunter bags a pheasant or when a barrel of oil is brought to the surface. The stock itself, be it the pheasant population or the entire underground reservoir of oil, remains unowned. As a result, the new "race" is to claim the present flow $R(t)$ by capturing the product (e.g., the dead pheasant) first.

As a rule of capture, first possession can lead to classic open access dissipation (Epstein 1986, Lueck 1995). Under the rule of capture no one owns the asset's entire stream of flows, $\int_0^\infty R(t)dt$. Now the formal economic analysis of dissipation is just one-period, rather than inter-temporal as in the race, and in fact is identical to the open access model developed in section 2.1, with an equilibrium level of effort given equation (2.2).

3.4. *First Possession in Law*

The law of first possession is generally consistent with the model that includes two potential paths of dissipation (racing and over-exploitation). When first possession has the potential for a race, the law tends to mitigate dissipation by assigning possession when claimant heterogeneity is greatest. On the other hand, when first possession breeds a rule of capture, the law tends to limit access and restrict the transfer of access rights to limit open access exploitation. It should be noted that judicial opinions and statutes may use such terms as "first in time, first in right," "priority in time," or the "rule of capture." Regardless of the precise legal terminology, all of the subjects examined below are governed by rules in which legitimate ownership is created by establishing possession before anyone else. Table 1 summarizes some important first possession rules.[38]

[Table 1 here]

In those cases where first possession rules establish ownership in a resource stock, a number of common principles are evident. First, possession tends to be defined so that valid claims are made at low cost and before dissipating races begin, thus exploiting claimant heterogeneity. Second, once rights are established the transfer of rights to the resource is allowed routinely. Third, the use of auctions or other administrative allocation mechanisms are high cost alternatives.

In certain cases, establishing possession of an entire stock is especially costly and leads to the rule of capture, as in the case of so-called "fugitive" resources (Rose 1986) such as oil and wildlife. In these cases a number of common principles can be found. First, the rule of capture may not produce severe dissipation when there are but a few users or when there are what Rose (1986) calls "plenteous" goods. Thus open access may persist optimally as in the case of nineteenth-century whaling. Second, when dissipation becomes severe, access to the resource tends to be limited through legal, contractual, or regulatory methods. Third, transfer of rights to capturable flows tends to be restricted.

Even possession under the rule of capture can vary, as illustrated in the famous case of *Pierson v. Post* where the court was divided over whether possession of a wild fox was determined by "hot pursuit" or physical capture.[39] A similar distinction was present in nineteenth century Atlantic whaling (Holmes 1881, Ellickson (1989). The rule of capture typically required that a whaler's harpoon be fixed to the mammal before a legitimate ownership interest was established, the "fast-fish, loose-fish" rule. In the case of the aggressive sperm whale, however, the "iron holds the whale" rule granted ownership to a whaler whose harpoon first was affixed to the whale so long as the whaler remained in fresh pursuit. The law seems to recognize how the precise way in

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[38] The analysis here suggests broad confirmation of the economics models, but the literature shows considerable disagreement among law and economics scholars on the merits of first possession rules (Merrill 1986). For instance, in studies of homesteading (Anderson and Hill 1990) and water (Williams 1983) first possession has been criticized as causing wasteful races. In contrast, studies of the broadcast spectrum (Hazlett 1990), homesteading (Allen 1991), and patents and mining (Kitch 1977) argue that racing dissipation was minimal.

[39] *Pierson v. Post*, 1805, 3 Cal. R. 175, 2 Am. Dec. 264 (Sup. Ct. of N.Y. 1805). Dharmapala and Pitchford (2002) develop a formal model of the differential incentives under the two rules.

which possession is defined will influence the outcome and tends to define possession so that waste (e.g., fruitless whaling effort) will be minimized.

What must be done to maintain a legitimate claim?[40] Ownership, says Blackstone, remains with the original taker, "till such time as he does some other act which shows an intention to abandon it."[41] In general the law tends not to require a claimant to continually exert the effort required for an initial claim, but he cannot remain an owner without incurring some continued possession costs (Holmes 1881).[42] An owner must actively and continuously enforce his ownership claim, regardless of whether he obtained ownership by first possession or by subsequent method such as purchase, inheritance, or bankruptcy. The law has two responses to a party lax in exerting effort at continued possession. If an owner intentionally ignores the property it can become abandoned and subject to being reclaimed under first possession. In certain cases, (e.g., minerals, trademarks, water) specific rules, often lumped together as "use-it-or-lose-it," have developed to determine precisely when the right has been abandoned. If an owner is simply inattentive enough to allow another party to establish continued use of the property, then adverse users can ultimately gain ownership under the doctrine of adverse possession (see section 6.1). Thus the law requires that an owner continue to exert effort to maintain possession but certainly not to the degree initially required to establish possession. In Holmes's words (1881, p.236): "Everyone agrees that it is not necessary to have always present power over the thing, otherwise one could only possess what was under his hand." The general rule of not requiring the same effort for continuing possession as for establishing possession recognizes economies of enforcement by collective institutions and a protection of specific investments by the original claimant.

A first possession rule that leads to an optimal system of ownership for one attribute can leave rights unspecified to another attribute.[43] Establishing rights to land for farming, for instance, might create a system of rights inconsistent with the optimal use of wildlife or groundwater. The process of establishing possession might cause damage to adjacent environmental assets, as when the diversion of water under prior appropriation damages in-stream resources (Leshy 1987, Sprankling 1996). Indeed, the application of first possession to environmental goods (e.g., scenic view) is not well developed in the law. Private contracting to consolidate land holdings is a possible solution to the ownership problem for the attached resource, but this is an imperfect solution when contracting costs are positive (Libecap and Wiggins 1984). For example, detailed property rights to small, urban parcels of land can lead to severe open access dissipation for subsurface oil and gas production.

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[40] Continued possession or maintenance costs can be added to the first possession model, noting that net rents are $R(t)$-$c(t)$ where $c(t)$ is the current cost of maintaining possession. This addition will increase t^* in the claim model.

[41] Book II, Chapter 1. Of course, property rights can also be relinquished by gift or sale to another.

[42] This principle is clearly articulated in the famous "dung case," *Haslem v. Lockwood*, 37 Conn. 500 (1871). In *Haslem* the plaintiff was a farmer who gathered manure from the ditch along a public highway into "heaps", leaving them overnight while he returned to his farm to get a cart for transport of the heaps. Before he returned the defendant had begun to load the heaps and take them away. The court, in deciding for the plaintiff, ruled that the manure was abandoned property in the public ditch, that the plaintiff established ownership via first possession by piling the dung into heaps, and finally, that the plaintiff having established ownership did not have to exert the same effort to maintain possession and was therefore justified in returning home to fetch his carts. Implicit in this case and elsewhere is the fact that collective institutions (e.g., courts, custom, police) actively enforce property rights once they are established, thus minimizing the resources devoted to continued possession.

[43] Nuisance law, as discussed in section 7.4, mitigates these problems.

Possession rules can also swing dramatically from a rule of capture to a perpetual right to a stock. Water law illustrates the issue clearly. Under absolute ownership a landowner can claim groundwater under the rule of capture by pumping water to the surface; under prior appropriation, however, a successful first claimant earns a permanent withdrawal right to a measured quantity extracted each year. Indeed, such a switch in regimes begs the question of what is the actual stock that is valuable to potential users. Is the bison herd the valuable stock, or is a single bison (which can yield meat and hides) a valuable stock in its own right? Ultimately the answer depends on the uses of the resource as well as on the relative costs (*e.g.*, claiming possession, enforcing common property).

While their treatment in legal texts often suggests otherwise, first possession rules are still relevant and likely to be important in the future. Berger (1985) notes many cases not examined here where first possession is the primary rule. For example, while the common law has tended to move away from the "coming to the nuisance" doctrine (Wittman, 1980), nearly all states have enacted "right to farm" statutes which effectively codify this first possession principle; namely, that no one can make a legitimate nuisance claim for activities in place prior to a location decision by the affected party (Berger 1985). The recent environmental policies that use transferable use or access permits require an initial allocation of property rights. For both fisheries regulations that use individual transferable quotas (ITQs) and pollution emission systems with transferable permits, rights tend to be established by being grandfathered in to the permit system. For fisheries, allocations have been based on historical catch; for pollution, allocation has been based on historical emissions (e.g., sulfur dioxide trading program under the Clean Air Act amendments of 1990). Some economists have considered this a "free distribution" (e.g., Stavins 1995) or "give away," but it is more appropriately viewed as an allocation based on first possession. In these cases, first possession may protect the specific investments made by the original users of the assets and avoid the administrative and rent-seeking costs of auctions. Though it might seem reasonable to think that the era of discovering new resources has long passed, space (McDougal *et al.* 1963) and the deep sea may have surprises to offer. In space, geosynchronous satellite orbits have been claimed by first possessors, but the deep sea has been treated differently. For example, Epstein (1979) noted that the Law of the Sea conference rejected first possession rules for allocating claims to deep sea minerals, while recent legislation awards ownership of abandoned shipwrecks found in U.S. waters to the federal government rather than to the finder (Hallwood and Miceli, 2004).

3.5. *Alternatives: Auctions, Bureaucracy, Politics, and Violence*

Law and economics scholars studying first possession have often recommended auctions as the efficient method of establishing rights without closely examining the costs of auctions (e.g., Barzel 1968, Coase 1959, Haddock 1986, Posner 1992, Williams 1983). Assuming the same costs of establishing the rights (C), the winner of the "ideal" auction pays V^S and begins production at t^S, thus maximizing the value of the asset. Yet, in practice, auctions will entail real and often large costs (Epstein 1979, McMillan 1994). Under first possession, private claimants must bear the cost, Ce^{-rt}, of enforcing a claim to the resource. Similarly, before the auction can take place, the state must establish rights to the asset at a cost, $C^S e^{-rt}$, and also incur costs, $C^A e^{-rt}$, of administering the auction. In addition, the state must survey and police the resource, determine what size parcels of the asset to sell, the method of auction to use, and so on

(McMillan 1994). If the state cannot protect property rights adequately after the auction, potential buyers will bid less than V^*. [44]

Epstein (1979) also notes that interest groups will attempt to alter the auction rules to suit their own advantage, leading to further dissipation of rent. Indeed, he notes that administrative alternatives simply were not available (*i.e.*, too costly) during much of the development of the common law. As a result, only if the state's costs $(C^S + C^A)e^{-rt}$ are less than Ce^{-rt} will V^* result from an auction. The choice between auctions (or other administrative policies) and first possession is ultimately a trade-off between costly auctions and potential dissipation from races. In some cases -- future patentable innovations, sunken treasure, and the unused electromagnetic spectrum -- the resource cannot be auctioned because it has yet to be identified.

4. The Evolution of Property Rights

To this point several different property rights regimes have been studied in isolation, and the establishment of rights has been considered under the rule of first possession. This section examines the determinants of changes in property rights and how these changes take place. Though changes or differences in property rights can be examined with cross section or time series data, the earliest studies focused on temporal changes, and thus the term "evolution of property rights" has come to define the literature. [45]

4.1 The Demsetz Thesis

The evolution of property rights is one of the oldest topics in the economics of property rights beginning with Demsetz' (1967) pioneering paper. Demsetz argues that property rights emerge to internalize the externalities present in open access. Further, in what has become the classic argument on the topic, he argues that an increase in the value of an asset will increase the gains from ownership and thus lead to the creation of property rights. In support of this thesis, Demsetz recounts the anthropological evidence of alterations in property rights among the Montagne Indians of Quebec during the 18th century. Prior to the emergence of the beaver trade with Europeans, rights to beaver could be characterized as open access. However, once the trade increased their value, property rights to beaver populations emerged and were held by family units. The story of the emergence of rights to beaver among the Montagne has become the most famous story in the economics of property rights.

