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INSTITUTIONS AND INDIRECTNESS IN
INTELLECTUAL PROPERTY

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INTRODUCTION

Institutions are important to intellectual property. Information is a major subject of exchange, and the special challenges of contracting

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over information have long been at the heart of economic theories of contracting. Exchanges involving information are difficult because a buyer will be reluctant to make a purchase without knowing what he is buying, but once the seller reveals the information, the buyer will no longer need to pay for it.[1] Contractors can also face challenges from asymmetric information, and some of the limits on people's ability to contract stem from the problems of incomplete information.

Where does this leave property? Although intellectual property is technically a form of personal property and some of its mechanisms are shared with regular property, commentators have found the notion of intellectual property problematic in a way that regular property is not. Because information itself is nonrival, in that one person's use of it does not diminish the value of another's use of the same information, excluding others from information when they could use it at zero marginal cost seems wasteful. And while intellectual property is one device among many that could provide incentives to people to create information, the nonrival nature of information is a count against intellectual property in comparison with rewards, kudos, lead times, and other alternatives to appropriating the returns from inventive and other creative activity. Should intellectual property be property at all?

One might expect the New Institutional Economics (NIE) to be helpful in addressing this question. In this Article, I will argue that the NIE is very helpful, but in a less straightforward way than one might think. The NIE shows promise because it is concerned with information and institutions, including "property rights" and the problems of contracting. But the concern in using the NIE to explain intellectual property lies in its generally thin notion of property. In the NIE, property rights are a subset of institutions, which comprise all the "rules of the game of a society," including both formal law and informal norms, all of which are "humanly devised constraints that shape human interaction."[2] But currently a very broad range of institutions would count as "property rights" in the NIE. The standard

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[1] *See* Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention, in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 615 (Nat'l Bureau of Econ. Research 1962) (setting out what has come to be known as Arrow's paradox of information).

[2] Douglass C. North, *The New Institutional Economics and Third World Development, in* THE NEW INSTITUTIONAL ECONOMICS AND THIRD WORLD DEVELOPMENT 17, 23 (John Harriss et al. eds., 1995). *See generally* DOUGLASS C. NORTH, INSTITUTIONS, INSTITUTIONAL CHANGE, AND ECONOMIC PERFORMANCE (1990).

definition of property in the NIE is a right to engage in a set of actions with respect to a valuable resource, or the expectation of deriving utility from the use, exchange, or transformation of an asset.[3] This is fine as far as it goes, but it leaves several issues unaddressed. In particular, the NIE commonly adopts an extreme version of the bundle-of-rights theory of property, under which property is a collection of "rights, privileges, duties, and so forth,"[4] with no particular defining characteristics.[5] The list of uses over which the owner has authority corresponds to this collection of sticks from the bundle-of-rights picture inherited from the legal realists. In the case of land, such sticks would include the right to build, the right to plant, the right to prevent development, and so on. Using this assumption of a list of uses, the NIE does not have much of an explanation for why property rights are, at their core, rights to things good against the world (in rem). This problem is especially acute in intellectual property. A system of rewards would be a "property rights system" in the NIE, but it would be one very different from patent, copyright, trademark, and the other intellectual property regimes with which we are familiar.

   Because the NIE incorporates information costs and bounded rationality, it has the tools to provide a rationale for intellectual property *as* property. In particular, because assets are collections of valued attributes that are hard to measure,[6] actors face the economic question of how to group them—how to aggregate them, or more accurately, how to carve them up—for purposes of delineating property rights. In theory, one could build property up out of the smallest sticks, in an additive fashion. Thus, fee simple ownership of Blackacre would be delineated as the sum of the right to exclude, the right or privilege to farm (in many different ways), the right to park cars, the

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   [3] Armen Alchian provides a particularly famous and oft-cited definition. *See* Armen A. Alchian, *Some Economics of Property Rights*, 30 IL POLITICO 816 (1965), *reprinted in* ARMEN A. ALCHIAN, ECONOMIC FORCES AT WORK 127, 130 (1977) ("By a system of property rights I mean a method of assigning to particular individuals the 'authority' to select, for specific goods, any use from a nonprohibited class of uses.").
   [4] Thomas W. Merrill & Henry E. Smith, *What Happened to Property in Law and Economics?*, 111 YALE L.J. 357, 364 (2001).
   [5] *See* J.E. Penner, *The "Bundle of Rights" Picture of Property*, 43 UCLA L. REV. 711, 723-24 (1996) (noting that traditional conceptions of property embrace a bundle-of-rights model where property is "without any necessary defining features").
   [6] *See* Yoram Barzel, *Measurement Cost and the Organization of Markets*, 25 J.L. & ECON. 27, 48 (1982) (arguing that the "problems and costs" of measuring the value of assets "significantly affect all economic transactions").

right to prevent development (nature preservation of various kinds), and so on.

There are two problems with this bottom-up, stick-by-stick, legal-realist approach to delineation, and both problems relate to how directly rights should make reference to valued attributes of assets and the uses that people make of them. First, the bottom-up delineation of asset uses is a highly duplicative and needlessly cumbersome way to describe the set. If the law gives a right to exclude (as it does prominently through the doctrine of trespass), supplemented and modified with respect to a limited set of uses (i.e., in the law of nuisance, the doctrine of necessity, etc.), one can get an extensionally very similar set of legal relations at a much lower cost. Consider situations of necessity such as the hiker stranded on a snowy mountainside who needs the food in an unoccupied cabin or those on a ship who need another's dock in a storm. The bottom-up method would treat the "breaking in and eating the food" stick or the "docking during the storm" stick as no different from any other stick except in its assignment to another party—the one facing the necessity. In actuality, the law gives the owner a presumptive right to exclude and then modifies this by removing protection against one facing certain emergency situations. In other words, the law starts out with a cheap and crude exclusion regime and in high-stakes situations moves over to a governance regime that focuses on particular uses.[7] Where contracting is not cost-effective, the governance regime is supplied off the rack. This method of presumptive exclusion with refinement through governance economizes greatly on delineation and processing costs for dutyholders and courts.[8] Many problems are taken care of with one stroke through the exclusion strategy, and the delineation effort is concentrated where it is most needed. Overall, the set of sticks in the bundle is numerous and factoring out some of their common elements is economizing.

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[7] *See* Henry E. Smith, *Exclusion and Property Rules in the Law of Nuisance*, 90 VA. L. REV. 965, 975-76 (2004) [hereinafter Smith, *Exclusion and Property Rules*] (noting that while much of property law is based upon a "rough but basic" exclusionary philosophy, "further refinement and precision are sometimes achieved through a supplementary governance regime"); Henry E. Smith, *Property and Property Rules*, 79 N.Y.U. L. REV. 1719, 1754 (2004) [hereinafter Smith, *Property and Property Rules*] (arguing that while property law involves a "basic exclusionary system," "refinement in high-stakes borderline cases will be necessary").

[8] *See* Henry E. Smith, *Exclusion Versus Governance: Two Strategies for Delineating Property Rights*, 31 J. LEGAL STUD. S453, S457-78 (2002) (presenting models that suggest that a broad exclusionary philosophy in property law reduces transaction costs).

This Article emphasizes methods of economizing on delineating property rights that sound in indirectness between the interests served and the mechanism by which the interests are secured. Our interest in resources relates to potential and actual uses (i.e., farming, parking, etc.). The exclusion strategy protects these interests in use indirectly, without having to delineate them individually most of the time. The right to exclude can also be regarded as the right to determine use, but when it comes to delineation, the exclusion strategy often economizes on cost through its lack of reference to specific uses at all. By invoking the law of trespass, the farmer can prevent damage to crops and enjoy the use of the land for farming without the law having to make reference to use. Indeed, trespass law, unlike nuisance, does not require allegations of actual harm[9] and, in the absence of proof of harm, will afford nominal damages.[10] And although injunctions for trespass to land are nominally an exceptional remedy, in practice they are quite routine.[11] Trespass law prohibits entry into the column of space defined by the ad coelum rule,[12] which sends a simple message of "keep off" to outsiders and requires very little contextual information for courts.[13] Further, much of the detail that trespass avoids is not relevant to outsiders and is not useful much of the time. So there is no sense in delineating various uses separately, and doing so would just lead to information overload for outsiders like dutyholders and

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[9] *See* RESTATEMENT (SECOND) OF TORTS § 163 cmt. d (1965) ("[E]ven a harmless entry or remaining, if intentional, is a trespass.").

[10] In fact, an actor may show "such a complete disregard of the possessor's legally protected interest" in her land as to "justify the imposition of punitive in addition to nominal damages for even a harmless trespass." *Id.* § 163 cmt. e.

[11] *See, e.g.*, Shyamkrishna Balganesh, *Demystifying the* Right *to Exclude: Of Property, Inviolability, and Automatic Injunctions*, 31 HARV. J.L. & PUB. POL'Y 593, 644-46 (2008) (describing how courts now grant injunctions for trespass to land as a matter of course except when "exceptional situations" merit otherwise).

[12] *See* Smith, *Exclusion and Property Rules, supra* note 7, at 992 & n.80 ("The full statement of the maxim is *cujus est solum, ejus est usque ad coelum et ad inferos* (he who owns the soil owns also to the sky and to the depths). The maxim is routinely followed in resolving issues about ownership of air rights, building encroachments, overhanging tree limbs, mineral rights, and so forth, and is subject to certain limited exceptions for activities like airplane overflights."); *see also* Brown v. United States, 73 F.3d 1100, 1103 (Fed. Cir. 1996) ("At common law, the owner of real property was considered to own from the center of the earth to the top of the sky." (internal citations omitted)).

