The Creation of Effective Property Rights

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To say that an agent has an effective property right means that this agent controls the allocation of some valuable resources and the distribution of the fruits of this allocation. Traditionally, general-equilibrium models have taken effective property rights to be given and have been concerned only with analyzing the allocation of resources among productive uses and the distribution of the resulting product. However, this formulation of the economic problem is incomplete, because it neglects the fact that the appropriative activities by which agents create the effective property rights that inform allocation and distribution are themselves an alternative use of scarce resources.

This paper develops two general-equilibrium models in which agents allocate scarce time and effort to creating effective property rights to valuable resources.[1] In contrast to much of the literature on property rights, both of these models relegate the state and the legal system to the background. Although political theory typically views the state to be the enforcer of cooperative action to protect property rights, the existence of a state and a legal system is neither necessary nor sufficient for the existence of effective property rights.[2] Even with an advanced modern state and legal system, the single most important action that one takes to secure property is probably the purely private activity of locking one's doors.

The two models in this paper differ in their specifications of the state of nature that exists prior to the creation of effective property rights. In one model, the valuable resources are initially in a common pool. Examples include wild animals, fish, or plants that agents want to harvest, minerals that agents want to extract, or land that agents want to cultivate or to use for grazing, but over which no agent as yet has created an effective property right. In this model, agents create effective property rights by using time and effort to appropriate resources from the common pool.

In the other model, agents initially have claims, which can be more or less secure, to the valuable resources. These claims can be natural in the sense that they arose in the process of discovery or creation of these resources. Examples include a person's claim to his own ideas or to things that he has produced with his own hands. Alternatively, these claims can result from prior appropriation of resources from a common pool. Examples include claims that agents staked out to public lands, as in the California Gold Rush of 1849.[3] In this model, agents create effective property rights, or more precisely, convert initial claims into effective property rights, by using time and effort to defend their own initial claims and to challenge

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[1] In a brief and long-neglected contribution Trygve Haavelmo (1954 pp. 91–98) provided a canonical general-equilibrium model of the allocation of resources between productive and appropriative activities. Over the years, a number of authors have reinvented and extended Haavelmo's formalization of this problem. The present paper builds most directly on the analysis of Winston Bush and Lawrence Mayer (1974). Other related papers include Stergios Skaperdas (1992), Jack Hirshleifer (1995), and Grossman and Minseong Kim (1995). In contrast to the present paper, these papers assume that agents use only a single resource both to appropriate resources and to produce consumables.

[2] Effective property rights are synonymous with what Dani Rodrik (2000) calls "control rights." Rodrik contrasts control rights with the formal property rights entailed in legal ownership. Rodrik writes, "The key word is 'control' rather than 'ownership.' Formal property rights do not count for much if they do not confer control rights. By the same token, sufficiently strong control rights may do the trick even in the absence of formal property rights" (p. 5). Many authors, however, stress that the formal property rights enhance control rights (see e.g., Lee Alston et al., 1996). In a more abstract context, Grossman (2000) derives conditions under which the existence of a state that protects property rights is or is not a Pareto improvement over anarchy, whereas Juan Mendoza (1999) derives conditions under which the state chooses to free-ride on the efforts of private agents to protect property rights.

[3] In this example, in allocating time and effort to the competition to stake out claims to resources, agents should anticipate having to defend these claims subsequently. I leave the modeling of such a two-stage process for another time.

the initial claims of others. Relative success in challenging and defending initial claims determines the security of initial claims.

I. The Creation of Property Rights from a Common Pool of Resources

Consider a group of $n + 1$ identical unitary agents, $n \in \{1, 2, 3, \cdots\}$. These agents can be individuals, or they can be groups, such as families, tribes, or even sovereign states, as long as one can assume that these coalitions act as unitary agents. Each agent is endowed with one unit of inalienable time and effort.

Let there also be $(n + 1)E$ divisible units of valuable resources, which are initially in a common pool. The analysis assumes, for simplicity, that resources are nondurable and nonrenewable. The appropriation of resources from the common pool requires time and effort. Also, both time and effort and resources are inputs into the production of consumables. Each agent must choose how to allocate its endowment of time and effort between the activities of appropriating from the common pool and production.[4]

To model the creation of effective property rights by appropriation from a common pool, let $i, j = 1, 2, \ldots, n + 1$, and assume that

$$(1) \qquad e_i = \frac{r_i}{r_i + \sum_{j \neq i} r_j}(n + 1)E$$

where e_i denotes the amount of resources that agent i appropriates from the common pool and where r_i and r_j denote the amounts of time and effort that agents i and j allocate to the appropriative competition.[5] Equation (1) simply says the following:

> Agent i creates an effective property right to a fraction of the resources in the common pool that equals the fraction that agent i contributes to the total time and effort that the $n + 1$ agents allocate to the appropriative competition.