4.2. Empirical studies

Demsetz' thesis was not again explored until Anderson and Hill's (1975) study of the emergence of property rights to rangeland, livestock, and water in the American West. Anderson and Hill argue that the history of the west is largely consistent with Demsetz' thesis; as the frontier was settled assets became more valuable, and property rights emerged out of what we would now call open access. In a remarkably convincing historical analysis they show how the range was

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[44] Allen (1991) argues that this is the reason homesteading was often chosen over auctions for assigning rights to frontier land in many countries.

[45] Anderson and Hill (1975) appear to be the originators of this phrase. Recently the Journal of Legal Studies (Vol. 31, No.2 (part 2) (June 2002) published a special issue titled "The Evolution of Property Rights."

privatized after the introduction of barbed wire dramatically reduced the cost of enforcing rights to grasslands. This history shows how, holding resource values constant, changes in property rights enforcement costs can have dramatic affects on the choice of property rights regimes.[46]

Umbeck (1977) and Libecap (1978) study the establishment of rights to gold and silver fields in California and Nevada, respectively, and find a history that again corresponds to Demsetz' beaver. In fact, the California gold rush is an even better application than the beaver because the discovery of gold signified a sharp increase in the asset's value and the property system that developed was much more detailed than that developed by the Montagne. Furthermore, for the gold case, there was no preexisting society as in the Montage case; open access truly was the prior regime. In his sweeping study of economic history, North (1981) suggests that the general rise of agricultural societies, with private property rights in land, is consistent with this view of emerging rights. Indeed, one might argue that the settlement of North America is broadly consistent as well.[47] Over time rights to land, water, minerals, and even air in recent times, have been established as asset values have increased.

Econometric evidence to test the Demsetz thesis has been scarce because of the severe data requirements. Such a test requires data on property rights regimes and the relevant economic parameters. Quantification of property regimes is particularly difficult and over a time series even harder. Libecap (1978), however, couples his historical account of changes in mining law with some econometric evidence, showing in a short time series that mining law became more precise as the value of mineral deposits increased. More recently Geddes and Lueck (2002) use panel data on state laws defining the rights of married women to hold property and contract, and find that states with a greater potential value of human capital (as approximated by levels of wealth, education, and the size of the market) tended to be the first states to expand rights for women. Geddes and Lueck's study is consistent with Demsetz and also with Schultz (1968) who noted that individual freedoms (or rights to one's own human capital) have tended to increase with increases in the value of human capital.

Despite numerous studies in support of the Demsetz thesis, there are many instances where property rights did not emerge even as asset values increased considerably. The case of oil and gas is the most dramatic, where rights to underground reservoirs remained subject to a rule of capture (see section 3.1) even as the value of these resources rose dramatically (Libecap 1989, Libecap and Smith 2002). Rights to the oil and gas stocks themselves took nearly a century to develop and did not ever emerge in common law doctrine. In another example, property rights never emerged for the wild bison herds despite the rather dramatic increase in the market value of the bison with the advent of the bison hide market (Lueck 2002). In fact, it is precisely during the period of the most intense market activity that the bison's demise was swiftest. Property rights to marine fisheries often have also remained open access for extended periods, despite significant increases in the asset's value.

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[46] What is not discussed in Anderson and Hill is the destruction of Native American property regimes as these asset values increased.

[47] Eggertsson (1990) summarizes this literature; see also the Journal of Legal Studies (2002).

4.3. The Theory of Rights Evolution and Variation

Demsetz' original theory was informal and simple: increases in the net benefits of enforcing rights would increase the level of rights enforcement. His main theoretical contribution was simply and importantly to note that property rights themselves are economic goods amenable to the tools of economic theory and potentially subject to empirical analysis. While it seems trivial now, as do many breakthroughs, the insight has been critical to the economics of property rights and institutions. Yet, Demsetz did not develop a formal model, and his paper said little about the costs of a property regime, the mechanism of choosing rights, and the form of property rights.

Umbeck (1977) was the first to formalize Demsetz in his study of the California gold rush. Umbeck postulates that the net value of rights (V) was simply the benefits of rights (B) less the cost of enforcing rights (C). He postulates further that B was exactly the market value R of the asset (e.g., the price of a beaver pelt, or the rental value of a plot of land), and that enforcement costs positively depended on the asset value $C=c_0+c(R)$ where $c'(R) > 0$. The first-best, or zero transaction cost value of the asset is $V^* = R$, but the second-best value of the asset is $V = R - C(R)$. Property rights emerge only when $R > C(R)$, so that for low asset values the asset remains unowned. This is exactly the Demsetz thesis.[48]

Implicit in the Demsetz model was the assumption that the there will exist an asset value for which $R = C$, so that there are values for which property rights will be enforced and values for which they will not. Umbeck, however, notes that this outcome depends on the structure of the enforcement cost function C.[49] It is possible that as asset values increase there may be an even greater incentive to steal the asset thus raising enforcement costs. Simply, if enforcement costs rise faster than asset values, then the implication is that no property rights will be established at all, regardless of how high the asset value becomes. This simply means that if $c'(R) > 1$,[50] then no rights will be established because $C(R) > R$ for all values of R. This means the only clear prediction from the model is that parametric decreases in enforcement costs will increase the probability that property rights will emerge.[51] Thus changes in asset values do not give unambiguous predictions. Allen (2002) notes the possibility that enforcement costs are increasing and convex in asset values (i.e., $c'(R) > 0$, $c''(R) > 0$). This extension implies that at lower asset values, an increase would lead to the establishment of property rights, but that at higher asset values, a further increase could actually lead to a reversal or abandonment of property rights.[52] A consideration of complex assets can also alter the model (Lueck 2002). If, for instance, land is valuable for the production of both bison and wheat, then an increase the value of bison might not lead to an increase in rights to bison if this increase is correlated with an increase in the value of wheat, which requires land ownership on a smaller scale than is optimal for bison.

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[48] The first possession model from section 3.1.1 also implies that rights will emerge over time as asset values increase, given some costs of claiming and a first possession rule.

[49] Field (1986) also notes that enforcement costs depend on asset values. His model focuses on the number of owners of a tract of land, or what he calls the 'optimal number of commons.'

[50] Since $B = R$, $B' = 1$.

[51] The case of the barbed wire fence fits this prediction (Anderson and Hill 1975).

[52] Such reversals have been noted by Anderson and Hill (1975) and Smith (2002).

The choice of property rights can be put in a framework in which the maximization problem is $max \{V_1, ..., V_n\}$ where V_i is the net value of the asset generated under the ith property rights regime (e.g., common property, state property, private property).[53] Each regime's value depends on market parameters and transaction cost parameters. With many viable choices an analytical solution may be not be available, but in many empirical settings the choices may be rather limited. In the case of just two alternative property regimes, comparative statics predictions can be generated from $\partial(V^i/V^j)/\partial\chi$, where V^i and V^j are value functions for property regimes i and j and χ is a parameter. If this derivative can be signed, then there is a prediction for the choice of property regime.

4.4. The Mechanism of Rights Changes

The analysis of the mechanism by which property rights are established can be divided into several categories. First, there is what might be called an 'institutional invisible hand,' which can be attributed to Demsetz and even to Coase (1960). This is often linked to the common law (Posner, 2003). The evidence on whether the law has evolved in a manner consistent with efficient property rights is mixed. The development of the prior appropriation water doctrine in the western states seems to be an affirmative case. In one of the defining cases, *Coffin et al., v. Left Hand Ditch Co.*,[54] a Colorado court noted that the riparian system used in eastern states was not useful for western water, which needed to be diverted for use. Yet, in recent years courts in western states have been reluctant to allow water rights to be defined for increasingly valuable 'instream uses' such as those for recreation and wildlife.[55]

Second, game theory suggests that in the presence of repeated interaction, agents in open access can generate conventions or norms in which the parties agree to create a system of rights (Sugden 1986). For instance, Sugden (1986) suggests an evolutionary explanation for such property conventions as 'first possession' and respect for property rights. Experimental work by James Walker that shows how property regimes can emerge with repeated interaction, even with anonymous players.

A third line of analysis, closely related to the second, is contracting for rights (Libecap 1989). That is, when the gains from another ownership regime exist, there is the potential for existing users or those who have access to form a deal to establish a new regime. Such an outcome is explicit in the formation of a unitization agreement to establish rights to an underground oil reservoir among parties who previously operated under a rule of capture. For such a contract to be an economic equilibrium there has to be rent from the new property regime, and each party to the contract must expect to increase their own rents. In the language of modern contract theory, a successful contract must satisfy the incentive compatibility and rationality constraints of all parties. Libecap (1989) finds that in many cases there is sufficient heterogeneity and information asymmetry among contracting parties that it is prohibitively costly to find a contract that meets

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[53] Under the conditions of the Coase Theorem, of course, each regime would generate identical asset use and value.

[54] 6 Colo. 443 (1882).

[55] Only recent statutory changes have allowed the definition of these rights, suggesting that there is a tradeoff between common law and statutory rule-making. Similar outcomes can be found in the law of oil and gas, wildlife, and groundwater.

the individual rationality constraints of all. Thus open access under a rule of capture can persist even when the potential rents are enormous.

A fourth mechanism by which rights can be established is through politics and statutory rule-making.[56] Since rights are often initiated via political institutions, there must be rents for the political actors (e.g., politicians, interest groups, and bureaucrats) to implement the changes. Thus, there is yet another set of incentive compatibility and individual rationality constraints to add to the purely private contracting model. Rose (1998) recognizes these forces and, without developing a model, suggests that the modern evolution of rights to environmental goods has been more or less consistent with the Demsetz thesis. Riker and Sened (1991) explicitly show how transferable rights to airport landing slots – established in the 1980s -- did not emerge until the Secretary of Transportation and the Office of Management and Budget signed on.

5. Voluntary Transfers of Property

This section examines voluntary transfers of property, including market transfers (sales) and leases (temporary transfers). It also examines laws governing inheritance, or the transfer of property from one generation to the next. For the most part, the focus is on transfers of land, though the principles are more general.

5.1. Market Transfers

In addition to the use and investment incentives inherent in private ownership, there are the allocation incentives inherent in the market transfer of private property rights. As the Coase Theorem implies, because transaction costs are positive and property rights are imperfect actual market transfers must contend with various problems of enforcement. One particularly important problem in the transfer of property rights is the possibility of a claim by a previously defrauded owner. An important function of property law is to minimize the uncertainty over ownership, thereby facilitating market exchange (Baird and Jackson, 1984).

Information about potential prior claims on property is costly, however, so an efficient system for enforcing or maintaining ownership will balance the cost of greater certainty against the benefit. For example, consider a parcel of land worth V if ownership is certain, but subject to a risk $p(x)$ that a past owner will assert a claim based on error or fraud, where x is the effort (in dollar terms) devoted to ensuring title. This might represent the cost of searching a public record of past transactions or obtaining a government certification of ownership. Assume that $p'<0$ and $p''>0$. The owner's problem is to choose x to maximize $(1-p(x))V-x$, which must satisfy $-p'(x)V=1$, or, marginal search costs must equal the expected reduction in the value of the parcel. It follows that it is not generally optimal ($p(x^*) > 0$) to eliminate all risk of loss, though owners of more valuable property will invest more to secure ownership.[57]

Actual efforts to protect ownership of property, both public and private, vary in accordance with this conclusion. All jurisdictions in the U.S. maintain a public record of transactions for land and also certify title to automobiles, thereby providing buyers with some guarantee of good title,

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[56] Eggertsson (1990) calls the other models "naïve."

[57] This comes from the comparative statics derivative $\partial x^*/\partial V = -p''/p''V > 0$.

while owners often invest in private security systems and insurance to further protect their interests. For property of lesser value, buyers generally rely on possession and the reputation of the current owner as the primary evidence of ownership.