[13] *See* Thomas W. Merrill, *Trespass, Nuisance, and the Costs of Determining Property Rights*, 14 J. LEGAL STUD. 13, 16 (1985) (noting that the ad coelum rule involves "[n]o weighing or balancing of costs and benefits," but rather is "exceptionally simple and exceptionally rigorous" (internal citations omitted)).

courts. Delineating rights to aggregates of sticks instead of stick by stick is more indirect, and it conserves delineation and processing costs.

There is another sense in which the indirectness of property law avoids problems of delineation in terms of the valued uses of resources. One issue that receives scant attention by bundle-of-rights theorists is that their bottom-up strategy presents no principled way by which to specify the sticks. How fine-grained should the sticks be? Is it the right to farm, or the right to plant crops plus reaping, or planting different crops, and on and on? Furthermore, once delineated, these sticks can be combined and recombined for many different purposes, not all of which are known to every actor—or even, at any given moment, known to any actor. As yet undiscovered attributes and uses lead to all sorts of timing decisions regarding when to discover attributes and when to put them to which uses. Thus, the owner as decision maker holds a complex set of options. Moreover, the uses of an asset are not just risky (e.g., with a variance in outcomes forming a probability distribution), but *uncertain*, in the Knightian sense.[14] That is, the set of uses of an asset may not correspond to a known probability distribution, and nonowners may not even know the members of the set. Property law helps manage this uncertainty by not making knowledge of the uses or even the probability distributions of their values relevant to dutyholders. In previous work, I have argued that Knightian uncertainty is more conducive to property rules than to liability rules, which do require more knowledge of probabilistic information by officials or courts.[15]

Crucially, much of the time property forces nonowners *not* to know, and in this sense property involves information hiding, a key aspect of modularity.[16] A modular system is one in which interactions are intense within components of the system (modules) but are con-

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[14] *See* FRANK H. KNIGHT, RISK, UNCERTAINTY AND PROFIT 19-20, 197-232 (1921) (distinguishing "risk" from "uncertainty" by noting that "uncertainty" is immeasurable in principle).

[15] *See* Smith, *Property and Property Rules, supra* note 7, at 1724-27 ("Property itself is a response to uncertainty, and property rules derive some advantage as a response to uncertainty.").

[16] Information hiding and modularity are important in computer programming, especially object-oriented programming, which has been an inspiration for application of modularity to economics. *See, e.g.*, GRADY BOOCH, OBJECT-ORIENTED ANALYSIS AND DESIGN WITH APPLICATIONS 27 (2d ed. 1994) (noting that object-oriented technology encompasses principles of encapsulation and modularity); EDWARD YOURDON, OBJECT-ORIENTED SYSTEMS DESIGN: AN INTEGRATED APPROACH 6 (1994) (describing "encapsulation," the ability to modularize components of a system, as one of the "fundamental characteristics of an object-oriented approach to developing systems").

strained between modules.[17] This architecture allows activity in one module to occur without the need to worry about unanticipated ripple effects. In a nonmodular system beyond a minimal level of complexity, it becomes difficult to track or even predict the ramifications of very local actions. Whether a system can be modularized depends in part on the pattern of interactions between elements, and in particular whether a system is "nearly decomposable" in Herbert Simon's sense: parts of the system must have minimal interactions with the rest of the system and as a result may be considered modules in which internal interaction is intense (and unconstrained), but in which external interaction is limited.[18]

When property rights are treated like black boxes in the exclusion strategy, the system as a whole benefits from its modular structure. Information about many attributes and uses of assets does not flow across property boundaries. The set of resource attributes and asset uses is a nearly decomposable system. First of all, dividing the world into assets reflects near decomposability. For small events, what one does with one parcel or asset is unlikely to impact the attributes or uses of another asset or parcel.[19] Thus the decoupling or asset partitioning, effected by the basic right to exclude and its associated liberties, handles this set of (non)interactions. Even for interactions that

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[17] *See* Richard N. Langlois, *Modularity in Technology and Organization*, 49 J. ECON. BEHAV. & ORG. 19, 19 (2002) (describing a modular system as one in which modules "communicate with one another only through standardized interfaces within a standardized architecture" toward the end of managing complexity).

[18] HERBERT A. SIMON, THE SCIENCES OF THE ARTIFICIAL 195-98 (2d ed. 1981) (describing a nearly decomposable system as one "in which the interactions among the subsystems are weak but not negligible"); *see also* 1 CARLISS Y. BALDWIN & KIM B. CLARK, DESIGN RULES: THE POWER OF MODULARITY 65 (2000) (quoting Herbert Simon's story about two watchmakers that illustrated an early theory of modularity); MANAGING IN THE MODULAR AGE: ARCHITECTURES, NETWORKS AND ORGANIZATIONS (Raghu Garud et al. eds., 2003). Simon's theory has been expanded upon in a number of different contexts. *See, e.g.*, Langlois, *supra* note 17, at 24-26 (attempting to "find the modularization that minimizes interdependencies and most cleanly decomposes the system"); Ron Sanchez & Joseph T. Mahoney, *Modularity, Flexibility, and Knowledge Management in Product and Organization Design*, 17 STRATEGIC MGMT. J. (SPECIAL ISSUE) 63, 64-65 (1996) (expanding on Simon's notion of a nearly decomposable system by proposing that product and organizational designs "follow the fundamental principles of decomposition"); Erich Schanze, *Legalism, Economism, and Professional Attitudes Toward Institutional Design*, 149 J. INSTITUTIONAL & THEOR. ECON. 122, 130-36 (1993) (discussing institutional modules with regard to professional organizations while noting the significance of "structural patterns" of interaction).

[19] *See* Robert C. Ellickson, *Property in Land*, 102 YALE L.J. 1315, 1327-30 (1993) (noting that when minor uses of land "have no spillover effects," private ownership "directly and precisely punishes land misuse and rewards productive labor").

might in principle impact each other, the property system sometimes suppresses their effects. For example, in tort law, landowners are not required to anticipate the negligence of another actor.[20] So if a railroad negligently sends sparks onto a farmer's land, the farmer need not place hay with a view to the likely negligence of the railroad. The farmer's rights are a black box and the message to the railroad is simple: full liability. The modularity of property rights allows them to be indefinite with respect to the set of valued uses. Modular property is characterized by a second-order indirectness in delineation of rights.

Both kinds of indirectness—the employment of proxies that stand in for numerous uses and the hiding of uncertain groups of attributes and uses behind boundaries—allow property to maximize the value of embedded options. Option theory has been used to explain the structure of entitlements. I will pursue this idea within the NIE in order to show how modular delineation with its associated indirectness maximizes the value of options. All the uses to which attributes can be put in various combinations present real options, and the indirectness of property allows the exercise of those options without the high coordination costs that would be present if every decision could, in principle, impact every other decision with respect to other users and attributes.

Finally, it is this modular indirectness that is property's main contribution to intellectual property. In this Article I will argue that these two forms of indirectness—first-order indirectness relating to attributes and second-order indirectness relating to uncertain and open-ended sets of attributes—are crucial for understanding the contribution that property makes to intellectual property. Because these forms of indirectness follow from transaction-cost theory in the NIE, the NIE has the potential to explain why intellectual property might be usefully treated as property in the first place. This is not to say that these tools can, without more, justify the system that we have. Instead, the NIE provides a perspective that needs to be taken into account in further empirical and policy-oriented work on intellectual property.

I. PROPERTY AND INFORMATION COSTS

The notion of property is central to the NIE. Previous definitions of property in the NIE have tended to be hyperrealist in their embrace of the bundle-of-rights picture of property. But adding information costs (a central element of the NIE) allows us to define property

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[20] *See infra* note 49 and accompanying text.

so as to capture its aggregate aspects—its "lumpiness." Both the default bundle of rights and the set of real options to which it corresponds are lumpy for reasons related to information costs. Property relies heavily on exclusion and a modular structure to delineate options at a low cost and to preserve options for reconfiguring real options—i.e., options on options. Delineation of legal relations has to steer between insufficient precision, which fails to promote appropriation, and excessive precision, which stifles flexibility. Interestingly, this information-cost theory of property brings the NIE version of property much closer to the legal definition of property than previously thought.

A. *Property and Property Rights in the New Institutional Economics*

Property rights are central to the NIE, and sometimes the NIE styles itself "property rights economics."[21] Nevertheless, the NIE has traditionally operated using a very broad conception of property that does not correspond with the legal definition of property. There is, of course, nothing inherently wrong with this discrepancy, but it is useful to consider these broad definitions of property in order to highlight the special elements of property that they tend to obscure—elements that turn out to be important in explaining the nature of intellectual property.