The appropriative competition modeled by equation (1) could involve such disparate processes as a nonviolent scramble, a division under the threat of force, or a violent struggle. In this respect, equation (1) is like a standard black-box production function. Equation (1) does not indicate how agents appropriate from the common pool any more than a production function indicates how to make cars.

Turning to the technology of production, let ℓ_i denote the amount of time and effort that agent i allocates to the production of consumables, and let c_i denote agent i's consumption. Assume that c_i depends on ℓ_i and on e_i according to a standard Cobb-Douglas technology:

$$(2) \qquad c_i = e_i^{\alpha} \ell_i^{1-\alpha} \qquad 0 < \alpha < 1.$$

The parameter α in equation (2) measures the importance of resources relative to time and effort for producing consumables.

Equation (1) implies that time and effort are essential to the appropriation of resources from the common pool. Equation (2) implies that resources appropriated from the common pool are essential for production. Thus, equations (1) and (2) together imply that the dominant strategy of each agent, taking as given the allocation decisions of other agents, is to allocate time and effort to the appropriative competition. This model precludes the possibility that the agents would choose to allow the valuable resources to remain in the common pool.[6]

[4] Bush and Mayer (1974) tell an isomorphic story in which each agent, having an initial claim to a unit of resources, allocates time and effort to appropriating the claims of others but allocates no time and effort explicitly to defending its own initial claim.

[5] Hirshleifer (1995) suggests a generalization of equation (1) in which each agent's allocation of time and effort to the appropriative competition is raised to a positive power. Hirshleifer calls this exponent the "decisiveness parameter." Grossman et al. (2000) explore the importance of the decisiveness parameter.

[6] In contrast, David de Meza and J. R. Gould (1992) and Aaron Tornell (1997) assume that appropriating resources from a common pool involves a fixed cost and that agents can exploit valuable resources under conditions of open access without appropriating them from a common pool. Under these assumptions, the agents might choose to allow resources to remain in a common pool. Another literature explores the possibility that, if agents interact repeatedly, then they can avoid appropriative competition by making credible commitments to share resources that are in a common pool (see e.g., Elinor Ostrom, 1990; Ostrom et al., 1994). Presumably, such commitments are the basis for forming unitary agents out of groups of people. The present

Agent i chooses r_i and ℓ_i to maximize its consumption subject to $r_i + \ell_i = 1$. Assume that in making these choices agent i takes other agents' choices, r_j for all $j \neq i$, as given. Thus, the first-order condition for the solution to agent i's choice problem is

$$\text{(3)} \qquad \frac{dc_i}{dr_i} = \frac{\partial c_i}{\partial e_i}\frac{\partial e_i}{\partial r_i} - \frac{\partial c_i}{\partial \ell_i} = 0.$$

Equation (3) says that agent i chooses r_i such that the marginal benefit of r_i in increasing the amount of resources that agent i appropriates from the common pool equals the marginal cost of r_i in decreasing the amount of time and effort that agent i allocates to production.

Equation (3) implies a unique, symmetrical equilibrium in which r_i equals r_j for all pairs i and j. Using this equality and equations (1) and (2) to solve equation (3), one obtains the following for the equilibrium allocation of time and effort:

$$\text{(4)} \qquad \frac{r_i}{\ell_i} = \left(\frac{n}{n+1}\right)\left(\frac{\alpha}{1-\alpha}\right) \qquad \text{for all } i.$$

Equation (4) implies that the amount of time and effort that each agent allocates to the appropriative competition is larger (and hence, the amount of time and effort that each agent allocates to production is smaller) the larger is n, the scale of the economy, and the larger is α, the relative importance of resources for producing consumables. The effect of n obtains because in a symmetrical equilibrium the marginal effect of an agent's allocating more time and effort to the appropriative competition on the amount of resources that the agent appropriates from the common pool is increasing in n.[7]

Also, in equation (4) the allocation of time and effort does not depend on E, the per capita amount of resources in the common pool. This result obtains because in this model agents allocate time and effort either to appropriation or to production, and the return to both activities increases proportionately with the amount of resources in the common pool.[8]

II. The Conversion of Initial Claims into Effective Property Rights

As an alternative to resources being initially in a common pool, assume now that each agent has an initial nonoverlapping claim to E units of resources.[9] The existence of initial claims creates an essential distinction between defending one's own initial claim and challenging the initial claims of other agents. In this model, each agent must choose how to allocate its time and effort among these distinct appropriative activities and production.

For simplicity, assume that there are only two agents, agent 1 and agent 2. To model the challenging and defending of initial claims, let i, $j = 1, 2$, and let p_i and p_j denote the fractions of their initial claims that agents i and j successfully defend.[10]

analysis of the creation of effective property rights can be regarded as complementary to the analysis of cooperation, with the present analysis becoming relevant when agents have exhausted opportunities for amicable sharing of resources.