5.1.1. Title Systems for Land

Land title in the U.S. is primarily protected by a recording system that allows potential buyers to verify title by searching the record of past transfers, theoretically back to the root of ownership.[58] Title search is a costly process, however, especially as one goes back in time and the quality of records deteriorates. Most states therefore have enacted statutes of limitation (so-called Marketable Title Acts), or less formal guidelines (established by local bars or title insurers), aimed at limiting title searches to a reasonable length. Baker, et al. (2002) develop a sequential search model to characterize how far back in time buyers should search a title. They show that it is not generally optimal to search the entire record, implying that optimal search involves some residual uncertainty. A test of the model using cross-state data shows that title search guidelines vary according to the predictions of the theory. Specifically, prescribed search lengths are increasing in the cost of a title defect (as measured by title insurance premiums), the likelihood of errors in the record (proxied by the percent of developed land and the frequency of land transfer), and decreasing in title search costs.

Although the recording system is the predominant land title system in the U.S., common law countries (and some states) have also used a system of land registration, called the Torrens system.[59] Under land registration, the government certifies ownership at the time of a transfer, thereby protecting the owner against nearly all claims. Thus, claimants can at most seek monetary compensation from a public fund (financed by registration fees). This is in contrast to the recording system, which awards successful claimants an interest in the land itself. Landowners subject to this system thus ordinarily purchase title insurance to provide them with financial compensation in the event of a loss.

The two title systems therefore provide opposing answers to the fundamental question of whom a title system should protect, the current possessor or the last rightful owner (Baird and Jackson, 1984). The question is whether one is preferred on efficiency grounds. If transaction costs are zero, land will be used efficiently under both systems, and the only effect will be distributional (Miceli and Sirmans, 1995a). In reality, however, the transaction costs of land transfer are significant, in which case the preferred system is the one that minimizes these costs, thereby facilitating exchange and investment (Miceli, Sirmans, and Turnbull, 1998).

Proponents of land registration claim that it lowers transaction costs relative to the recording system because it dispenses with the need to search anew the entire history of a parcel with each transfer. Actual attempts to compare the costs of registration and recording in those jurisdictions in the U.S. where they co-exist, however, have yielded mixed results (Janczyk, 1977; Shick and Plotkin, 1978). Such comparisons, however, may miss the chief advantage of registration-- namely, that it clears title to land in cases where land records are poor or have been destroyed.

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[58] According to Black's Law Dictionary 'title is the means whereby the owner of land has the just possession of his property. A 'deed' is a legal document which constitutes evidence of title.
[59] See, for example, Bostick (1987) and Shick and Plotkin (1978).

For example, land registration was instituted in Cook County, Illinois following the Great Chicago Fire, which destroyed nearly all land records. A recent study of land transactions in that county used the co-existence of both systems throughout most of the twentieth century as a natural experiment to compare land values under each system (Miceli, et al., 2002). Because theory predicts that owners of higher risk properties should prefer the Torrens system, the empirical analysis controlled for sample selection bias in the data. Once this was done, the study found that land values in the sample were indeed higher under the registration system as compared to the recording system.

5.1.2. Title Systems and Development

Economists have recently begun to examine the role of land title systems in promoting economic development. For example, De Soto (2000) argues that the absence of a well-functioning system for protecting land ownership is the single largest impediment to economic growth in most developing countries. Lack of secure title inhibits land sales, discourages investment, and prevents owners from converting land assets (which are abundant) into financial capital. De Soto's evidence is largely anecdotal, but several empirical studies have established a clear link between formal land title and economic investment in various developing countries (Besley, 1995; Alston, et al., 1996; Miceli, Sirmans, and Kieyah, 2002). De Soto also makes the argument that legally enforced property rights are superior to those enforced by extra-legal means, thus emphasizing the economic importance of law.

5.2. Leases

A lease represents a voluntary transfer of possessory rights in property (the right of use) for a limited period of time. Such an arrangement can enhance efficiency by allowing gains from specialization. The division of ownership and use, however, creates potential incentive problems for both landlords and tenants regarding the optimal maintenance and use of the property. The problem is one of moral hazard, though it is sometimes referred to as the "rental externality" (Henderson and Ioannides, 1983).

To illustrate, suppose that the value of a piece of property, $V(x,y)$, is an increasing function of inputs by both the tenant (x) and the landlord (y).[60] Further, suppose that V is divided into the value of the property to the tenant during the term of the lease, $T(x,y)$, and the residual value (the value of the reversion), $R(x,y)$. The first-best choices of x and y maximize the joint value of the property, $V(x,y)-x-y$, but both the landlord and tenant will make their choices to maximize their individual returns. Specifically, the tenant will choose x to maximize $T(x,y)-x-r$, where r is the rent, while the landlord will choose y to maximize $R(x,y)-y+r$. Given a fixed rent, both parties will therefore underinvest in maintenance. We will see that several aspects of lease law can be interpreted as responses to this problem.

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[60] Thus, both inputs can be interpreted as maintenance. The analysis would not change if the tenant input is interpreted as the rate of utilization, which has a negative impact on V.

5.2.1. The Lease: A Contract or a Conveyance

Historically, all leases fell under the law of property, which viewed the lease as a conveyance of an interest in land to the tenant (Dukeminier and Krier 2002). This gave the tenant the right to exclude the landlord from entry during the term of the lease in return for a promise to pay rent. Yet even if the tenant defaulted on the rent, the landlord could not evict the tenant; he could only sue for recovery of the rent. At the same time, the landlord had no duty to maintain the premises during the lease period. The lease thus provided strong protection of the tenant's possessory interest in the property.

In contrast, modern leases, usually for housing, are generally viewed by courts as contracts rather than conveyances.[61] This change has altered the obligations of the parties in important ways. First, landlords have a duty to maintain the property in a habitable state according to an "implied warranty of habitability,"[62] which tenants can enforce by withholding rent. Symmetrically, however, landlords who meet their duty of maintenance can evict tenants who fail to pay rent. The obligations of the landlord and tenant, like those of the parties to a contract, are therefore mutual.

From an economic perspective, this change in the law makes sense (Miceli, Sirmans, and Turnbull, 2001). Historical leases were primarily for agricultural land, and landlord inputs were relatively less important. (In the context of the above model, T did not depend on y.) In this context, legal protection of a strong possessory interest promoted efficient tenant investment during the term of the lease. For example, landlords could not opportunistically re-take possession of the land after the crops were planted but before harvest. Further, tenant use ordinarily did not have a detrimental effect on the value of the reversion (i.e., R did not depend on x).

The situation is different in modern real estate leases, which are primarily for housing. Now, landlord maintenance during the term of the lease is crucial, so the law has provided tenants with an enforcement mechanism by transforming the lease into a contract with an implied warranty of habitability.[63] In addition, tenant inputs are much more likely to have an effect on the value of the landlord's reversion. For example, overutilization of rental housing will accelerate the rate of depreciation. The law addresses this problem with the doctrine of waste (Posner, 2003, p. 73), under which a tenant has a duty to invest in reasonable maintenance of the property. In terms of the above model, this forces the tenant to internalize the effect of his actions on the value of the reversion. The doctrine of waste and the warranty of habitability thus work in combination to create efficient bilateral incentives for maintenance in the presence of the rental externality.[64]

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[61] In some states, commercial leases are still interpreted as conveyances.

[62] The key case is *Javins v. First National Realty Corp.*, 428 F.2d 1071 (1970). Also see Rabin (1984).

[63] See Hirsch (1999, Ch. 3) for an empirical analysis of the impact of habitability laws.

[64] In this sense, the two doctrines resemble the tort rule of negligence with a contributory negligence defense, which establishes efficient bilateral incentives in accident settings. See Chapter xx.

5.2.2. The Duty to Mitigate Damages

Another effect of the transformation of the lease from a conveyance to a contract concerns the duty to mitigate damages. Under the law of property, landlords had no duty to mitigate damages. If the tenant abandoned the property, the landlord had no obligation to attempt to re-let it; he could just sit tight and sue the tenant for the entire rent. The transformation of the lease to a form of contract, however, imposed on landlords the contractual duty to mitigate damages by taking all reasonable steps to re-let the property.[65] The law enforces this duty by limiting the damages from tenant breach to the difference between the contract rent and the best rent the landlord could have obtained by reasonable efforts.

Mitigation of damages provides a clear economic benefit by preventing the property from being left idle. Thus, it appears to be an efficient aspect of lease law. However, this raises the question of why the traditional law of leases did not impose such a duty. Economic theory suggests three possible reasons. First, agricultural tenants may have been in a better position than landlords to find substitute tenants, whereas the situation is reversed for modern residential leases. The change in the law thus simply reflects an application of the cheaper cost-avoider principle. Second, a duty to mitigate damages may result in inefficient re-letting of the property by landlords who mistakenly interpret tenant absence as a sign of breach. The no-mitigate rule therefore protects the tenant's possessory rights in settings where absentee use may be valuable-- a situation that is more reflective of agricultural as compared to residential leases. A third possibility is that in agricultural settings the law is often less important than market enforcement via repeated interaction (Allen and Lueck 2003). For agriculture the law simply may not have developed to address this issue.

5.2.3. Sharecrop versus Cash Rent Leases in Agriculture

The choice between a cash rent lease and a cropshare lease has been an important topic since the beginning of economics.[66] Adam Smith argued that the cropshare acted as an inefficient tax on effort. Writing roughly a century later than Smith, however, John Stuart Mill noted that cropshare leases had an ancient origin and that the level of cultivation was not suffering. Thus, he was reluctant to claim widespread inefficiency. Smith's tax analogy, however, influenced Alfred Marshall and other neoclassical economists who later analyzed the problem. Not until Cheung (1968) extended the Coase Theorem into share cropping did the modern analysis begin. Cheung demonstrates that if transaction costs are zero, then all land leases must be equivalent, and that, therefore, the (lease) contract choice must depend on transaction costs.[67]

We present a model from Allen and Lueck (2003) that recognizes the complexity of assets and property rights to those assets as discussed in section 2.4. In both a cash rent and cropshare lease, property rights to the land are imperfect. Typically a lease agreement can only specify and enforce such basic parameters as acreage of the plot and type of crop. Such important features as soil moisture and soil nutrients cannot be economically enforced in the lease, so these attributes are essentially open access goods. In a cash rent lease the farmer pays a fixed annual amount per

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[65] See generally Goetz and Scott (1983).
[66] Allen and Lueck (2003, chapter 4) give a detailed history of this literature.
[67] Cheung also postulated a risk-sharing effect that is discussed below.

acre of land and owns the entire crop. As a result he supplies the optimal amount of his own inputs but overuses any inputs provided by the landowner, including the un-priced attributes of the land. In a cropshare lease, in contrast, the farmer does not pay any fee for use of the land but simply pays a predetermined share of the crop to the landowner at the time of harvest. In this arrangement the farmer and the landowner have shared ownership of the crop, so the farmer has an incentive, as Adam Smith noted, to under-provide these inputs. The farmer will also have less incentive to use inputs provided by the landowner, compared to a cash rent lease.

Consider a tract of farmland which can be used to produce crops according to $Q = h(e,l) + \theta$ where Q is the harvested crop, e is the farmer's composite input called effort, l is a composite input of land quality attributes, and $\theta \sim (0, \sigma^2)$ is a randomly distributed composite input that includes weather and pests. We assume that $h_e > 0$, $h_l > 0$, $h_{ee} < 0$, $h_{ll} < 0$, and $h_{el} = 0$, where the subscripts denote partial derivatives. The opportunity cost of the farmer's input is the competitive wage rate w per unit of farmer's effort, and the opportunity cost of the unpriced land input l is r per unit.

With risk-neutral landowners and farmers, the expected profit from the farming operation is maximized, resulting in the employment of e^* and l^* units of farmer and landowner inputs. These first-best input levels are identical for the cropshare and cash rent leases and satisfy the standard conditions that marginal products equal marginal costs for both inputs. When transaction costs are positive and lease enforcement is costly, however, the input choices will be second-best. In either lease, farmers have an incentive to exploit the land's un-priced attribute because they do not face the full costs. In addition, farmers have an incentive to under-report the output in the cropshare lease.