Like much of economics, the NIE is concerned with incentives, and, again like economics, the NIE employs the rational-actor paradigm or one of its behavioral variants.[22] Common to these approaches is an underlying premise that actors' behavior responds to their expectations, whether the expectations or the response are perfectly or imperfectly rational. This is where property rights enter the picture. In the broadest version of property in the NIE, property rights are identified with actors' expectations of deriving value from resources. The only difference between property rights and general expectations is that the expectation in property should relate to some resource, but

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[21] *See, e.g.*, YORAM BARZEL, ECONOMIC ANALYSIS OF PROPERTY RIGHTS 3-4, 10-15 (2d ed. 1997) (describing the "property rights approach"); OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS 1 (1975) (classifying property rights economics as one of the fields having "a bearing on" the "renaissance" of new institutional economics).

[22] *See generally* THRÁINN EGGERTSSON, ECONOMIC BEHAVIOR AND INSTITUTIONS 33 (1990); L.J. Alston, *New Institutional Economics*, *in* 6 THE NEW PALGRAVE DICTIONARY OF ECONOMICS 32-37 (Steven N. Durlauf & Lawrence E. Blume eds., 2d ed. 2008) (providing an overview of the NIE framework).

a resource is simply anything of value. Thus, ownership of Blackacre is interesting insofar as it forms the basis for its owner (and perhaps others) to extract value from the land. But this expectations-based notion of property can be quite broad: one's expectation of deriving value could stem from law or norms or, in the extreme, from physical facts about the world. Thus, in the words of John Umbeck, someone may acquire property rights in coconuts "because he is the only one who can climb a tree."[23]

Perhaps the most common definition of property in the NIE holds that property is a set of expectations to be able to take a permitted set of actions with respect to a resource, backed by some normative force. These actions are significant because they allow the holders to derive value from resources. The right to cultivate and reap, for example, gives the rights holder an expectation of value. If the rights holder also has the right to transfer those rights, she can derive value indirectly from another's planned use of the resource.

Closely related to property in the NIE, and a step closer to our ultimate concerns, is the notion of a residual claim. Thus, in NIE fashion, Yoram Barzel "define[s] the economic property rights an individual has over a commodity (or an asset) to be *the individual's ability, in expected terms, to consume the good (or the services of the asset)* directly or to consume it indirectly through exchange."[24] Barzel notes the congruence of this definition with a long line of NIE definitions of property in terms of the authority to select one of a set of uses.[25] Barzel then observes that "[t]he notion of rights is closely related to that of residual claimancy,"[26] and much of his theory is an explanation of the institutions that give rise to residual claims over collections of valued attributes. If an asset is a collection of valued attributes, as Barzel assumes,[27] one can explain much of contracting behavior over assets as an effort to allocate residual claims in proportion to the actor's abil-

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[23] John Umbeck, *Might Makes Rights: A Theory of the Formation and Initial Distribution of Property Rights*, 19 ECON. INQUIRY 38, 39 (1981). Nonetheless, most in the NIE would see some humanly created constraint as a necessary condition for an institution and particularly for property rights.

[24] BARZEL, *supra* note 21, at 3.

[25] *Id.* at 3 n.2; *see also* Alchian, *supra* note 3, at 130 (defining a "system of property rights" as "a method of assigning to particular individuals the 'authority' to select, for specific goods, any use from a nonprohibited class of uses").

[26] BARZEL, *supra* note 21, at 3.

[27] *See* Barzel, *supra* note 6, at 27 (asserting that, because "[p]eople will exchange only if they perceive what they get to be more valuable than what they give[,] . . . the attributes of the tracked items have to be measured").

ity to affect the mean return from that collection of attributes. Thus, the owner of Blackacre is in the position to affect its mean return and has a residual claim on the land—but more subtle residual claims are possible. Where a building owner contracts for fire insurance, for instance, the insurance company may require the installation of certain equipment in addition to setting and collecting premiums. According to Barzel, the insurance company has a residual claim on attributes relating to fires.[28] Similarly, in a lease, the tenant and the landlord each have residual claims over different attributes, depending on the nature of the lease in question.[29] For Barzel, as for many in the NIE, contracting behavior is central to the theory of property rights.

Definitions of property in the NIE tend to be very contractarian or tort based, in that they focus on the individual uses or attributes that remain after contracting ends.[30] This stick-by-stick approach is a legacy of legal realism and has largely characterized transaction-cost economics since Coase, who adopted a hyperrealist version of the bundle-of-rights picture of property.[31] For Coase, property was the tort-like resolution for deciding who had control over a list of activities; apart from the need for stability, it was not at all important or desirable to speak in terms of ownership.

This realist picture overlooks an important aspect of property: its in rem nature. Property rights bind people generally. If I own Blackacre, all others have a duty to keep off. This is not the be-all and end-all of property, but it is important, especially where property forms the basis of expectation between anonymous parties.[32] Also, the in rem aspect is related to property's heavy reliance on rights to exclude from defined things. A right to a defined thing is easy to communicate to a wide and diverse audience of dutyholders and officials, some of whom will have no personal dealings with the owner. If I pass parked cars in a parking lot, for example, I know not to take them; it does not matter

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[28] BARZEL, *supra* note 21, at 60.

[29] *See id.* at 33-54 (detailing the kinds and benefits of tenancy conyracts).

[30] *See* Merrill & Smith, *supra* note 4, at 376-77 (characterizing Barzel's definition of property as fundamentally premised on notions of contract).

[31] *See id.* at 366 (noting that Coase's definition took "the realists one step further, implicitly conceiving of property as a list of particularized use rights that individuals have in resources").

[32] *See* Henry E. Smith, *The Language of Property: Form, Context, and Audience*, 55 STAN. L. REV. 1105, 1151-53 (2003) (analyzing the costs of communicating information about legal rights to audiences of various sizes); *see also* Smith, *supra* note 8, at S468-69 (discussing the need for proxies to measure the costs of accessing and using property).

if they are owned by a person or a corporation, what the owner's features are, what possible leases or bailments may exist, and so on.[33]

But what is a thing? It can be regarded as the asset implicitly defined in the exclusion strategy: the parcel of land, the car, the invention.[34] Some things come predefined by our everyday experience and others do not. The inventions of patent law require a great deal of delineation effort in the way that a chair or even a parcel of land does not.[35]

Things in property are closely identified with its modular structure: modules track the things defined by the exclusion strategy. In deciding what should count as a thing, Simon's concept of near-decomposability is helpful.[36] For Simon, a nearly decomposable system is one in which interactions between proper subsets of the system are internally multiplex and intense but sparse between such subsets. One can draw boundaries around such subsets and allow only certain defined types of interactions, because the number and intensity of the interactions is low from the start. These components of the overall system are modules.

Property accomplishes something similar. The exclusion regime defines a thing and its boundary, with trespass, nuisance, and other doctrines adjusting the rights and duties of owners forming the interface among property modules. Like the NIE, we take assets to be aggregates of valued attributes, but the primary focus here is on how this aggregation is accomplished. Which attributes should go with which? All else being equal, complementary attributes should be grouped together.[37] Otherwise the interface among property rights will have to control many spillovers or be subject to intense contracting. Relatedly, an asset boundary should correspond to the optimal scale of use.[38] Otherwise, spillovers and contracting are again needlessly

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[33] *See, e.g.*, J.E. PENNER, THE IDEA OF PROPERTY IN LAW 75-76 (1997).

[34] *See* Smith, *Property and Property Rules*, *supra* note 7, at 1767 (noting that the exclusion strategy "sweeps a broad class of uses into the definition of the entitlement"); Henry E. Smith, *Self-Help and the Nature of Property*, 1 J.L. ECON. & POL'Y 69, 106 (2005) [hereinafter Smith, *Self-Help*] (arguing that an exclusion strategy leads to a broad definition of property).

[35] *See* Henry E. Smith, *Intellectual Property as Property: Delineating Entitlements in Information*, 116 YALE L.J. 1742, 1795-97 (2007) (describing how patent law involves high delineation costs).

[36] SIMON, *supra* note 18, at 193-229.

[37] *See* Smith, *supra* note 8, at S471 ("[W]e would expect a tendency to see the world carved up into assets that embrace complementary sets of attributes . . . .").

[38] *See, e.g.*, Lee Anne Fennell, *Commons, Anticommons, Semicommons* 6-10, *in* RESEARCH HANDBOOK IN THE ECONOMICS OF PROPERTY LAW (Kenneth Ayotte & Henry E. Smith eds., forthcoming 2009) (proposing placing more elements under common

prominent. The boundaries should occur where interaction is correspondingly sparse and weak.

Mixing exclusion with governance manages the complexity of actors' interactions through property's modularity. A complex system is one in which internal interactions are many and multiplex such that it is difficult to infer the properties of the whole from the properties of the parts.[39] A nearly decomposable system consists of a pattern of interactions where module boundaries can be drawn so that interactions are intense within the module but sparse and constrained among modules. This allows for information hiding: decisions in one module can be made largely without considering what is happening in other modules; the only constraint is satisfaction of the interface conditions. Modularity has been a key concept in many areas ranging from evolutionary biology to cognitive science, software, and organization theory. To take one example, teams writing software tend to be modular, often reflecting the structure of programs. In a nonmodular structure, any part could potentially impact every other, requiring superhuman efforts at acquiring and tracking information.

The traditional view of markets has a strongly modular flavor, and one role of modular property is to support markets. On Adam Smith's account, each actor need only consult that actor's own self-interest against the background of the market and will be guided as if "by an invisible hand" toward actions that contribute to efficiency.[40] The informational responsibility of each actor is limited and local. Likewise, Hayek's theory of markets as devices for processing informa-

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ownership and utilization as two means of dealing with the pattern of scale); Dean Lueck, *The Economic Nature of Wildlife Law*, 18 J. LEGAL STUD. 291, 300-03 (1989) (applying theories of asset boundaries to wildlife ownership).