[7] We can view the positive relation between r_i and n as consistent with the common observation that life is more competitive in large cities than in small towns. I thank Harl Ryder for this observation.

[8] Grossman and Mendoza (2000) extend this model by assuming that, if resources are scarce, then consumption and, hence, appropriated resources have a large effect on the probability of survival. Given this assumption, agents allocate more time and effort to the appropriative competition the smaller the per capita amount of resources in the common pool. In contrast, Grossman (1992) and Kai Konrad and Skaperdas (1998) assume that the alternative cost of time and effort allocated to appropriative conflict is independent of the value of the appropriable endowment. In these models, the allocation of time and effort to appropriative conflict is positively related to the value of the appropriable endowment.

[9] A more complete analysis would allow for differences among individuals in their initial claims. The present analysis shows that interpersonal differences are not essential for rationalizing appropriative conflict.

[10] Generalizing the analysis to allow for many agents is not trivial, because the appropriate specification depends on the nature of the matching process involved in agents' challenging the initial claims of other agents. One possibility would have every agent challenging the initial claim of every other agent and defending its initial claim from a challenge by every other agent. A more ambitious possibility would be to introduce a fixed cost of challenging the initial claim of another agent. In this setup, each agent would have to choose which subset of initial claims to challenge.

In this model, p_i measures the security of the agent i's initial claim. If p_i equals 1, then this initial claim is perfectly secure. If p_i is smaller than 1, then this initial claim is less than perfectly secure.

Using this notation, agent i creates an effective property right to e_i units of resources, where

$$(5) \qquad e_i = p_i E + (1 - p_j)E \qquad j \neq i.$$

Equation (5) says that e_i equals the amount of its own initial claim that agent i successfully defends plus the amount of the initial claim of agent j that agent i successfully challenges.[11]

To determine the security of initial claims, assume that

$$(6) \qquad p_i = \begin{cases} \dfrac{1}{1 + \theta g_j / h_i} & \text{for } g_j > 0 \quad 0 < \theta < 1 \\ 1 & \text{for } g_j = 0 \end{cases}$$

where g_j denotes the fraction of its time and effort that agent j, $j \neq i$, allocates to challenging the initial claim of agent i, and h_i denotes the fraction of its time and effort that agent i allocates to defending its own initial claim. Equation (6) says that, if g_j is positive, then p_i is smaller the larger is g_j relative to h_i.

The parameter θ in equation (6) measures the effectiveness of time and effort allocated to challenging initial claims relative to time and effort allocated to defending initial claims. This parameter reflects the technology for the challenging and defending of initial claims. It also can reflect social institutions, such as formal property rights entailed in legal ownership or an informal norm of respect for initial claims, that facilitate either the challenging and or the defending of initial claims. The restriction that θ is smaller than 1 insures that agent i could not increase the equilibrium value of e_i by giving its initial claim to agent j and then challenging that claim.

Like equation (1), which described the creation of property rights from a common pool of resources, equation (6) is a black box. It does not specify the processes by which claims are challenged and defended. For example, the outcome modeled by equation (6) could involve either a division under the threat of force or a violent struggle.

Assume again that agent i's consumption, c_i, depends on e_i and on the amount of time and effort that agent i allocates to production, ℓ_i, according to the Cobb-Douglas technology specified in equation (2). Agent i chooses h_i, g_i, and ℓ_i to maximize its consumption subject to $h_i + g_i + \ell_i = 1$. Assume that in making these choices agent i takes agent j's choices of g_j and h_j as given. Thus, the first-order conditions for the solution to agent i's choice problem are

$$(7) \qquad \frac{\partial c_i}{\partial h_i} = \frac{\partial c_i}{\partial e_i}\frac{\partial e_i}{\partial h_i} - \frac{\partial c_i}{\partial \ell_i} = 0$$

and

$$(8) \qquad \frac{\partial c_i}{\partial g_i} = \frac{\partial c_i}{\partial e_i}\frac{\partial e_i}{\partial g_i} - \frac{\partial c_i}{\partial \ell_i} = 0.$$

Equation (7) says that agent i chooses h_i such that the marginal benefit of h_i in increasing the amount of its own initial claim that it successfully defends equals the marginal cost of h_i in decreasing the amount of time and effort that it allocates to production. Equation (8) says that agent i chooses g_i such that the marginal benefit of g_i in increasing the amount of the initial claim of agent j that agent i successfully challenges equals the marginal cost of g_i in decreasing the amount of time and effort that it allocates to production.