For the cash rent lease, the farmer owns the entire crop and chooses his inputs to maximize expected profit. Because the farmer does not have indefinite tenure of the land, he does not face the true opportunity cost of using the attributes of the land. If we denote the reduced costs he faces as $r' < r$, the farmer's objective is:

$$\max_{e,l} \Pi^r = h(e,l) - we - r'l. \tag{5.1}$$

The second-best solutions e^r and l^r satisfy $h_e(e^r) \equiv w$ and $h_l(l^r) \equiv r'$. Since $h_{el} = 0$, we note that the farmer's input level is identical to the first-best optimum; that is, $e^r = e^*$. However, since $r' < r$, the land is over-worked ($l^r > l^*$) because the farmer does not face the full cost of using the land's attributes.

In a cropshare lease, the farmer receive sQ and the landowner receives $(1-s)Q$, where $0 < s < 1$. The farmer's objective is:

$$\max_{e,l} \Pi^s = s[h(e,l)] - we - r'l. \tag{5.2}$$

Now the second-best solutions e^s and l^s satisfy $sh_e(e^s) \equiv w$ and $sh_l(l^s) \equiv r'$. These solutions indicate that the farmer supplies too few of his inputs because he must share the output with the landowner; that is $e^s < e^*$. As with cash rent, the farmer over uses the land attributes, or $l^s > l^*$;

however, since $l^r > l^s > l^*$, the use of the land is less excessive than it is with cash rent. This means that although a share lease still provides the farmer with an incentive to over use the land, this incentive is not as powerful as it is with the cash rent lease.

Farmers and landowners choose the lease that maximizes the joint expected return to the tract of land. This requires comparing the expected net return to the land in both leases, where the net return is given by the appropriate indirect objective function. For the cash rent lease,

$$V^r(w,r,r') = h(e^r,l^r) - we^r - rl^r. \tag{5.3}$$

With the cropshare lease there are additional costs of measuring and dividing the harvested crop (Barzel 1982, Holmstrom and Milgrom 1992). These costs are given by μ so that the net value function is,

$$V^s(w,r,r',\mu) = h(e^s,l^s) - we^s - rl^s - \mu. \tag{5.4}$$

The joint maximization problem is *max {V^r,V^s}*. The tradeoff between the two leases is straightforward.[68] The benefit of cash rent is the avoidance of the costs of dividing the harvested ouptut. The benefit of cropshare is the reduction in the total distortion of input levels. Thus cropsharing should be observed when output measurement costs are low, and when soil attributes are easy to exploit. Cash rent leases should be observed under the opposite conditions. The effect of parameter changes on the net value of each contract can illuminate this tradeoff and lead to hypotheses about lease choice.

Consider first how changes in μ affect V^r and V^s. The net value of the cash rent lease V^r does not depend on output division costs. The net value of the crop share lease V^s however, declines as these costs increase. By the Envelope Theorem $\partial V^s / \partial \mu < 0$. This implies that as the costs of output division increase it is less likely that the cropshare contract will be chosen. The comparative statics for r are similar. By the Envelope Theorem $\partial V^s / \partial r = -l^s$ and $\partial V^s / \partial r = -l^r$. Because neither l^s nor l^r depend on r, the second derivatives of V^s and V^r with respect to r are zero. Therefore, V^s and V^r are linear functions of r. Thus, an increase in the cost of land attributes will lower the value of either lease (holding r' constant), but it will lower the value of the cash rent lease more because land inputs are used more intensively in a cash rent lease than in a cropshare lease ($l^r > l^s$). This implies that a cropshare lease is more likely to be chosen both as the unpriced attributes of the land become more easily damaged, and as land value increases.

Allen and Lueck (2003) find support for these predictions using data from North America and evidence from around the world. They show that cropshare leases are more likely when crop division costs are low and where the ability of farmers to adversely affect the soil is high, and that cash rent leases often contain clauses that discourage exploitation of the soil. For example, hay crops are more susceptible to under-reporting, since they are used on the premises and found to be more often cash rented. Land used for row crops is more susceptible to overuse than is land used for grains, and the data show that row crops are more likely to be cropshared.

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[68] The formal comparative statics predictions are derived in Allen and Lueck (2003, chapter 4).

The property rights - transaction cost approach to leases assumes that everyone is risk neutral, and relies on a trade-off between different incentive margins to explain lease terms. This approach contrasts with the dominant economic approach – the traditional Principal-Agent (P-A) model – which assumes leases (or generally contracts) are designed to balance risk against moral hazard incentives. Despite the prominence of the risk-sharing paradigm (Newberry and Stiglitz 1979, Hayami and Otsuka 1993), the empirical evidence to support its implications is scarce, especially for agriculture. In one of the early studies to confront risk-sharing and contract choice, Rao (1971) found that crops with high yield and profit variability were less likely to be sharecropped than crops with low yield and profit variability – a refutation of the P-A model. Using data from several thousand farmland leases, Allen and Lueck (1999, 2003) present a series of empirical tests that find virtually no support for the risk-share approach. In a variety of empirical tests, Allen and Lueck find no support for the general hypothesis that share leases are more likely to be chosen over cash rent leases when crop riskiness increases. In fact, there is evidence that the relationship is the opposite; that is, as crop riskiness (in terms of yield variability) increases, cash rent leases are often more likely (Allen and Lueck 1995, 2003, and Prendergast 2000, 2002). This result holds across all crops and regions examined in Allen and Lueck (2003).[69]

Compared to the basic P-A model, the transaction cost approach does not explicitly distinguish between principals and agents, nor does it make differential assumption about the risk preferences of the contracting parties. In modern farming it is especially difficult to establish such a dichotomy because farmers and landowners have nearly identical demographic characteristics. Both farmers and landowners make decisions, so formal models more in line with double moral hazard are more appropriate (e.g., Eswaran and Kotwol, 1985; Prendergast 2002). More importantly, by diverting attention away from risk-sharing – which is hard to test and has thus far generated little empirical support – the approach opens the door to a wider array of pure incentive effects that shape organization.

5.3. Inheritance of Land

Inheritance rules govern the intergenerational transfer of land and other property. One function of these rules is to ensure that the wishes of testators regarding the disposal of their property are fulfilled -- in this sense, inheritance is a voluntary transfer -- but an offsetting concern is to limit the extent to which the "dead hand" can constrain the uses of property into the uncertain future (Stake, 1998). In attempting to balance these goals, Anglo-American law gives testators considerable freedom in the disposal of their property, but imposes some constraints. We discuss two here: primogeniture and the Rule Against Perpetuities.

The rule of primogeniture, under which all property passes to a decedent's eldest son, was the predominant rule in early English common law and has also been used in cultures throughout the

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[69] Outside the area of agriculture a series of papers have found similar results (see the summary in Prendergast 2002). Ackerberg and Botticini (2002), however, argue that risk sharing might still be important in contract choice if one takes into account the endogenous matching of farmer with different risk preferences and land suitable to crops of varying risk. Nearly all of this literature can be criticized though for data that does not reliably measure exogenous risk.

world. The most common economic explanation for the rule is that it prevents inefficient fragmentation of land (Posner, 2003, p. 517). There are, however, two objections to this rationale. First, a well-functioning land market should allow entrepreneurs to counteract the effects of fragmentation. Thus, we would expect the rule to be most prevalent in societies where land markets are primitive or do not exist. (Baker, et al. (2004) provide evidence for this prediction.) Second, even if scale economies are important, why constrain a testator's choice of the most suitable inheritor? One possible explanation is that a "best-qualified" rule might promote wasteful rent seeking by competing heirs (Buchanan, 1983).

Another constraint on a testator's discretion is the Rule Against Perpetuities, which limits restrictions that can be imposed in a will to a set period of time, equal to the lifetime of anyone alive when the will was created plus twenty-one years. This time limit balances offsetting economic factors (Ellickson, 1986). On one hand, greater discretion on the part of testators gives them an incentive to acquire wealth during their lifetime in anticipation of having the ability to control it after their death. Such controls are especially beneficial if immediate heirs are known to be spendthrifts. On the other hand, the value of such restrictions fades in the future where later heirs would benefit from the ability to respond to unforeseen events. The time limit on a testator's control reflects this factor.[70]

6. Involuntary Transfers of Property

This section examines involuntary transfers of property from one private party to another. (We examine involuntary transfers from private parties to the state in Section 8.) Initially, we discuss transfers that occur as a result of uncertainty about ownership or boundary location, and hence, for the most part, are unintentional. We conclude by discussing intentional involuntary transfers, or theft.

6.1. Adverse Possession

Adverse possession is a curious doctrine that appears to legitimize the theft of land by squatters. The doctrine establishes title in property to the current user or possessor without the consent of, or compensation to, the original legal owner.[71] In order to gain title the adverse possessor must "openly and notoriously" maintain exclusive possession for a statutorily specified term that ranges from one to thirty years in the United States. The precept of adverse possession is embedded in the common law and can be traced to an English statute enacted in 1275. Contemporary American law is a mixture of statutory and case law in which statutes define required time periods and other specific conditions, while court decisions define "notorious" possession and other less specific requirements.

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[70] There has been a debate over the efficiency of the rule against perpetuities. Epstein (1986), for example, argues that the rule constrains the wishes of current property owners and is thus inefficient. Ellickson (1986), however, argues that future transaction costs justify the rule and are likely to outweigh any inefficiencies in the current period. See also Dukeminier and Krier (2002).

[71] It therefore has little rationale in the absence of transaction costs and is viewed typically as a method of clarifying title that has become clouded over time. See Dukemineir and Krier (2002).

Adverse possession is recognizable as a first possession doctrine. The adverse possessor has "relative title," by virtue of prior possession, or has "rights against the rest of the world from the moment that he claims possession." (Epstein 1986, p. 675.) Excluding the original owner, the adverse possessor acquires relative title through first possession. Moreover, in a successful adverse possession action the original owner's title is deemed to be invalid. Consequently, first possession becomes an accurate description of the process by which ownership is established. The law essentially treats the property as abandoned by the original owner. Historical adverse possession cases have dealt with such issues as abandoned farmland, cabins in the woods, and old mining sites. Typical cases today deal with title to real estate in situations where property boundaries are either unknown or misunderstood. For example, a homeowner builds an addition that, it turns out, is actually on the neighbor's legal property. Under adverse possession the homeowner gains title to the property in question by virtue of his possession through building the addition. In the historical cases, heterogeneity probably served to mitigate dissipation from first possession, and there is little evidence of racing among potential adverse possessors. In the modern real estate boundary cases, heterogeneity is at its extreme. There is only one potential claimant; hence, there is no dissipation.

Economists have formulated several theories to explain the details of adverse possession doctrine, treating it as a time-limited property right.[72] Perhaps the most compelling one is based on the presence of offsetting risks to ownership of land. The first risk arises from the possibility, discussed in Section 5, of past claims by previous owners who were deprived of their title through fraud or error. A time limit on such claims limits this risk to current owners. Specifically, let $p(t)$ be the risk of such a claim, where t is the duration of the prior owner's property right. We assume that $p'(t)>0$, reflecting a higher risk for longer-lasting property rights, and $p(0)=0$.[73] The other risk is that the current owner may himself be displaced by a squatter. This possibility can be reduced, however, by periodic monitoring of the property to eject squatters or correct boundary errors (Ellickson, 1986). A longer time limit on the owner's property right lowers this cost by reducing the required frequency of monitoring. Formally, let $m(t)$ be the cost of monitoring that the owner must spend to retain title with certainty, where $m'<0$ and $m(\infty)=0$.