[39] SIMON, *supra* note 17, at 195.

[40] 1 ADAM SMITH, AN INQUIRY INTO THE NATURE AND CAUSES OF THE WEALTH OF NATIONS 477 (E. Cannan ed. 1976).

> As every individual, therefore, endeavors as much as he can both to employ his capital in the support of domestic industry, and so to direct that industry that its produce may be of the greatest value; every individual necessarily labours to render the annual revenue of the society as great as he can. He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention.

Id.

tion employs what we would call modularity.[41] Each market actor possesses local knowledge about her use of resources but needs only consult prices in order to make economizing decisions about the acquisition and use of those resources. The information that each actor uses can impact prices, but no other actor need know it. As the interface conditions among participants in the market, prices allow other information to be hidden. By contrast, the central planner is nonmodular and is expected to gather and act on all this information, without any interaction between two pieces of information being ruled out in principle. The NIE points to the importance of many institutions for market exchange. In this Article, I suggest that modularity is characteristic of one of these supporting institutions: the law of property.

However, the kinds of interactions facilitated by modular property extend beyond the market. Again, the warnings to potential thieves against trespass and theft partake of modularity. Property law manages much complexity through modularity. The exclusion strategy, with its presumptive right to exclude, is the starting point in property, and the effect of this strategy is to economize on information costs. In effect, the exclusion strategy allows the system of resource usage to manage complexity with modularity, with much information hidden in property modules. In trespass to land, the unauthorized crossing of a boundary serves as a (very) rough proxy for harmful use; any voluntary entry into the column of space defined by the ad coelum rule counts as a trespass.[42] "Keep out" is a simple message that is part of a first-cut delineation of rights. Thus, from the dutyholder's perspective, property is like a black box—a module—in that much information about uses and users is simply irrelevant to the dutyholder's duty of abstention. Only in specific contexts does the law inquire into uses more directly, such as when one landowner produces odors that annoy a neighbor; these governance rules of nuisance law can be thought of as the interface between adjacent bundles of rights.[43] Nonetheless it is the exclusion factor that keeps the bundles lumpy and opaque, operating as modules in which interactions and interde-

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[41] *See* F.A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519, 526 (1945) (describing a system in which relevant facts are dispersed and processed by individual actors).

[42] *See supra* note 13 and accompanying text.

[43] *See* Wesley Newcomb Hohfeld, *Some Fundamental Legal Conceptions as Applied in Judicial Reasoning*, 23 YALE L.J. 16, 30-36 (1913), *reprinted in* FUNDAMENTAL LEGAL CONCEPTIONS AS APPLIED IN JUDICIAL REASONING AND OTHER LEGAL ESSAYS 23, 36-42 (Walter Wheeler Cook ed., 1923) (describing the interrelation of rights, privileges, duties, and other "jural opposites" and "correlatives").

pendencies are intense inside but sparse across the interface connect-ing the modules. Actions within a module do not have hard-to-predict ripple effects through the entire system. On the information-cost theory, the combination of exclusion and governance in property fur-nishes modules and interfaces for actors who take potentially conflict-ing actions with respect to resources.

This modular structure can be easy to overlook. If a given asset is considered a separate thing, a security interest makes reference to that cluster of attributes and not to another. For example, if *A* has a security interest securing a loan to *B*, the treatment of *A* and the fluc-tuations in value are what matter to *A*; *A* can concentrate on *A*'s asset without needing to know as much about other assets that *B* may own or *B*'s relations with other creditors. Likewise, the owner of a related but separate asset need not worry about the security interest.[44] This asset-partitioning function of property forms the basis of Hansmann and Kraakman's property-related theory of corporate law,[45] in which actors can safely ignore information in a way that is not possible in the absence of asset partitioning. Thus, if an airline and a storm-door company are within one firm, those dealing with each business must know about the other one. In separate firms, specialization of infor-mation can occur. In particular, the creditors of the firm know that the personal creditors of its owners (and the creditors of its supplier, the creditors of its employees, and so on) cannot reach the firms' as-sets, an organizational style that Hansmann and Kraakman call "af-firmative asset partitioning."[46] Conversely, in other organizational forms, the creditors of the firm cannot reach the assets of the owners. They call this "defensive asset partitioning," and it is usually known as corporate limited liability.[47] The effect of asset partitioning is to make

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[44] The monitoring-cost theory of security interests thus depends on the modular effect of property rights. *See, e.g.*, Saul Levmore, *Monitors and Freeriders in Commercial and Corporate Settings*, 92 YALE L.J. 58 (1982) (explaining secured debt in terms of spe-cialization of monitoring by secured creditors); *cf.* Thomas H. Jackson & Anthony T. Kronman, *Secured Financing and Priorities Among Creditors*, 88 YALE L.J. 1143, 1154 (1979) ("[T]he debtor can be expected to give a security interest to *C*1. . . when *C*2 either needs to do less monitoring, or is able to monitor more cheaply, than *C*1."). *But see, e.g.*, Alan Schwartz, *The Continuing Puzzle of Secured Debt*, 37 VAND. L. REV. 1051, 1055-59 (1984) (critiquing Levmore's monitoring theory as underdeveloped).

[45] *See* Henry Hansmann & Reinier Kraakman, *The Essential Role of Organizational Law*, 110 YALE L.J. 387, 390 (2000) (theorizing that organizational law is fundamentally concerned with "the creation of a pattern of creditors' rights" and arguing that it should thus be considered more akin to property law than to contract law).

[46] *Id.* at 394-95.

[47] *Id.* at 395-96.

the shareholders' interest (and those of other stakeholders) more modular: no shareholding depends on the creditworthiness of other shareholders.

It is worthwhile to note that even in property proper, asset partitioning is only possible because the set of things, actors, and interactions among them is a nearly decomposable system, and property law serves to modularize this complex system. From the point of view of dutyholders, on the outside, much of what goes on in these property modules is irrelevant: again, parked cars are not to be taken, regardless of the status of the owner or the owner's planned uses. Much of the decision making by an owner need not take account of the internal workings of another asset because they are separate assets. This black-box approach is taken further than those with a focus on torts would expect. Tort scholars express surprise that a property owner is not responsible for minimizing the damage from an external actor's negligence.[48] In the famous case of *LeRoy Fibre Co. v. Chicago, Milwaukee & St. Paul Railway*,[49] a farmer was not held responsible for the damage caused by a fire that started when the hay that he stacked near the boundary of his land was ignited by negligently spewed sparks from a passing train. The railroad had a duty to respect the farmer's property, and each actor's calculation was simplified by treating the farmer's choices as irrelevant from the railroad's point of view. Likewise, whether a bailee is liable to the bailor is irrelevant to whether a

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[48] *See, e.g.*, Susan Rose-Ackerman, *Dikes, Dams, and Vicious Hogs: Entitlement and Efficiency in Tort Law*, 18 J. LEGAL STUD. 25, 35–38 (1989) (discussing the lack of contributory negligence as a defense where real property is involved); *see also* Mark F. Grady, *Common Law Control of Strategic Behavior: Railroad Sparks and the Farmer*, 17 J. LEGAL STUD. 15, 30-37 (1988) (noting that railroads typically have not been able to use the defense of contributory negligence when setting farmers' property on fire even when such property was placed dangerously close to railroad tracks).

[49] 232 U.S. 340 (1914). Wood's treatise gives a classic formulation:

> It is the duty of every person or public body to prevent a nuisance, and the fact that the person injured could, but does not, prevent damages to his property therefrom is no defense either to an action at law or in equity. A party is not bound to expend a dollar, or to do any act to secure for himself the exercise or enjoyment of a legal right of which he is deprived by reason of the wrongful acts of another.

1 H.G. WOOD, A PRACTICAL TREATISE ON THE LAW OF NUISANCES IN THEIR VARIOUS FORMS; INCLUDING REMEDIES THEREFOR AT LAW AND IN EQUITY § 435 (Bancroft-Whitney Co. 3d ed., 1893) (citation omitted).

third-party tortfeasor is liable to the bailee for destruction of personal property.[50]

Things form the basis for the residual claim, which is also explained by information-cost theory. Recall that in the NIE the residual claim is closely identified with property. The question is why control and the residual do—or should—go together. Some deny that they should, as in the stakeholder approach to corporate law where the board of directors is seen as a mediating hierarch and no special control rights go to shareholders or other residual claimants.[51] But much work in the NIE views residual claims and control as descriptively going together, and theorists have sought an explanation. The most common conclusion is that the residual goes to the actor who makes the most important contribution or who is most vulnerable to opportunism.[52]

Recall that in Barzel's theory, the residual over a set of attributes goes to the one who is in the best position to affect its mean return.[53] In other words, residual claims follow control. But if this contribution were easy to measure, one could pay it off just as the other contributions. Closer to the information-cost theory is Barzel's hypothesis that the residual goes to the contribution that is hardest to measure, with entrepreneurs therefore getting the residual (i.e., the cash flow from a firm after all the other claimants have been paid off).[54] Interestingly,

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[50] *See* The Winkfield, [1902] P. 42, 56 (C.A.) (appeal taken from Eng.) (rejecting jus tertii defense).