Equations (7) and (8) imply a unique symmetrical equilibrium in which h_i equals h_j, and in which g_i equals g_j. Using these equalities and equations (2), (5), and (6) to solve equations (7) and (8), one obtains the following for the equilibrium allocation of time of effort:

$$(9) \qquad h_i = g_j = \left(\frac{\alpha}{1 - \alpha}\right)\left(\frac{\theta}{(1 + \theta)^2}\right) \ell_i \qquad \text{for all } i \text{ and } j.$$

[11] In Grossman and Kim (1995), it is shown how the analysis could easily incorporate possible destruction of resources as the result of the challenging and defending of claims.

Equation (9) implies that the equilibrium values of h_i and g_j are equal and, over the range $0 < \theta < 1$, are larger the larger is θ. Equation (9) also implies that the amount of time and effort that each agent allocates to defending and challenging initial claims is larger the larger is α, the relative importance of resources for producing consumables, but that the allocation of time and effort does not depend on E, the amount of resources to which each agent has an initial claim. These results about α and E are analogous to results obtained in the preceding analysis of appropriation from a common pool.

Because g_j is positive, equation (6) indicates that p_i, the fraction of its initial claim that agent i successfully defends, is smaller than 1. In this model, initial claims to resources are less than perfectly secure. Also, because h_i equals g_j, p_i equals $1/(1 + \theta)$. In equilibrium the security of initial claims depends only on θ, the effectiveness of time and effort allocated to challenging initial claims relative to time and effort allocated to defending initial claims.

III. Perfectly Secure Initial Claims

Casual observation suggests that, in many, if not most, cases, agents in fact do not challenge the initial claims of other agents, and as a result, initial claims to resources are perfectly secure. Examples range from personal possessions most of the time to most international borders most of the time. There are several ways to modify the model to allow the possibility of an equilibrium in which initial claims to resources are perfectly secure.

(i) *A Fixed Cost of Challenging Initial Claims.*—Formally, one can introduce such a fixed cost, denoted by κ, $\kappa > 0$, by assuming, in place of equation (2), that $c_j = e_j^{\alpha}\ell_j^{1-\alpha} - \kappa$ for $g_j > 0$, with $c_j = e_j^{\alpha}$ for $g_j = 0$. If κ were sufficiently large relative to E, then, even if agent i were to set h_i equal to zero, agent j would set g_j equal to zero. This analysis shows that a large enough fixed cost of challenging initial claims would make initial claims perfectly secure. However, it seems unlikely that large fixed costs are sufficiently pervasive to account for all cases of perfectly secure initial claims.

(ii) *Social Institutions.*—Suppose that social institutions, such as either formal property rights entailed in enforceable legal ownership or an informal norm of respect for initial claims, in addition to influencing the parameter θ, also directly augment the time and effort that agents allocate to defending their initial claims. Formally, one can replace h_i in equation (6) with $h_i + \rho$, $\rho > 0$, where ρ measures this additive effect of social institutions. The analysis in Konrad and Skaperdas (1998) shows that, if ρ is sufficiently large relative to E, even if agent i were to set h_i equal to zero, agent j would set g_j equal to zero. This analysis suggests that either legal ownership or an informal social norm can account for some examples in which initial claims are perfectly secure. However, examples in which initial claims are perfectly secure do not seem to be limited to cases in which such social institutions exist.

(iii) *Repeated Interactions.*—The preceding analysis ignored the possibility that agents interact repeatedly. If agents interact repeatedly, and if, among other things, agents are sufficiently foresighted, then each agent might be able to make a credible commitment not to challenge the initial claim of the other agent (see Abhinay Muthoo [2000] for a recent example of such a model).[12] However, credible commitments do not seem to be the entire story, because initial claims apparently are perfectly secure even in some cases in which agents do not interact repeatedly.

(iv) *Deterrence.*—In the preceding analysis, agent i took agent j's choice of g_j as given. An alternative is to assume that agent i chooses h_i before agent j chooses g_j and that agent i's choice of h_i is irreversible. Given these assumptions, agent i would take into account the effect of h_i on agent j's choice of g_j. Specifically, if the parameter θ were sufficiently small, then each agent would allocate enough time and effort to defending its initial claim to deter other agents from challenging its initial

[12] This approach to modeling secure initial claims is related to the literature noted above on amicable sharing of resources in a common pool.

claim. For an example of such a model, see Grossman and Kim (1995).

This model of deterrence suggests an explanation for the fact that one commonly observes not only individuals, but also groups, such as tribes and nations, who allocate resources to defending their own claims to property but do not challenge the claims of others. For example, in our society, although everyone allocates some resources to protecting property from theft, relatively few people engage in activities like robbery and burglary. This analysis also suggests that differences in θ, which can reflect differences in the technology for challenging and defending initial claims as well as differences in social institutions, account for why initial claims are perfectly secure in some cases but not in others.

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