Now suppose the current owner contemplates investing in the land. Let $V(x)$ be the market value of an investment of x dollars, where $V'>0$ and $V''<0$. Given this uncertainty, the owner will choose x to maximize the expected value, $(1-p(t))[V(x)-m(t)]-x$, taking t as given. This yields the first-order condition

$$(1-p(t))V'(x) - 1 = 0. \tag{6.1}$$

Condition (6.1) defines the optimal investment, $x^*(t)$, as a function of the time limit, where $\partial x^*/\partial t = p'V'/(1-p)V''<0$. Thus, increasing the duration of property rights actually *reduces* investment incentives by increasing the risk of a past claim.

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[72] See, for example, Ellickson (1986), Merrill (1985a), and Miceli and Sirmans (1995b).

[73] Note that land registration under the Torrens system effectively sets $t=0$ by extinguishing most past claims.

Given this characterization of the landowner's problem, we can derive the optimal duration of property rights as the value of *t* that maximizes the total value of the land net of monitoring costs:[74]

$$V(x^*(t)) - x^*(t) - m(t). \tag{6.2}$$

Differentiating (6.2) and substituting from (6.1) yields

$$p(t)V'(x)(\partial x^*/\partial t) = m'(t). \tag{6.3}$$

Thus, the optimal time limit balances the detrimental effect of longer *t* on investment incentives (the left-hand side) against the savings in monitoring costs (the right-hand side).

Although all fifty states have adverse possession statutes, as noted, the length of the statutory period varies, ranging from one to thirty years with mean length of 13.63 years.[75] Two empirical studies of adverse possessions statutes show that this cross-state variation is broadly explained by the economic model (Netter, et al., 1986; Baker, et al., 2001).

6.2. The Mistaken Improver Problem

The analysis to this point has treated the probability of a claim as a function only of the statutory period, but owners can lower the risk of a claim by surveying the property prior to development to detect boundary errors, or by searching the land records (as discussed in Section 5) to uncover disputed title. Suppose that a survey reveals ownership with certainty. If the developer is the owner, he can proceed with development as if there is no risk of a loss,[76] whereas if someone else is the owner, he can purchase the land if it is more valuable in a developed state. In this way, the value of the land is maximized. Determining ownership is costly, however, which may make it more profitable for the developer to proceed without a survey. This raises the possibility of mistaken improvement of another's property—the so-called mistaken improver problem.

To examine this problem formally, let *V* be the market value of the improved land, and let *p* be the probability that the land is owned by someone else who values it in its unimproved state at *R*. Further, suppose *R* is unobservable to the developer but is known to vary according to the distribution function *F(R)*. If the developer surveys at cost *s* prior to developing, the expected value of the land is *(1−p)V+p*Emax*[V,R]−s*, or

$$(1-p)V + p[F(V)V + \int_V^\infty RdF(R)] - s. \tag{6.4}$$

Equation (6.4) shows this value comes in three parts: the value if developed, the value if not developed, and survey costs. If, however, the developer proceeds without a survey, the value of

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[74] We assume that whoever ends up as owner will spend *m(t)*.
[75] The data are from Leiter (1999). In some states, the length is conditional on whether the squatter has "color of title" (i.e., evidence that appears to, but does not legally, convey title).
[76] In that case, he will invest an amount *x*>x*(t)* for any *t>0*.

the land is fixed at *V*, regardless of who turns out to be the owner. A survey is optimal if (6.4) exceeds *V*, or if

$$p\int_V^\infty (R-V)dF(R) > s. \tag{6.5}$$

The left-hand side of this condition is the expected benefit of avoiding irreversible improvement of the land when it is owned by someone else who values it more highly in its unimproved state. Developers will not necessarily make the first-best survey decision on their own, however, because they will ignore the opportunity cost of development when someone else is the owner.

The law, however, provides victims of mistaken improvement remedies that potentially create the right incentives. The law of mistaken improvement dates back at least to Roman times, where the law of accession stated that materials affixed to land became the property of the owner. The mistaken improver could at most seek compensation for the value of the improvements. The modern law in most states is dictated by so-called betterment acts, which typically allow landowners the option of either paying for the improvements (according to the old rule), or forcing the improver to buy the land at its unimproved value (Dickinson, 1985). It turns out that this "option" remedy induces would-be improvers to internalize the opportunity cost of the improvements in the face of ownership uncertainty and hence gives them exactly the right incentives to conduct a survey (Miceli and Sirmans, 1999).

6.3. Partition of Real Estate

Another form of involuntary transfer, this time involving joint owners of property, is the right to partition real estate. Under the common law, each co-owner of a parcel of land has the right to force a physical partition of the property (partition in kind) into separately owned parcels. While this solution overcomes transaction costs among co-owners (due, for example, to the anti-commons problem (Heller, 1998)), it may result in excessive fragmentation if there are scale economies associated with the best use of the land. State partition statutes have sought to address this problem by providing courts with an alternative to in-kind partition--namely, forced sale of the undivided parcel with division of the proceeds to the co-owners in proportion to their ownership shares.

The problem with forced sales, however, is that non-consenting owners only receive the market value of their shares, thus depriving them of any subjective value that they may attach to the land. (In effect, forced sale substitutes liability rule protection of owners' shares for property rule protection, thus creating the possibility of an inefficient sale (Calabresi and Melamed, 1972).) In terms of efficiency, forced sale will only be preferred to partition in kind if the preserved scale economies exceed the foregone subjective value of all non-consenting owners (Miceli and Sirmans, 2000). Courts seem sensitive to this trade-off. In particular, they tend to favor partition in kind (property rule protection), unless the resulting fragmentation would *materially* reduce the aggregate value of the land.[77] This standard offers courts a margin for protecting subjective value of non-consenting owners against expropriation.

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[77] See, e.g., *Trowbridge v. Donner*, 40 N.W.2d 655 (1950).

6.4. Theft

The most obvious form of involuntary transfer of property is theft, which is classified as a crime. The economic theory of criminal enforcement is well developed and is discussed in Chapter xx. Here we comment on the intersection of criminal law and property law. In economic terms, the transfer of property by theft presents the following paradox--if a thief values the stolen property more than the owner does, then the transfer is efficient (though coercive). Thus, why not simply force the thief to pay a fine equal to the value of the stolen property, in effect, treating the theft as a tort? One objection is that the thief will sometimes avoid detection, thus lowering his expected cost and allowing some inefficient transfers, but this problem could be addressed by simply inflating the fine in proportion to the inverse of the probability of detection.[78]

A more fundamental objection to the "efficient theft" argument is that it permits individuals to violate the general transaction structure by converting property rules into liability rules; that is, to substitute coercive transfers for market transfers (Calabresi and Melamed, 1972; Kelvorick, 1985; Coleman, 1988). Market transfers are more efficient than coercive transfers in low transaction cost settings, first, because courts may err in setting the right amount of compensation (the standard problem with liability rules), and second, because owners, fearing such a transfer, will devote excessive resources to the protection of their property (a form of rent seeking).

If the preceding argument makes sense for tangible property, it is all the more persuasive when the violation concerns one's bodily integrity or civil rights. The law therefore seeks to deter such violations by setting the penalty above compensatory damages (possibly including the risk of imprisonment) and labeling them as crimes (illegitimate transfers). (See the discussion of inalienability in Section 9.)

7. Land Use Conflicts: Externalities and Property

Externalities arise when one party uses his property in a way that imposes a cost (or confers a benefit) on another party without first obtaining that party's consent. In this sense, externalities are a form of involuntary transfer. When assets are complex and transaction costs are positive, externalities are ubiquitous. This is because property rights to at least some of the attributes of an asset will be imperfect and thus contain problems of open access or moral hazard. In the case of land, externalities are important since any parcel (except an island or continent) will have neighboring owners, but they also arise in the context of air quality, noise, and water, where property rights are especially hard to define and enforce.

In this section, we analyze various remedies for externalities (primarily harmful externalities),[79] focusing specifically on a comparison of the standard tax-subsidy approach most commonly associated with Pigou, with the property rights, or Coasian, approach.[80] We also discuss the common law remedies of trespass and nuisance, as well as public controls like zoning.

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[78] See Chapter xx on law enforcement, and also Chapter xx, which offers a similar economic rationale for punitive damages in torts.

[79] Public goods, discussed in the next section, are examples of beneficial externalities.

[80] The analysis is based on Polinsky (1979) and White and Wittman (1979).

7.1. A Model of Externalities in the Short and Long Run

This section develops a simple model of external costs that we will use to examine the various remedies. The model considers both short and long run notions of efficiency in anticipation of the fact that some remedies that are efficient in the short run are inefficient in the long run. To be specific, consider, as did Coase (1960), a railroad whose trains emit sparks that occasionally set fire to crops on farmland adjacent to the tracks. Suppose that the number of trains being run is n_T and the number of farms (total acreage) is n_F, resulting in crop damage equal to $n_T n_F D(x,y)$, where D is the damage (in terms of reduced crop value per acre) each train causes, x is dollar spending on precaution per train by the railroad (e.g., whether to install a spark arrester), and y is dollar spending on precaution by each farmer (e.g., where to locate the crops).[81] We assume that $D_x < 0$, $D_y < 0$, $D_{xx} > 0$, and $D_{yy} > 0$, reflecting diminishing marginal benefits to precaution. The benefits of railroading and farming are captured by $b_T(n_T)$ and $b_F(n_F)$, which are the marginal benefit functions for the two activities, respectively, both of which are assumed to display diminishing marginal benefits (i.e., $b_j' < 0$, $j=T,F$). The total value of the land in this model is given by

$$W = \int_0^{n_T} b_T(n_T)\,du + \int_0^{n_F} b_F(n_F)\,dz - [n_T n_F D(x,y) + n_T x + n_F y] \tag{7.1}$$

In the short run, the numbers of trains and farms are fixed. Thus, short run efficiency only concerns the expenditures on precaution (x,y) that maximize (7.1) and are given by

$$n_F D_x(x^*,y^*) + 1 \equiv 0 \tag{7.2}$$

$$n_T D_y(x^*,y^*) + 1 \equiv 0. \tag{7.3}$$

These conditions state that the parties should invest in precaution up to the point where marginal benefits in terms of saved damages equal marginal costs. In the long run all assets become choice variables so the number of trains and farms (n_T, n_F) must also be chosen to maximize (7.1). The resulting first-order conditions for n_T and n_F are

$$b_T(n_T) - [n_F D(x,y) + x] \equiv 0 \tag{7.4}$$

$$b_F(n_F) - [n_T D(x,y) + y] \equiv 0, \tag{7.5}$$

which state that each activity should be increased to the point where the last unit (train or farm) yields zero profit.

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[81] This formulation of expected damages assumes constant returns to scale in number of trains and farms. See Shavell (1980) for a similar model in the context of tort law.

7.2. The Pigovian Tax-Subsidy Approach

The traditional (pre-Coase) approach to the control of externalities is the Pigovian, or tax-subsidy approach. The idea is that the government needs to impose a tax on, or pay a subsidy to, the source of the externality (the railroad in this case) in order to force it to internalize the damage that it causes. Consider first short run incentives regarding precaution, holding the number of trains and farms fixed. Under a tax, the railroad pays the government based on damages imposed. Both the railroad and farmer will choose efficient care under this remedy provided that, first, the marginal tax equals the marginal damages imposed on farmers (from (7.2), $t'(x)=n_F D_x$), and second, that farmers do not receive the revenue from the tax (except possibly as a lump sum payment). Symmetrically, a subsidy scheme under which the government pays the railroad to reduce crop damage achieves bilateral efficiency in the short run provided that the marginal reduction in the subsidy equals marginal damages (i.e., $-s'(x)=n_F D_x$).

Note that the structures of the tax-subsidy schedules are not fully determined by these conditions. This is not the case, however, when we take into account long run efficiency. Consider first the railroad's decision about the number of trains. According to condition (7.4), the railroad will only choose the efficient number if it internalizes the full cost of the crop damage per train. This requires that it pay a tax per train equal to $n_F D(x,y)$. (Note that this tax satisfies the marginal condition above.) Clearly, a subsidy that involves any payments to the railroad will therefore result in too many trains. As for farming, condition (7.5) says that efficient entry of farmers requires that each farmer internalize the crop damage that his entry contributes to total damages. This condition is satisfied as long as farmers do not expect to receive any compensation for their losses (including lump sum compensation). In combination, these results show that only a tax scheme can achieve bilateral efficiency in both the short and long run.