[51] *See, e.g.*, Margaret M. Blair & Lynn A. Stout, *A Team Production Theory of Corporate Law*, 85 VA. L. REV. 247, 305 (1999) (suggesting that the mediating-hierarchy model supports the long-term interests of shareholders); Lynn A. Stout, *Bad and Not-So-Bad Arguments for Shareholder Primacy*, 75 S. CAL. L. REV. 1189, 1208 (2002) (discounting arguments advanced regarding shareholder primacy as empirically hollow).

[52] *See, e.g.*, Armen A. Alchian & Harold Demsetz, *Production, Information Costs, and Economic Organization*, 62 AM. ECON. REV. 777 (1972) (describing the residual claimant as one with incentives to reduce shirking and with the most significant management potential); D. Bruce Johnsen, *The Quasi-Rent Structure of Corporate Enterprise: A Transaction Cost Theory*, 44 EMORY L.J. 1277, 1354-56 (1995) (noting that the assignment of residual claims occurs based on value flows). *See generally* Benjamin Klein et al., *Vertical Integration, Appropriable Rents, and the Competitive Contracting Process*, 21 J.L. & ECON. 297 (1978); Oliver E. Williamson, *Corporate Finance and Corporate Governance*, 43 J. FIN. 567, 576-82 (1988) (presenting a theory of the residual claim based on one's vulnerability to opportunism).

[53] *See supra* text accompanying notes 24-29.

[54] Yoram Barzel, *The Entrepreneur's Reward for Self-Policing*, 25 ECON. INQUIRY 103 (1987); *see also* Alchian & Demsetz, *supra* note 52, at 782 (hypothesizing that the residual claimant will be the monitor of the organization responsible for metering the productivity of individual inputs to the team's output).

this is slightly different from his theory of residual claims in property. The difficulty of measurement helps to explain this difference. Most concisely, if the residual is what remains after paying other claims, it requires no additional measurement. All one needs is the outer boundary of the firm module (or asset module, in a property context) after the subtraction of all the other payments (sticks)—the residual is what is left. Of course, the value of the whole will fluctuate for a variety of reasons, including the activities of the residual claimant. However, the use of the residual claim obviates the need to separate these out. While this means that the residual claimant will sometimes benefit from windfalls,[55] it also means that the holder of the residual is exposed to exogenous risk as well. For highly risk-averse parties, being a residual claimant may not be worthwhile even if the cost savings from measuring the actor's contribution in the residual fashion (i.e., the asset as a whole minus payments to other actors) would be large. In some models that trade off agency costs and manager risk aversion, it is the risk aversion that explains why a manager is not the residual claimant.[56] Indeed, an entrepreneur differs from a manager partly in a willingness to be exposed to exogenous risk as well as the results of the entrepreneur's own entrepreneurial activity.

In the NIE, governance rules would count as property rights and there would be nothing special about exclusion, but I argue that the exclusion approach is itself an economizing move. Exclusion serves as a shortcut for a more clearly articulated set of detailed governance rules. Our interactions can be relatively anonymous precisely because they are mediated by a thing (e.g., the cars in the example above). The focus on exclusion for reasons of simplicity and cheapness only makes sense because of positive transaction costs—here broadly taken to include the nonzero cost of delineating property rights.[57] In a

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[55] Some theorists have argued that the law should do more to separate out windfalls for taxation or other special treatment. *See, e.g.*, Eric Kades, *Windfalls*, 108 YALE L.J. 1489, 1566 (1999) (noting that an optimal tax theory would entail efficient capture of windfalls); Gideon Parchomovsky, Peter Siegelman & Steve Thel, *Of Equal Wrongs and Half Rights*, 82 N.Y.U. L. REV. 738, 757-63 (2007) (advocating for a "split the difference" approach to private windfalls). However, the information-cost theory suggests how difficult this would be in many contexts.

[56] *See, e.g.*, Michael C. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure*, 3 J. FIN. ECON. 305, 348-49 (1976) (noting that some owners "have only a relatively small fraction of their wealth invested in the organization they manage" and arguing that risk aversion can explain owner-manager diversification in part).

[57] *See, e.g.*, Douglas W. Allen, *What Are Transaction Costs?*, 14 RES. L. & ECON. 1, 3-4 (1991) (arguing that transaction costs are better defined as the costs of establishing

world of zero transaction costs, we might accept for all purposes the economists' definition of a property right as a right to take one of a list of actions with respect to a thing—with such a thing being merely a backdrop to the direct specification of what actions are permissible as between any pair of members of society. But in our world of positive transaction costs, specifying all of the actions that each actor in society may take with respect to each other is not cost effective. Moreover, the architecture of property law in terms of exclusion and governance implements a modular structure that helps to manage the complexity of actors' interactions with respect to resources.

B. *Information Costs and the Structure of Entitlements*

Previous theorists of "entitlement structure" have found option theory to be a useful tool for analysis and an inspiration for ever more elaborate schemes of liability rules. Liability rules are options to purchase entitlements nonconsensually (calls) or, less familiarly, options to force a sale on some other actor (puts). I argue, however, that entitlement structure should instead be analyzed in terms of real-option theory.[58] The theory of real options applies tools for analyzing and valuing financial options to the decisions that actors take outside of financial markets, such as opening a new plant or pursuing a line of business. Real-option theory has direct relevance to the entire set of entitlement structures, not just remedies, because the decisions that an owner might or might not make correspond with real options— when to build, when to farm, whether to repair, and all the myriad uses that might or might not be made of an asset—and these decisions correspond in interesting ways with the entitlement structure that serves these interests. Likewise, creating and developing information involves real options in which the investment aspect is readily apparent.[59] The real-option theory, in conjunction with information costs, can be used to explain the structure of the intellectual property entitlements that facilitate those decisions. Our interest in resources corresponds to real options and the question becomes how entitlement

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property rights, in the economist's sense of a de facto ability to derive utility from an action, rather than narrowly as the costs of exchange); Steven N.S. Cheung, *The Transaction Costs Paradigm*, 36 ECON. INQUIRY 514, 515 (1998) ("'Transaction costs' must be defined to be all the costs which do not exist in a Robinson Crusoe economy.").

[58] *See, e.g.*, AVINASH K. DIXIT & ROBERT S. PINDYCK, INVESTMENT UNDER UNCERTAINTY (1994).

[59] *See, e.g.*, PHILIPP N. BAECKER, REAL OPTIONS AND INTELLECTUAL PROPERTY: CAPITAL BUDGETING UNDER IMPERFECT PATENT PROTECTION (2007).

structure serves those interests. In the next Part, I will show how this happens indirectly in intellectual property, but the indirectness between interests (real options) and the property mechanisms that serve them is crucial, if less extreme, in the case of tangible property. In this Section, I will argue that an indirect and modular structure helps to maximize the value of these embedded options—our ultimate interest in resources—in a way very different from the entitlement theory that emerges in the options-related, liability-rule literature.

The bundle-of-rights theory can be viewed through the lens of real-option theory. Particularly through the study of remedies in the property-rule/liability-rule framework of Calabresi and Melamed (C&M),[60] theorists have analyzed various types of liability rules as options, but interestingly, these theorists believe that an option-like approach to liability rules determines the nature of "entitlements."[61] The use of the term *entitlement* suggests that these theorists subscribe to the bundle-of-rights picture in which entitlement structure is quite flexible. Indeed "entitlements" are merely empty boxes with no particular content, just like property rights in most versions of the NIE.[62] Thus, if *A* has "the entitlement" (whatever that is) protected by a liability rule with respect to *B*, *A* can take the entitlement upon payment of officially determined damages (Rule 2). If that is the case, then *B* has a call option to purchase the entitlement for the amount of the damages. Others have entertained the possibility of liability rules based on put options, where the holder of the entitlement can force a sale on another.[63] This device is used in a limited way in unjust-enrichment cases and border encroachments, but not in generalized

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[60] Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1106-10 (1972). Calabresi and Melamed also identified and analyzed inalienability rules, under which transfers of entitlements are prohibited. *Id.* at 1111-15.

[61] *See* IAN AYRES, OPTIONAL LAW: THE STRUCTURE OF LEGAL ENTITLEMENTS (2005); Lee Anne Fennell, *Revealing Options*, 118 HARV. L. REV. 1399, 1405 (2005) (arguing that "entitlements could be restructured to exploit the revealing potential" of option agreements, which offers "a middle ground between property rules and liability rules"); Madeline Morris, *The Structure of Entitlements*, 78 CORNELL L. REV. 822 (1993).

[62] *See* Merrill & Smith, *supra* note 4, at 385 ("Property rights are simply 'entitlements,' little empty boxes filled with a miscellany of use rights that operate in the background of a world consisting of nothing but in personam obligations."); Smith, *Self-Help*, *supra* note 34, at 70-76 (arguing that entitlements do not actually show the degree of symmetry suggested by a traditional law and economics approach).

[63] *See, e.g.*, AYRES, *supra* note 61, at 22; Ian Ayres, *Protecting Property with Puts*, 32 VAL. U. L. REV. 793, 795-96 (1998).

in rem contexts.[64] For one thing, the information for which a duty-holder is responsible under a put-style rule is greater than under a call-style liability rule. A nonowner who wants to avoid dealings with the asset and its owner need only avoid them in the case of the call, but the nonowner is always potentially on the hook under the put. This type of unknown—and possibly unknowable—information in the in rem context would require massive amounts of information gathering, wasteful avoidance efforts, and debilitating uncertainty.