7.3. The Property Rule-Liability Rule Approach

As discussed above, one of the contributions of Coase (1960) was to challenge the Pigovian assumption that externalities necessarily lead to market failure. This recognition suggests an expanded set of remedies for controlling externalities, which is best exemplified by the choice between property rules and liability rules (Calabresi and Melamed, 1972).[82] Under property rules, right holders can refuse any unwanted infringements of their rights, enforceable by injunctions (or criminal sanctions in the case of theft). Property rules thus form the legal basis for voluntary (market) exchange of rights. In contrast, liability rules do not entitle right holders to refuse infringements of their rights; instead, they can only seek monetary compensation in the form of damages. Liability rules thus form the basis for court-ordered or non-consensual transactions.[83]

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[82] Also see Polinsky (1980a) and Kaplow and Shavell (1996) for more recent analyses of property rules versus liability rules.

[83] Calabresi and Melamed (1972) also discuss a third rule, an inalienability rule, which prevents transfer of right under any circumstances (including consensual transfers). This rule is used to protect rights like freedom of religion and speech, the right to vote, and so on, that are deemed fundamental ("inalienable"). We do not pursue economic (or other) justifications for inalienability rules here.

From an economic perspective, the choice between property rules and liability rules therefore turns on the relative efficiency of markets versus courts (or some other third party arbiter) for allocating resources. When transaction costs are relatively low and markets function well, property rules are preferred because they ensure that all transactions are mutually beneficial.[84] When transaction costs are high, however, the costs of reaching an agreement under property rules may prevent otherwise efficient transactions from occurring. Liability rules have an advantage in this case because they allow the court to force a transfer. In this way, a court-ordered transaction replaces a market transaction. (The advantage of liability rules in economizing on transaction costs, however, needs to be weighed against court administrative costs and the possibility of court error in setting damages, which may result in too many or too few transactions, plus litigation costs.) Property rules thus form the basis for settling property disputes when transaction costs are relatively low, while liability rules form the basis when they are not.

In the context of the railroad-farmer conflict, a liability rule entitles farmers (victims) to seek monetary compensation for their damages but not to stop the damage from occurring.[85] If liability is strict, the railroad (injurer) must pay full compensation regardless of its level of precaution. In terms of short run efficiency, strict liability induces efficient precaution by the railroad, but because farmers are fully compensated, they have no incentive to take precaution. (The outcome is identical to a tax scheme where the revenue is paid to victims as compensation.) In contrast, a negligence rule, which only holds the railroad liable for damages if it takes less than the efficient level of abatement as defined by (7.2) (for example, if it fails to install spark arresters), will induce both parties to take efficient care. The railroad will take care to avoid liability, and the farmers will take care to minimize their losses.[86]

Neither liability rule, however, will achieve long run efficiency. Under strict liability, too many farmers will enter because they do not consider the impact that their entry has on total damages. Although the railroad does face full liability for each train that it runs, equal to $n_F D(x,y)$, this amount is too large because of the excessive number of farms. Thus, too few trains will run (though the number of trains is efficient, given the number of farms). The situation is reversed under a negligence rule. The railroad will invest in optimal abatement to avoid liability, but as a result, it will run too many trains (Polinsky, 1980b). In contrast, farmers will face the full amount of their damages, $n_T D(x,y)$, but too few farmers will enter because the number of trains is too large. In general, liability rules cannot create efficient long run incentives because of the constraint that what one party pays the other must receive.[87]

If the farmers' rights are protected by a property rule, they can block the railroad from running any trains by means of an injunction. The railroad, however, can seek to purchase rights to impose crop damage. For each train that it runs, the railroad will invest in abatement up to the point where the last dollar spent just equals aggregate marginal damages to all farmers, after

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[84] Kaplow and Shavell (1996) argue that when transaction costs are zero, property rules and liability rules should be equally efficient. However, because liability rules require courts to establish the initial terms of a transaction by setting damages (which the parties may later adjust), the administrative costs of using this rule may be higher than using a property rule.

[85] Note that the Coasian tradition would not use victim given the 'reciprocal nature' of the externality problem.

[86] See Chapter xx for a fuller discussion of the various negligence rules.

[87] This reflects the compensatory function of tort law.

which it will prefer to compensate farmers for the residual damages. Then, given efficient abatement per train, the railroad will run trains up to the point where the aggregate amount it has to compensate farmers equals the marginal benefit of one more train. This results in the first-best number of trains.

Efficient precaution by farmers can similarly be achieved by contracting. This requires that the railroad compensate farmers for their costs of precaution up to the point where the last dollar spent on precaution equals the marginal reduction in aggregate damages owed. Achieving the efficient *number* of farms is much more problematic. According to condition (7.5), long run efficiency requires that farmers enter up to the point where the marginal benefits of the last farm equal its marginal contribution to crop damage plus cost of precaution. But since farmers are compensated for these costs under the current assignment of rights, there exists be an incentive for too many to enter. In theory, private contracting can prevent excessive entry, but only if the railroad can identify all *potential* entrants into farming and offer to pay them their marginal benefit of entry if they agree to stay out. Clearly this poses a significant informational demand on the railroad. (Of course, a similar problem faces farmers if the property right is initially assigned to the railroad.) This discussion illustrates the limited usefulness of private contracting in internalizing externalities, especially regarding long run efficiency (Frech, 1979; Wittman, 1984; Holderness, 1989).

7.4. The Law of Trespass and Nuisance

As we noted above, in the case of real property, externalities arise because of conflicting uses of adjacent parcels. The primary common law remedies for unwanted invasions are trespass and nuisance. The law distinguishes the two by defining trespass as an invasion that deprives the owner of exclusive possession of land, and nuisance as an interference with the use and enjoyment of land. Examples of trespass are squatters and boundary encroachment, while examples of nuisance are air, water, and noise pollution.

The primary remedy under trespass is an injunction against the unwanted intrusion. Thus, the landowner's right to exclude is protected by a property rule. The remedy under nuisance law is more complicated. First, the landowner can only obtain relief if the invasion is substantial, and even then, he may have to be satisfied with money damages (a liability rule). If the landowner wishes the harm to be enjoined, he must meet the further legal standard of showing that the harm outweighs the benefit of the nuisance-creating activity (Keeton, et al., 1984, p. 630).

Merrill (1985a, 1998) argues that this distinction between trespass and nuisance can be broadly understood in terms of the choice between property rules and liability rules. Cases of trespass ordinarily involve a small number of parties where the intruder is easily identifiable. Thus, transaction costs tend to be low, and property rules are the preferred remedy. In contrast, cases of nuisance often involve large numbers or sources of harm that are difficult to identify. Thus, transaction costs are high and contracting is unlikely to lead to the efficient outcome. In cases like this liability rules are preferred.

The well-known case of *Boomer v. Atlantic Cement Co.* provides an illustration of this choice.[88] The case involved a group of landowners who sought an injunction against a large cement factory because of the dirt, smoke, and noise that it produced. The court denied the injunction and instead awarded money damages on the grounds that the injunction would have forced the factory to shut down, causing a loss of jobs and the company's substantial capital investment. The court's decision seems correct in view of the high transaction costs (owing to the large number of effected homeowners) that would have been necessary to keep the plant operating under an injunction.

7.5. Zoning, Covenants, and Common Law Control

Probably the most common legal response to land market externalities in the United States is zoning, a form of public regulation.[89] The economic rationale for zoning is that "similar land uses have no (or only small) external effects on each other whereas dissimilar land uses may have large effects" (White, 1975, p. 32). The widespread use of zoning, however, does not necessarily make it the most efficient response to externalities. High administrative and enforcement costs often exceed the saved "nuisance costs," thereby making the system inefficient (Ellickson, 1973). This would not be a problem, however, if the penalty for violations were payment of an appropriate fine, which would allow landowners to circumvent inefficient regulations. In this sense, zoning regulations are best enforced by a liability rule (White and Wittman, 1979). The fact that compliance with zoning ordinances is required, however, (that is, they are enforced by a property rule) forecloses this route to efficiency.

A private alternative to zoning is the use of land use servitudes (e.g., covenants, easements, or equitable servitudes) that impose limits on what landowners can do with their property. Such restrictions are usually put in place by developers when they first sub-divide a parcel of land in recognition of the fact that, once divided, individual landowners will often undertake activities that impose externalities on one another (Hughes and Turnbull 1996). By attaching the restriction up front, the developer maximizes the aggregate value of the development (and hence his profit) by internalizing the neighborhood externalities. Further, since the restrictions are attached to the deed rather than to the landowner (that is, they "run with the land"), they avoid the transaction costs that would be necessary if each new resident had to negotiate anew with all existing residents. In this sense, land use servitudes represent an effective private alternative to zoning for small-scale developments. They are less effective, however, in controlling externalities in large-scale urban areas where development occurs in a piecemeal fashion over time.

Trespass and nuisance law also represent private alternatives to zoning. As noted above, trespass is effective in internalizing small-scale intrusions (for example, boundary disputes between neighbors), while nuisance law is best suited to harms that affect a few individuals (Ellickson, 1973). However, nuisance law is inadequate to internalize harms that are dispersed across a large number of landowners because no one owner has an adequate incentive to incur the cost of bringing a nuisance suit, even though the aggregate harm may exceed the benefit (Landes and

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[88] 26 N.Y.2d 219, 309 N.Y.S.2d 312, 257 N.E.2d 870 (Court of Appeals of New York, 1970.
[89] Zoning was declared constitutional in *Village of Euclid v. Ambler Realty*, 272 U.S. 365 (1926).

Posner, 1987, Chapter 2). For these types of externalities, public regulation, whereby the government acts as an agent of the victims, is usually the best remedy.

8. State Property and State Use of Private Property

In section 2 we noted that state or government ownership was one of the primary types of property rights. Here we examine the rationale for state ownership and for state control (including regulation and takings) of private property.

8.1. The Optimal Scale of Ownership

Private ownership of land is not always the most efficient means of maximizing land value. The primary advantage of private ownership is that it creates the proper incentives for use and investment for actions taken within the boundaries of the property. Since different uses of land have different optimal boundary requirements, it may be the case that the scale of an activity exceeds the existing boundaries of ownership (Ellickson, 1993). For example, Coase's example of straying cattle suggests that the rancher's parcel was too small. One solution to this problem is contracting between ranchers and neighboring owners who suffer harm (Ellickson, 1991), but if contracting costs are high, a better solution may be to consolidate ownership of the parcels (Libecap 1989). In this way, market transactions are replaced by internal governance methods (Ostrom, 1990). The optimal solution depends on the cost of contracting among landowners (which increases with greater decentralization) compared to the cost of governance (which increases with scale).[90] In an empirical application Lueck (1989) examines the ownership regimes that govern wildlife a resource that often has an optimal scale of management that far exceeds the typical boundaries of private land holdings. Lueck finds a mix of private contracting and government ownership regimes that have developed in response to the potential externality problems.

Another benefit of group ownership, besides internalizing externalities, is risk sharing. Group ownership of land spreads the risk of uncertain events like crop failure, thereby providing a form of insurance. Group ownership also promotes egalitarianism, or equal sharing of output, which historically has been the motivation for various communal societies (Ellickson, 1993; Cosgel, Miceli, and Murray, 1997). As noted in the discussion of common property, these benefits must be weighed against the cost of group ownership in the form of diluted incentives for effort.