While the C&M-inspired literature purports to be about entitlement structure, it actually focuses on remedies. Like C&M, theorists in this literature regard the issue of resource conflict as involving an initial question of who should get "the entitlement," and then move on to how it should be protected (e.g., through property rules, liability rules, or inalienability, and, if a liability rule, which of the many types of liability rules). This does not go far enough. The image here is of the state parceling out options in a stick-by-stick fashion. But this is not the way the law works. Instead, the law provides for lumpy entitlements based on a first-cut exclusion strategy, which is then refined to take into account various kinds of nuisance, necessity, and so on.[65] Actors thus have a limited ability to modify the package of rights through easements and licenses.[66] Property law furnishes a basic modular structure complete with interfaces that individual actors have limited discretion to modify.

II. UNCERTAINTY, OPTIONS, AND ENTITLEMENTS IN INFORMATION

Entitlement structure can be analyzed usefully in terms of real options because entitlements correspond to the actions that people might take with respect to resources and to the timing of those decisions. But a closer look at the implications of real-option theory and entitlements suggests why entitlements do not work in the stick-by-stick manner assumed and elaborated by the liability-rule theorists. Instead, a combination of real-option theory and the information

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[64] *See* Richard A. Epstein, Commentary, *Protecting Property Rights with Legal Remedies: A Common Sense Reply to Professor Ayres*, 32 VAL. U. L. REV. 833, 845-52 (1998) (noting that the common law has only rejected put options in extremely limited circumstances, involving private property).

[65] *See* Smith, *Exclusion and Property Rules, supra* note 7, at 970-74 (noting that "nuisance law rests on a foundation of exclusionary property rights"); Smith, *supra* note 8, at S485 (noting that "exclusion is often the first, low-cost (but low-precision) cut at defining and defending a resource").

[66] One such modification is to contract for an option to purchase.

costs in NIE points to powerful reasons for the lumpiness and modularity of property rights, with an indirect correspondence between legal relations and real options. This information-cost theory suggests a role for lumpy entitlements in information as a means for appropriating returns in a complex system of dispersed inputs to innovation and commercialization.

A. *Options and Modular Entitlements*

In real-options theory, the lumpy entitlements themselves can be analyzed in terms of options, but the picture that emerges is different from that of the liability-options theorists. What is within this lumpy bundle? In terms of who gets to do what, the full Hohfeldian analysis would break down ownership into a complex assortment of rights, privileges, powers, and immunities (as well as duties, no-rights, liabilities, and disabilities).[67] Because the aim of Hohfeldian analysis is to break down legal relationships into their smallest parts, each of these parts corresponds to a basic action that the actor in the relation might take. In other words, in the fully decomposed Hohfeldian analysis, pieces correspond to real options. The exercise of a right or a privilege is an option to prevent use or to engage in use, respectively. A power is an option to change an existing legal relation, and an immunity is the ability to exercise an option free of another's power. Each of these can be regarded either as an option or as closely identified with an option.

But the problem with this atomizing view, for our purposes, is that there may well be no unique way of decomposing a legal relation, and the bundle of real options is not uniquely defined in the corresponding way either. In other words, the bundle of legal relations called "property" and the set of real options to which it corresponds are both lumpy: in terms of delineation, the package is not built up stick by stick or option by option. Take rights and privileges. Many privileges are implicitly protected by the right to exclude.[68] Only when we need

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[67] *See* Hohfeld, *supra* note 43, at 28-59 (devising a relational "scheme of 'opposites' and 'correlatives'" consisting of eight basic conceptions in law, with the ultimate aim of "exhibit[ing] not only their intrinsic meaning and scope, but also their relations to one another and the methods by which they are applied, in judicial reasoning, to the solution of concrete problems of litigation").

[68] *See* Smith, *Exclusion and Property Rules, supra* note 7, at 978-79 (noting that many use rights are protected indirectly by exclusion).

to focus particularly on some uses does a right to use need to be separately delineated.

Further, how finely to characterize options and legal relations depends on the purpose at hand: should it be the right to farm, the right to plant, the right to plant tomatoes, the right to hoe, etc.? The groupings of these options will impact value, and the problem of option characterization becomes complex. Even from a static point of view, some options may be incompatible with others, and some combinations are more valuable than others.[69] In the case of land, this might be hunting and grain-growing, but not vice versa. This dynamic point of view is particularly relevant to intellectual property, in which combinations may only be possible or desirable in certain sequences, making the set of possibilities even larger.[70]

Interestingly, whether property is shaped by true Knightian uncertainty also has implications for how we think of entitlement structure in terms of real options. Like the liability-rule literature, the existing methods for valuing options presume risk rather than uncertainty.[71] Even if other sources of "uncertainty" are added, for interest rates or changes in the variance itself, the theory is still based on risk, not uncertainty. Some theorists have tried to model Knightian uncertainty in options theory by using a multiple-priors utility model in which the multiple priors are subject to aversion.[72] With uncertainty aversion, waiting tends not to be as advantageous as on standard models, because uncertainty aversion may overcome the value of

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[69] For a set of n uses taken r at a time, the number of combinations is as follows: $n!/((n-r)!r!)$.

[70] The number of permutations (ordered combinations) is $n!/(n-r)!$. So if the options in question include all the permutations, we have to multiply the number of possibilities by a factor of $r!$.

[71] In the Black-Scholes formula, means and variance are based on a normal distribution. Fischer Black & Myron Scholes, *The Pricing of Options and Corporate Liabilities*, 81 J. POL. ECON. 637, 642 (1973); Robert C. Merton, *Theory of Rational Option Pricing*, 4 BELL J. ECON. & MGMT. SCI. 141, 161 (1973). Likewise, in the Monte Carlo simulation model, the value of the stock or other source of value is modeled as having a known mean and variance, based again on a normal distribution. DON L. MCLEISH, MONTE CARLO SIMULATION & FINANCE (2005); Phelim P. Boyle, *Options: A Monte Carlo Approach*, 4 J. FIN. ECON. 323, 324-27 (1977).

[72] Uncertainty aversion or ambiguity aversion is often illustrated by the Ellsberg Paradox, in which people will value a gamble on a draw of equal numbers of black and red balls more than a gamble on an unknown proportion of balls. Daniel Ellsberg, *Risk, Ambiguity, and the Savage Axioms*, 75 Q.J. ECON. 643, 650-56 (1961); *see also* JOHN MAYNARD KEYNES, A TREATISE ON PROBABILITY 75-76, 315 & n.2 (1921) (calculating the effects of uncertainty and risk on decision making).

keeping an option open.[73] But the concern there is with capturing uncertainty aversion rather than the full range of responses—institutional and psychological—to uncertainty.[74]

More useful for our purposes is a combination of uncertainty in real options with the Austrian theory of entrepreneurship. Perhaps the greatest significance of uncertainty in real options is that different actors will vary in their ability to handle the uncertainty. After all, Knight originally developed the concept of uncertainty in order to explain the possibility of profit,[75] and theorists later have stressed uncertainty when explaining the role of entrepreneurs.[76] Further, the process of discovering the attributes of a resource can be regarded as an example of entrepreneurship.[77] For property, and intellectual property especially, the discovery of options (rather than the measurement of the value of options based on known risks) is something that the indirect modular structure of property tends to foster.

The problem of embedded options as the set of interests to which property must respond, directly or indirectly, is compounded by the interactions between the various options. Lon Fuller recognized this problem in law decades ago and, borrowing from Polanyi, labeled it "polycentric."[78] Fuller's first example is somewhat analogous to the

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[73] *See* Jianjun Miao & Neng Wang, *Risk, Uncertainty, and Option Exercise* 2 (Boston Univ. Dep't of Econ., Working Paper WP2007-016, 2007), *available at* http://people.bu.edu/maioj/optionR14.pdf (explaining that uncertainty reduces option value).

[74] *See, e.g.*, Larry G. Epstein, *A Definition of Uncertainty Aversion*, 66 REV. ECON. STUD. 579, 579-81 (1999) (proposing a definition of uncertainty aversion that aligns more appropriately with the Savage framework); Larry G. Epstein & Martin Schnieder, *Recursive Multiple-Priors*, 113 J. ECON. THEORY 1, 20 (2003) (extending the Gilboa-Schmiedler "atemporal model" and creating the authors' own "axiomatic model of dynamic preference"); Larry G. Epstein & Tan Wang, *Intertemporal Asset Pricing Under Knightian Uncertainty*, 62 ECONOMETRICA 283 (1994) (presenting "a formal model of asset price determination in which Knightian uncertainty plays a role"); Itzhak Gilboa & David Schmeidler, *Maxmin Expected Utility with a Non-Unique Prior*, 18 J. MATHEMATI-CAL ECON. 141 (1989) (extending the classical notion of expected utility with an axiom of uncertainty aversion).

[75] KNIGHT, *supra* note 14, at 20.

[76] *E.g.*, ISRAEL M. KIRZNER, COMPETITION AND ENTREPRENEURSHIP 78 (1973); Israel M. Kirzner, *Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach*, 35 J. ECON. LIT. 60, 69-71 (1997).