8.2. The Public Trust Doctrine

The public trust doctrine is an ancient doctrine which grants ownership of navigable rivers, shorelines, and the open sea to the public.[91] The public trust doctrine can be viewed as the judicial creation of common property, which has roots in Roman law and the English common law. English and Roman public trust law both acknowledged inalienable public rights in navigable waterways and the foreshore. They allowed, for example, unrestricted access to large watercourses for travel and transportation. The public trust doctrine also has been a part of American law, providing public access to navigable waterways and authorizing state control over

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[90] The problem is analogous to Coase's (1937) theory of the optimal boundary between the market and the firm.
[91] For an introduction see Dukeminier and Krier (2002, pp.816-823).

tidelands.[92] In essence, the public trust doctrine "defines an easement that members of the public hold in common" (Huffman, 1989, p. 527), thus creating a sort of common property resource among a disorganized public. In recent years some courts have extended the doctrine into new areas -- mostly environmental assets -- such as beaches, lakes, stream access, and wildlife (Sax 1970).   For example, *National Audubon Society v. Superior Court*,[93] perhaps the most important modern case, extended public trust status to wildlife habitat at California's Mono Lake, thereby effectively reallocating water rights.

In its traditional application, navigable waters, the public trust asset was essentially a public good. When an asset is a public good, unrestricted access will not cause dissipation from overuse of the resource. On the other hand, when the resource has private good characteristics, unrestricted access by a large number of people trigger the rule of capture and creates a classic open access problem. Indeed, some critics (Cohen 1992, Huffman 1989) of new environmental applications of the public trust doctrine argue that expanding access to resources will lead to their degradation through overuse.[94] For instance, a public trust conversion of a private beach into a public beach may well lead to crowding and pollution of the beach.

8.3. Takings

Large-scale economic developments like railroads, highways, and shopping centers often involve the assembly of land. In all of these cases, the provider, whether public or private, faces a potential holdout problem (Cohen, 1991; Strange, 1995). The source of this problem is that, once assembly becomes public knowledge, each landowner realizes that he or she can impose a substantial cost on the provider by refusing to sell. This knowledge confers monopoly power on owners, who can each hold out for prices in excess of their true valuations, thereby endangering completion of the project.[95]

One solution to the land assembly problem is to allow forced sales—that is, replace property rule protection of each owner's land with liability rule protection. This is the economic justification for the eminent domain, or "takings," clause of the U.S. Constitution, which says, "nor shall private property be taken for public use, without just compensation" (Posner, 2003, p. 55). Although eminent domain is a power reserved for the government based on the "public use" requirement, the preceding discussion suggests that it should be extended to any provider, public or private, facing a holdout problem.

8.3.1. Public Use of Private Property

Merrill (1986) examines the scope of the takings power in the context of the public use requirement. He draws a distinction between the "means" and "ends" approach to public use.

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[92] The seminal case is *Illinois Central Railroad v. Illinois*, 146 U.S. 387 (1892).

[93]   658 P.2d 709 (Cal. 1983).

[94] Cohen (1992) and Rose (1986), note how an expansive public trust doctrine can be used by governments to avoid the Constitution's takings clause.

[95] It is important to distinguish this problem from the case of single owners of dispersed parcels who seek the best price for their property in one-on-one transactions. This is not a holdout problem because the owners are not seeking a price above the true valuation of their property, nor does any one owner's refusal to sell affect the transfer of other parcels.

The means approach concerns the manner in which land is acquired for large-scale projects (is there a holdout problem?), while the ends approach refers to the use of the land (is it for a public or private good?). It is important to note that these are separable categories—that is, not all public goods require land assembly, and some private goods do. According to the ends approach, the takings power should be limited to provision of public goods by the government, whereas according to the means approach, it should be granted to any provider facing a holdout problem.[96]

The ends approach appears more consistent with the plain meaning of public use, but it potentially results in two types of "errors." First, it may result in the use of eminent domain for the provision of public goods not requiring land assembly (Fischel, 1995a, p. 74). Merrill argues, however, that this overuse of the takings power (i.e., the substitution of coercive for consensual transactions) is self-limiting in the sense that the costs of market acquisition are generally less than the costs of eminent domain. Second, the ends approach apparently denies use of eminent domain to private providers facing a holdout problem. Historically, however, courts have tended to act in accordance with the means approach by granting takings power to private parties like railroad and canal builders who face serious holdout problems, though they nearly always attempt to justify their action in terms of the ends approach--that is, they identify some public benefit from the project (Merrill, 1986, p. 67).[97] The need for such justification is somewhat surprising, however, given that courts routinely use liability rules (i.e., money damages) as a remedy in other disputes involving private parties. For example, awarding damages to the plaintiffs in the *Boomer* case rather than shutting the factory down amounted to a "private taking" by the factory. This was appropriate, we argued, because the factory faced a kind of holdout problem. The point is that the actual use of eminent domain appears to reflect economic logic (the means approach), and when necessary, courts bend the meaning of public use to conform to this standard (Fischel, 1995a, pp. 75-77).

8.3.2. Takings and Just Compensation

In addition to public use, the eminent domain clause requires payment of just compensation following a taking.[98] Courts have interpreted this to mean "fair market value." Several authors have argued, however, that fair market value almost certainly under compensates landowners because it ignores subjective value (e.g., Knetsch and Borcherding, 1979). Since subjective value is part of the opportunity cost of a taking, failure to compensate for it potentially results in over acquisition of land by the government.[99] Countering this is Epstein's (1985; Ch. 15) contention that taxes used to finance compensation are themselves a form of taking, which act as a limit on the amount of land taxpayers will permit the government to acquire (Fischel, 1995a, p. 211).

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[96] Ulen (1992) argues that eminent domain should only be used when both conditions are met.

[97] See, for example, the famous case of *Poletown Neighborhood Council v. City of Detroit*, 410 Mich. 616, 304 N.W.2d 455 (1981).

[98] Outside of the economics literature, the most influential article on the compensation question is by Michelman (1967). Fischel and Shapiro (1988) provide a useful interpretation of Michelman's utilitarian standard in light of the scholarship reviewed here

[99] In an empirical study of land acquisition in Chicago, Munch (1979) found that compensation amounts differed systematically from market value. Specifically, owners of high valued properties were overcompensated, while owners of low valued properties were under compensated.

One of the primary contributions of the economics literature on eminent domain has been to argue that it may be inefficient to pay *any* compensation. This claim was first advanced by Blume, Rubinfeld, and Shapiro (BRS) (1984) in their analysis of the impact of compensation on land use incentives. Their argument can be illustrated by a simplified version of their model. Consider a parcel of land worth *V(x)* if the landowner makes an irreversible investment *x*, where $V' > 0$ and $V'' < 0$. The land may also be valuable for public use, yielding a benefit of *B(y)*, where *y* is the fraction of the land taken. Setting *y*=1 therefore represents a taking of the entire parcel. Alternatively, *y* may be interpreted as the probability of a taking, or the fraction of the parcel's value that is extinguished by a regulation (a "regulatory taking"). Under either interpretation, $0 \leq y \leq 1$ and $B' > 0$, $B'' < 0$. If the land is taken or regulated, suppose that compensation of *C(x)* will be paid in proportion to the fraction taken or lost (i.e., *yC(x)* will be paid for an expected loss of a fraction *y* of the land's value), where $C(x) \geq 0$, and $C' \geq 0$.

The time sequence is that landowners choose *x* given the anticipated behavior of the government and the compensation rule; then the government chooses *y* and pays *C(x)*. We will assume various objective functions for the government below. First, however, consider the first-best choices (*x**, *y**) that must maximize *B(y)* + *(1−y)V(x)* − *x*. The relevant first-order conditions are

$$(1-y^*)V'(x^*) - 1 \equiv 0 \tag{8.1}$$

$$B'(y^*) - V(x^*) \equiv 0. \tag{8.2}$$

Now consider the decisions separately made by each party. In the first scenario, we view the government's taking decision as exogenous—that is, it is unaffected by the compensation rule. This is the assumption BRS (1984) make in their basic model, and represents what Fischel and Shapiro (1989) refer to as an "inexorable" government. In this case, *y* is fixed (so condition (8.2) is irrelevant), while the landowner chooses *x* to maximize *(1−y)V(x)* + *yC(x)* − *x*, which must satisfy

$$(1-y)V'(x^l) + yC'(x^l) - 1 \equiv 0. \tag{8.3}$$

Comparing this to (8.1) shows that $C' = 0$ is necessary for the landowner to invest efficiently; that is compensation must be lump sum to ensure that $x^l = x^*$ (BRS, 1984). Intuitively, any positive relationship between *x* and the amount of compensation creates a moral hazard problem that results in over-investment. It immediately follows that no compensation ($C(x) \equiv 0$ for all *x*) is efficient, although any lump sum rule is consistent with efficiency.[100]

The case of zero compensation, however, has attracted the most attention because it is both counterintuitive and controversial. The result does not hold up, however, under different assumptions about the government's behavior. Suppose, for example, that the government chooses *y* to maximize social welfare. Such a government has been characterized as

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[100] This is an example of the *paradox of compensation* (e.g., Cooter and Ulen 1999, p.169) which is also found in tort law and contract law remedies (Cooter 1985). It can be avoided with a contract or compensation mechanism that defines optimal choices for both parties.

"benevolent" (Hermalin, 1995) or "Pigovian" (Fischel and Shapiro, 1989). The optimal choice of *y* in this case is given by the first-order condition in (8.2). Note that, because the government chooses *y* after the landowner's investment of *x* is in place, (8.2) defines a function $y^g(x)$, where

$$\frac{\partial y^g}{\partial x} = \frac{V'}{B''} < 0.$$ (8.4)

The amount of land taken is decreasing in *x* because the more the landowner has invested, the higher is the opportunity cost of a taking.

The landowner's objective function is the same as above, but he now maximizes it subject to the anticipated behavior of the government as described in (8.4). The first-order condition is

$$(1-y)V'(x) + yC'(x) - [V(x) - C(x)](\partial y^g / \partial x) - 1 = 0.$$ (8.5)

Note that compensation must again be lump sum, but zero compensation is no longer consistent with efficiency. This is reflected by the third term in (8.5), which implies that the landowner will over-invest if *C(x)<V(x)* and under-invest if *C(x)>V(x)*. Intuitively, if the landowner expects to be under compensated in the event of a taking, he will increase his investment in order to lower the probability of a taking. Conversely, if he expects to be overcompensated, he will under-invest in order to raise the probability of a taking (Miceli, 1991; Hermalin, 1995).

This version of the model embodies two potential sources of moral hazard for the landowner. The first is the threat of overinvestment if compensation is an increasing function of *x* (the basis for the no-compensation result above), and the second is the effect of *x* on the government's taking decision. One compensation rule that resolves both problems and induces an efficient level of investment is *C=V(x*)*.[101] That is, compensation should be set at the full value of the land, evaluated at the efficient level of investment.

It is important to emphasize that the justification for compensation in this model is *not* to prevent excessive acquisition of land by the government, as is often argued. Suppose, however, that the government is not benevolent, but instead acts on behalf of the majority (those who receive the benefits of the taking) while ignoring the costs to individual property owners, except to the extent that it must pay them compensation (Fischel and Shapiro, 1989; Hermalin, 1995; Nosal, 2001). Such a government is said to have "fiscal illusion" in that only dollar costs enter its cost-benefit calculation (BRS, 1984).

In this case, the government chooses *y* to maximize $B(y) - yC(x)$, which yields the first-order condition

$$B'(y) - C(x) \equiv 0.$$ (8.6)

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[101] This rule is not the only one that achieves the efficient outcome. One alternative will be discussed below, and Hermalin (1995) proposes others.

As before, this defines a function $\hat{y}(x)$ whose characteristics depend on the nature of the compensation rule. The landowner now maximizes his objective function subject to $\hat{y}(x)$, which yields the first-order condition in (8.5) with $\partial y^g/\partial x$ replaced by $\partial \hat{y}/\partial x$. Clearly, $C=V(x^*)$ will induce efficient investment by the landowner in this case based on the same reasoning above. Moreover, setting $C=V(x^*)$ in (8.6) also yields the efficient taking decision by the government.[102]

Now consider an alternative compensation rule that also induces efficient behavior by both the landowner and government in this model:

$$(8.7) \qquad C = \begin{cases} 0, & \text{if } y \le y^* \\ V(x^*), & \text{if } y > y^*. \end{cases}$$

Note that this rule is conditional on the behavior of the government in that it pays full (lump-sum) compensation if it over-regulates, but pays nothing otherwise (Miceli and Segerson, 1994, 1996). In this sense, it is like a negligence rule in tort law. As we will see, it also resembles actual legal practice.