[77] *Cf.* Kirsten Foss & Nicolai J. Foss, *Resources and Transaction Costs: How Property Rights Economics Furthers the Resource-Based View*, 26 STRATEGIC MGMT. J. 541, 542 (2005) (noting that resource attributes can lead to value creation); Smith, *Property and Property Rules*, *supra* note 7, at 1724-25, 1729, 1781 (noting the entrepreneurial role of an owner in the presence of uncertainty over uses of property).

[78] *See* Lon L. Fuller, *The Forms and Limits of Adjudication*, 92 HARV. L. REV. 353, 394-95 (1978) (introducing the concept of polycentric tasks).

problems of managing uses of an asset, or, more accurately, how to aggregate sticks—here paintings—into a bundle:

> Some months ago a wealthy lady by the name of Timken died in New York leaving a valuable, but somewhat miscellaneous, collection of paintings to the Metropolitan Museum and the National Gallery "in equal shares," her will indicating no particular apportionment. When the will was probated the judge remarked something to the effect that the parties seemed to be confronted with a real problem. The attorney for one of the museums spoke up and said, "We are good friends. We will work it out somehow or other." What makes this problem of effecting an equal division of the paintings a polycentric task? It lies in the fact that the disposition of any single painting has implications for the proper disposition of every other painting. If it gets the Renoir, the Gallery may be less eager for the Cezanne but all the more eager for the Bellows, etc. If the proper apportionment were set for argument, there would be no clear issue to which either side could direct its proofs and contentions. Any judge assigned to hear such an argument would be tempted to assume the role of mediator or to adopt the classical solution: Let the older brother (here the Metropolitan) divide the estate into what he regards as equal shares, let the younger brother (the National Gallery) take his pick.[79]

Note that the problem of combining uses is likely to be at least as complex as Fuller's painting-allocation task, considering that there are also timing and simultaneous compatibility issues. Fuller's second example concerns the difficulty of central planning, and again the parallel between the liability-rule literature and central planning has been noted before: liability rules require a schedule of official prices and must respond in a dynamic fashion to the complex interaction of economic effects of resource use, technological change, and so on.[80] Fuller, in general, found the allocation of economic resources to be too polycentric for adjudication.[81]

The exercise of the real options associated with a resource is also polycentric and raises the concerns expressed by Fuller. Liability-rule schemes are modular in that they have to assume some asset aggrega-

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[79] *Id.* at 394 (citations omitted).

[80] *See* Ian Ayres & Paul M. Goldbart, *Optimal Delegation and Decoupling in the Design of Liability Rules*, 100 MICH. L. REV. 1, 10 (2001) (discussing dual-chooser rules for parties as a system of centralized planning); Smith, *Property and Property Rules, supra* note 7, at 1778-79 (noting a parallel between the centralized-planning aspect of liability rules and "socialism with prices").

[81] Fuller, *supra* note 78, at 400 ("Generally . . . problems in the allocation of economic resources present too strong a polycentric aspect to be suitable for adjudication. Thus, a proposal made in England after World War II that scarce newspaper print be allocated by jury verdict could hardly have been the product of serious reflection.").

tion (although without telling us where disaggregation is to stop), and they rely on context-stripping devices like average values.[82] In their limited way, they delegate decisions to actors—as in Fuller's cake-cutting solution (*A* cuts, *B* chooses). But I argue here that greater attention to asset definition and protection reveals their role in managing complex systems through modularity.

The type of polycentric task that worried Fuller and the problems of managing property options more generally are likely to be computationally complex. Modularity cuts down on the ripple effects from connectedness. In a system of *n* elements, the maximum number of links is $n(n-1)/2$, which increases much faster than in typical modular systems.[83] Problems involving these interactions are the subject of computational-complexity theory, the study of the minimum running time for programs to solve various problems.[84] The superficial simplicity of a problem is no guide to its complexity, and many simple-sounding problems are provably intractable, with many in a class that is probably intractable.[85] Of particular relevance to the selection of uses are combinatorial optimization problems. For example, in one version of the Knapsack Problem, one has to choose from a given set of *n* items, with given weights and values, the combination that has the maximum value but a weight under a given limit. Like enumerating the subsets of a given set, this problem requires exponential time as *n* increases. This problem is probably intractable and requires approximate methods—or changing the problem and managing the

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[82] *See, e.g.*, Louis Kaplow & Steven Shavell, *Property Rules Versus Liability Rules: An Economic Analysis*, 109 HARV. L. REV. 713, 719-20 (1996) (presenting a model in which liability rules based on average expected harm are more efficient than property rules).

[83] *See* Henry E. Smith, *Modularity in Contracts: Boilerplate and Information Flow*, 104 MICH. L. REV. 1175, 1182-84 (2006) (depicting graphically the webs of hierarchical organizations and the connections therein).

[84] *See, e.g.*, MICHAEL R. GAREY & DAVID S. JOHNSON, COMPUTERS AND INTRACTABILITY: A GUIDE TO THE THEORY OF NP-COMPLETENESS (1979); RAYMOND GREENLAW & H. JAMES HOOVER, FUNDAMENTALS OF THE THEORY OF COMPUTATION: PRINCIPLES AND PRACTICE 287-313 (1998). For an application of the computational-complexity theory to law, see Eric Kades, *The Laws of Complexity and the Complexity of Laws: The Implications of Computational Complexity Theory for the Law*, 49 RUTGERS L. REV. 403 (1997).

[85] *See* GREENLAW & HOOVER, *supra* note 84 (discussing NP-complete problems, i.e., those that are nondeterministic polynomial complete, or computable in polynomial time using a random choice of solutions with complete luck, which are considered probably intractable). For an informal introduction to the P-versus-NP problem, see KEITH DEVLIN, THE MILLENNIUM PROBLEMS: THE SEVEN GREATEST UNSOLVED MATHEMATICAL PUZZLES OF OUR TIME 105-29 (2002).

complexity through modularity.[86] And in the case of selecting a use of an asset, there may be more than one constraint.

Finally, as Fuller noted, polycentric tasks often, but not always, involve a multiplicity of parties—the Knapsack Problem and Fuller's example of the paintings passing under a will, for example, do not—but to the extent that property among other things deals with the interactions of owners with the world at large (as opposed to in personam contracts), property helps manage this highly polycentric system in an extremely modular fashion by making the interface among such anonymous interacting parties very simple.

Furthermore, the entrepreneurial aspect of asset ownership involves the exercise of options to create options. This extra level of uncertainty likely requires highly specialized and local knowledge. The creation of options might be expected to occur within one or a few property modules. The question is how best to find shortcuts and, equally important, who is in the best position to find them. Modularity theory suggests that over a large range of problems, specialization through delegation to owners is beneficial.[87] Modularity and information specialization can be accomplished through delegation to owners.

The problem of entrepreneurship raises the question of whether delegation though modularity is truly possible in principle. It might be thought that the information required to set up a modular architecture for the innovation and commercialization environment would be the same as that required to delineate narrow entitlements, implement a system of rewards, or engage in ex post restitution-style tracing. Although the question of the amount and type of information required to solve these architectural problems is an empirical one, there is no necessary identity of the information required to solve specific problems of developing information assets and the information needed to set up the modular architecture of the overall environment.

An analogy to computer programming is apt: designing a computer language is responsive to what people will do with it, but creating the language requires different, and far less, information than it would to foresee all the things that programmers will ever do with it. It is no accident that modularity plays an increasingly important role in the use of computer languages, especially with the rise of object-

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[86] In other words, this version of the Knapsack Problem is NP-complete.

[87] *Cf.* BALDWIN & CLARK, *supra* note 18, at 5 (analyzing the evolution of computers as an example of successful "modularity in design").

oriented programming.[88] Another analogy is to the Internet. Central control of the basic architecture—including its modularity and, very importantly, the nature of its interfaces—is essential to its success.[89] But these design questions do not require omniscience about all the uses to which these basic tools are put.

More generally, information is a good like water or broadcast spectrum, in that it is difficult to delineate rights to it and many of its potential uses are tightly interconnected.[90] This suggests both a possible limit on the degree of modularization and the idea that some areas of intellectual property are more susceptible to modularization than others. The question ultimately comes back to Simon's near decomposability: is the system of interactions such that a "fault line" can be found or imposed on the system at an acceptable cost?[91] Finding algorithms for determining the best modularization of a complex system is an active area of research.[92]

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[88] *See supra* note 16.

[89] *See, e.g.*, Joseph Farrell & Philip J. Weiser, *Modularity, Vertical Integration, and Open Access Policies: Towards a Convergence of Antitrust and Regulation in the Internet Age*, 17 HARV. J.L. & TECH. 85, 90-96 (2003) (recounting how the basic architecture of the Internet was a controlled government project); James B. Speta, *A Common Carrier Approach to Internet Interconnection*, 54 FED. COMM. L.J. 225, 246-47 (2002) (explaining how the standardization of connection protocols facilitated flexibility with network communication); Philip J. Weiser, *The Internet, Innovation, and Intellectual Property Policy*, 103 COLUM. L. REV. 534, 536 (2003) (discussing the development of the Internet under the guidance of the U.S. government).