To verify that (8.7) results in an efficient equilibrium, assume initially that the landowner makes the efficient level of investment, x^*. The government's problem is then to choose y to maximize

$$\begin{aligned} &B(y), & \text{if } y \le y^* \\ &B(y) - yV(x^*), & \text{if } y > y^*. \end{aligned} \qquad (8.8)$$

Note first that it will never choose $y<y^*$ given $B'>0$. Further, $B(y^*) > B(y^*)-y^*V(x^*) \ge \max_{y>y^*} B(y) - yV(x^*)$. Thus, the government chooses y^*, in which case $C=0$. The landowner therefore views compensation as zero and y as fixed at y^*. Thus, he chooses x^*.

One advantage of the rule in (8.7) over the unconditional compensation rule $C=V(x^*)$ is that the conditional rule will result in fewer takings claims (and hence lower administrative costs) because landowners only expect to be compensated if the government acts inefficiently. Another advantage, noted above, is that the rule in (8.7) is more descriptive of actual takings law in cases involving government regulations (regulatory takings), which constitute the vast majority of claims.[103] For example, it closely resembles the "diminution of value" and "nuisance exception" tests for compensation, both of which are conditional rules that limit compensation to cases of excessive regulatory action.[104] An offsetting benefit of unconditional compensation is that it

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[102] Alternatively, Fischel and Shapiro (1989) consider a compensation rule of the form $C=sV(x)$ where s is the fraction of the value of the land that the government will pay in the event of a taking. They argue that this is an easier rule to administer compared to $C=V(x^*)$ because it does not require the government to calculate x^*. The shortcoming is that the optimal value of s, which is strictly between zero and one, only achieves a second-best outcome.

[103] Compensation is always paid for physical invasions or outright takings.

[104] The diminution of value test was first articulated in the famous case of *Pennsylvania Coal Co. v. Mahon* (260 U.S. 393, 1922), and the nuisance exception was proposed in the more recent case of *Lucas v. South Carolina*

provides landowners insurance against takings risk, given that such insurance would be difficult for landowners to obtain in the market (Blume and Rubinfeld, 1984; Kaplow, 1986).

In a very influential article, Michelman (1967) says that compensation should depend on a comparison of the "settlement costs" of paying compensation and the "demoralization costs" of not paying compensation. In terms of the preceding analysis, settlement costs include administrative costs and the costs associated with moral hazard, while demoralization costs arise from the risk of an uncompensated taking (Fischel and Shapiro, 1988; Fischel, 1995, Chapter 4).

8.3.3. Compensation and the Timing of Development

It is clear from the above discussion that regulations often redefine property rights to the disadvantage of landowners. Faced with the threat of no compensation for alterations of their property rights, landowners can often reclaim these rights because they have private information and a first mover advantage over regulatory agencies and legislatures. In the process, they can preempt regulations and may do so in ways that counter the intended goals of the regulations. Land preservation and environmental regulations are perhaps the classic case (Cohen 1999, Dana 1995). While regulators consider restrictions to preserve land, developers race to beat the regulations, often leading to more rapid development than would have otherwise occurred.

The incentive to preemptively develop can be seen in a two-period model of a landowner and a regulatory agency which can invoke a land use regulation that will lower the value of the land by preserving some environmental amenity (e.g., endangered species habitat, open space).[105] The land's value under the regulation depends on the landowner's behavior. Specifically, the landowner can choose to maintain (m) or destroy (d) the amenity in period 1. The landowner has private information about the amenity and has a clear first mover advantage over the agency because of this information and because of his ownership incentives. Development and thus destroying the amenity has a one-time cost (C_D) and generates benefits (B_D) from development. C_D is the cost of developing early; for example, harvesting timber before it has reached the optimal harvest age. If the amenity is destroyed the probability that the land will be regulated is zero. If the amenity is maintained there is a probability, $\gamma \in (0,1)$, that the regulation will be invoked because the agency will deem the amenity worth preserving. If the regulation is invoked and no compensation is paid, the landowner loses all benefits from development in period 2 ($B_D = 0$ in period 2), but he may earn a smaller amount of benefits from an alternative land use that does not harm the amenity ($B_A < B_D$). If, however, the landowner waits until period 2 to develop, he faces no costs of development ($C_D = 0$). In the absence of the regulation, the optimal time to develop is in period 2. The landowner takes as given market prices (which determine the magnitudes of the various benefits and costs) and the probability the agency will invoke the regulation.

Coastal Council (112 S.Ct. 2886, 1992). For a more detailed discussion of the rule in (8.7) in relation to takings law, see Miceli and Segerson (1996). Also see Fischel (1995a).

[105] The model here follows Lueck and Micheal's (2003) application to the federal Endangered Species Act (ESA). Miceli and Segerson (1996) present a similar model of development with irreversible investment that generates premature development without compensation. Innes, Polasky, and Tschirhart (1998) also examine the incentives for landowners under the ESA.

The landowner will maximize the expected value of the land by choosing to destroy the amenity if the expected value of early development exceeds that of waiting, or if $[B_D\text{-}C_D] > (1\text{-}\gamma)B_D + (\gamma)B_A$. This inequality leads to several straightforward comparative statics predictions. First, increases in the probability that the land will be regulated (γ) will increase the probability of preemptive development. Second, as the net value of development ($B_D\text{-}B_A$) increases, amenity destruction is more likely. Third, as the opportunity cost of early development increases (C_D) it is less likely that habitat destruction will occur.

Dana (1995) offers anecdotal evidence of such preemptive development and Lueck and Michael (2003) find that the federal Endangered Species Act (ESA) has led some forest landowners to preemptively harvest timber in order to avoid costly land-use restrictions. For example, they find that landowners in North Carolina who are closer to populations of endangered red-cockaded woodpeckers (and thus subject to potentially costly timber harvest restrictions) are more likely to prematurely harvest their forest and choose shorter forest rotations. In this setting the empirical evidence indicates some endangered species habitat has been reduced on private land because of the ESA's land use regulations. The extent of such counter-productive regulations is not widely known and is a potentially important area of empirical research.

9. Conclusion

The economic analysis of property rights and the economic analysis of law were the twin offspring of Coase's (1960) seminal work. Yet, today the economics of property law is a poor cousin to the economics of contracts, torts, and many other areas. In part this is because economic analysis of property law has not been as welcome among property law scholars as it has been among legal scholars of antitrust, contracts and torts. In part is it because property law is so broad, making comprehensive analysis a daunting task.

In this chapter we have surveyed the somewhat disjoint literature developed by economists and by legal scholars, elaborated on some of the basic models, and highlighted areas where more work remains to be done. While many important issues remain it can be claimed that economic analysis shows a fundamental logic to the main doctrines and features of property law. Among the most important remaining issues for study is a systematic analysis of how the law addresses the use and transfer of complex assets. And, as always, more detailed empirical work is needed to fully test and understand the rationale for the law and its effects.

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TABLE 1: FIRST POSSESSION RULES

| Asset	Possession Rule	Stock-Flow & Duration of Rights
Chattels (abandoned, lost, unclaimed)	recover or show intent to recover	stock – permanent
Intellectual property	invent, write	stock -- varies (17 - 100 years)
Land	occupation & cultivation of land	stock – permanent
Minerals (hard rock)	locate mineral deposit	stock – permanent
Ocean fisheries	land fish	flow -- current catch
Petroleum	bring oil to surface	flow -- current production
Water- appropriation doctrine	develop a diversion plan	stock – permanent
Water-- riparian doctrine	pump or divert water	flow -- current use
Wild game	kill or capture animal	flow -- current kill
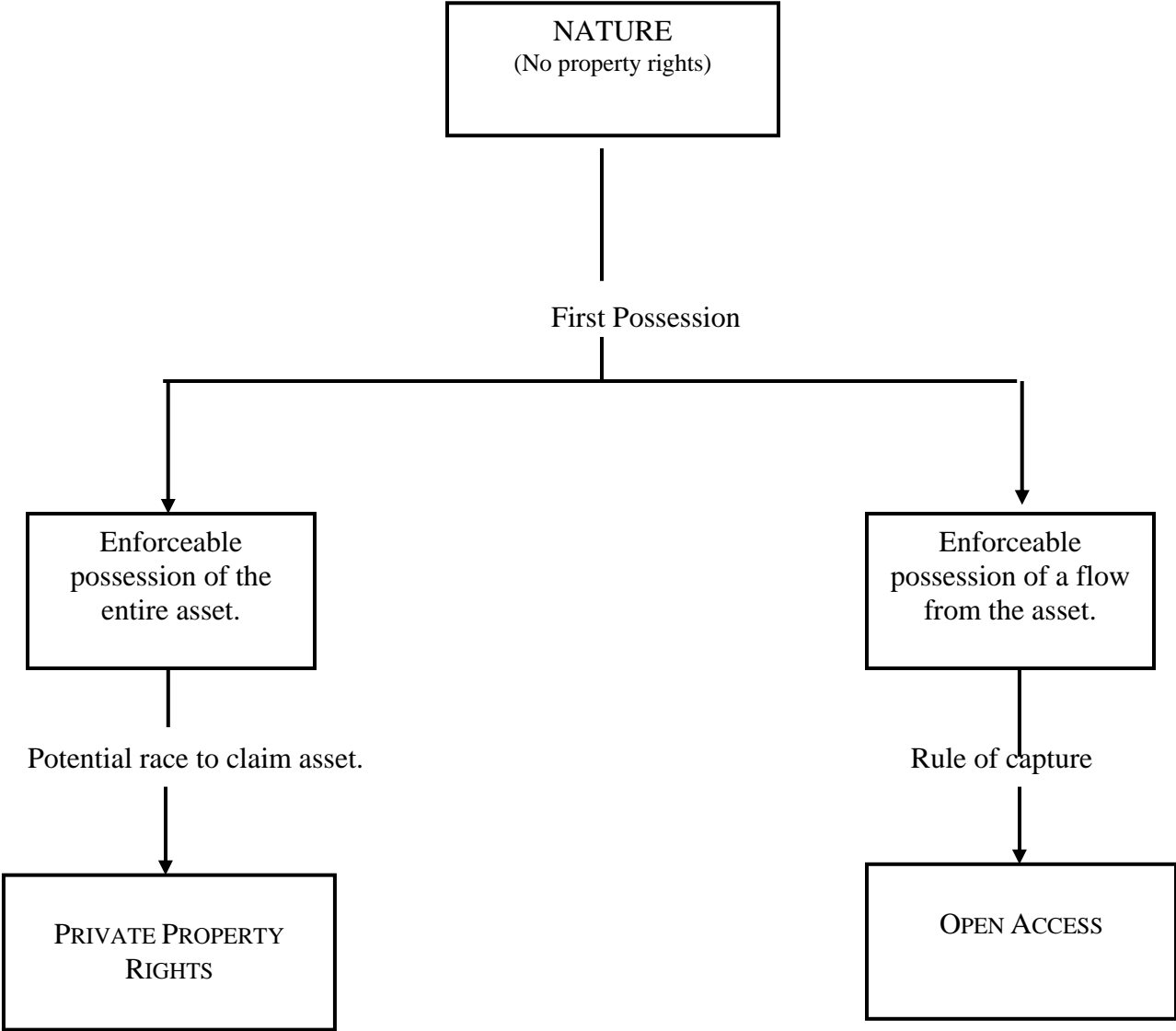
Figure 1: Property Rights under the Rule of First Possession