[90] *See, e.g.*, Thomas W. Hazlett, *Spectrum Tragedies*, 22 YALE J. ON REG. 242, 261-66 (2005) (analyzing the role of exclusion and governance in the radio spectrum); James B. Speta, *Spectrum Policy Experiments: What's Next?*, 2008 U. CHI. LEGAL F. 389, 413-14 (arguing that "spectrum policy has not grown" even though there is agreement that traditional models are "outdated"); Dale B. Thompson, *Of Rainbows and Rivers: Lessons for Telecommunications Spectrum Policy from Transitions in Property Rights and Commons in Water Law*, 54 BUFF. L. REV. 157, 160-61 (2006) (analogizing spectrum regulation to water law); Philip J. Weiser & Dale Hatfield, *Spectrum Policy Reform and the Next Frontier of Property Rights*, 15 GEO. MASON L. REV. 549, 605 (2008) (noting how "holdup-type behavior" by incumbents explains the need for telecommunications regulation to address connectivity).

[91] *See supra* note 36 and accompanying text.

[92] *See, e.g.*, Aaron Clauset et al., *Finding Community Structure in Very Large Networks*, 70 PHYS. REV. E 066,111-1 (2004) (presenting a "hierarchical agglomeration algorithm"); M.E.J. Newman, *Modularity and Community Structure in Networks*, 103 PROC. NAT'L ACAD. SCI. U.S. AM. 8577, 8581-82 (2006) (describing the implementation of a special modularity-based algorithm); Martin Rosvall & Carl T. Bergstrom, *An Information-Theoretic Framework for Resolving Community Structure in Complex Networks*, 104 PROC. NAT'L ACAD. SCI. U.S.A. 7327 (2007) (approaching this problem by determining an "optimal compression of [a network's] topology").

Thus, in patent law, patent rights may foreclose some interactions, which must be put on the ledger and set off against the benefits of modularity that are the focus of this Article. But it should be remembered that whether modularization is possible depends more on the degree of decomposability of the system of interactions with respect to information and its development, and not so much on the initial impression of complexity. Second, in many of the systems that I have termed "fluid"—water, broadband spectrum, wild animals, and information—the system of interfaces is a semicommons, with exclusion on one scale for some set of uses and a more complex interface on another scale for a somewhat separate, but potentially interacting, other set of uses.[93] To take an intellectual property example, Robert Merges has shown how patent holders subscribe to norms of sharing in an academic context and paid licensing for commercial purposes.[94] In joint ventures, the participants may reserve their assets for some purposes and contribute them for others in a semicommons.[95] These arrangements are more complex than pure exclusion regimes, and can be thought of as regimes in which exclusion gives way to governance quickly because of the high costs of using exclusion, but they too are modular, only less so. In previous work, I have focused on the problem of containing strategic behavior across the interface between the two interlocking systems.[96] In the case of the medieval and early modern open-field system, scattering of strips was, I argue, used to prevent participants from engaging in strategic use of the commons to favor what would be their parcels in the grain-growing periods.[97]

Furthermore, modular systems either can be designed or evolve spontaneously, or some combination of the two. Indeed one of the advantages of modularity is that it can adapt to shocks: under a wide

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[93] *See* Henry E. Smith, *Governing Water: The Semicommons of Fluid Property Rights*, 50 ARIZ. L. REV. 445, 475-77 (2008) (explaining how the exclusion and governance of water property rights tend toward a semicommons where common and private property interact).

[94] *See* Robert P. Merges, *Property Rights Theory and the Commons: The Case of Scientific Research*, SOC. PHIL. & POL'Y, Summer 1996, at 145, 150 (noting that "patented research results are often shared").

[95] Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J. LEGAL STUD. 131, 166-67 (2000).

[96] *See id.* at 169 (arguing that participants, rather than courts, would have an advantage in arranging an "optimal combination").

[97] For an explanation of the medieval open-field system and of scattering, see *id.* at 134-38. For an interpretation of why scattering of strips was a solution to the semicommons, see *id.* at 144-54.

variety of circumstances, systems evolve toward modularity.[98] Whether the intellectual property system itself—its architecture—should fall more on the designed or spontaneous end of this spectrum is a question that I leave open, but a few property analogies are suggestive. To the extent that the system is one of simple building blocks that can be combined in many ways, in generative fashion, it is easier to see how the state would have some advantage in setting the list of allowed building blocks (numerus clausus).[99] Because additional idiosyncratic blocks (basic forms of entitlement) raise information costs for those who need to avoid violation, those who would like to acquire, and those seeking to build on intellectual property, it is convenient for one authority—the legislature—to limit these forms.[100] There are probably economies of scale and scope in the operation of the numerus clausus. But intellectual property is not the same as regular property. For one thing, the audiences in intellectual property vary a great deal: anyone can be a copyright violator, though competitors tend to be the potential infringers of patents.[101] Further, problems of strategic behavior, to which I return later,[102] need not be identical to those in real property. An emerging theme in intellectual property, and patent law in particular, is concern about strategic behavior. It remains an open empirical question whether the problem of opportunistic invocation of rights, especially against those without good notice and after detrimental reliance (such as incorporating an invention into a

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[98] *See, e.g.*, Lauren W. Ancel & Walter Fontana, *Plasticity, Evolvability, and Modularity in RNA*, 288 J. EXPERIMENTAL ZOOLOGY 242, 281 (2000) (suggesting that modularity arises from environmental canalization of RNA); Nadav Kashtan & Uri Alon, *Spontaneous Evolution of Modularity and Network Motifs*, 102 PROC. NAT'L ACAD. SCI. U.S. AM. 13,773, 13,777 (2005) (finding that "modularly varying goals" in biological networks can lead to "spontaneous evolution of modular network architectures"); Günter P. Wagner & Lee Altenberg, *Complex Adaptations and the Evolution of Evolvability*, 50 EVOLUTION 967, 972-74 (1996) (reviewing multiple genetic models to explain modular design's evolutionary origin).

[99] *See* Thomas W. Merrill & Henry E. Smith, *Optimal Standardization in the Law of Property: The* Numerus Clausus *Principle*, 110 YALE L.J. 1, 49-51 (2000) (arguing that the widespread historical use of numerus clausus by governments suggests that it has advantages over purely private ordering).

[100] *See id.* at 42 (finding that advances in technology that lower information costs diminish the need for standardization of law); *see also* Clarisa Long, *Information Costs in Patent and Copyright*, 90 VA. L. REV. 465, 489-95 (2004) (describing observers of intellectual property as avoiders, transactors, and builders, where rules to reduce information costs will not be equally effective).

[101] Smith, *supra* note 32, at 1175 (contrasting the audiences in copyright and patent law by emphasizing the ease with which an individual can violate copyright protection).

[102] *See infra* Section II.B.

product or a standard), warrant additional efforts to define rights better ex ante or some safety valve ex post (the traditional role of equity).

An important issue faced by entitlement systems as well as computer languages, the Internet, and water law, is the tension between static and dynamic efficiency. In many situations, narrow tailoring may optimize a system for present uses but contribute to difficulty in changing the system architecture, including remodularization. As a historic example, the open-field system was an ingenious and complex system for managing strategic behavior in which agriculture was best conducted on two modes and on two corresponding scales: private strips for grain-growing temporally alternating with open-field animal grazing. With technological advances, such as new crops and agricultural methods, the system was difficult to change precisely because the governance system of interfaces among tightly interlocking entitlements was very elaborate. Similarly, water rights in prior appropriation wring out more use of water with doctrines like no-injury-to-return-flow, under which an appropriator cannot change a use (including by transfer) if it would harm return-flow that has been appropriated by downstream actors.[103] This no-injury rule maximizes the set of present uses but makes adjustment more difficult. Fluid property regimes face an especially harsh tradeoff between tailoring and rich interfaces to maximize the value of current uses of the resource and the problem of rigidity and obstacles to transfers of rights or negotiating a remodularization.

B. *Managing Complexity Involving Information*

The debate within the liability-rule literature over entitlement assignment is somewhat misleading in that such literature generally assumes that the entitlement refers to the ability to engage in an activity or a narrow set of activities. Both the NIE definitions of property discussed above and the entitlement approach can usefully be supplemented with a theory of entitlement delineation based on information costs. In particular, entitlements benefit from indirectness and modularity in a fashion that is somewhat obscured by the realist bundle picture assumed by both mainstream NIE and the liability-rule theorists.

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[103] *See, e.g.*, Ronald N. Johnson et al., *The Definition of a Surface Water Right and Transferability*, 24 J.L. & ECON. 273, 279-83 (1981) (discussing water transfer and third-party impairment); Smith, *supra* note 93, at 453-55, 469-71 (discussing rights, transfer, and deprivation of water of other appropriators under the Demsetz framework).

Exclusion and modularity help maximize the value of options. In a zero-transaction-cost world there would be less need to make the distinctions that lie at the heart of the information-cost theory of property. As Baldwin and Clark point out, the basic unit of economic activity involving more than one actor is the transfer.[104] Actor *A* can transfer material, energy, or information to actor *B*. An example would be a team of smiths transferring a pot hook to a team of cooks, as well as the many transfers within each of those teams. In principle, any actor on either team might interact with any other member of either team in any way imaginable. It is conceivable that allowing some interaction between the decisions of the cooks and the smiths would have a nonzero benefit, and in a zero-transaction-cost world, the system of formal transactions could track exactly the set of transfers. In our positive-transaction-cost world, though, transactions are costly; some transfers do not correspond to formal transactions and may not occur at all. Thus, the team of smiths and the team of cooks are separated into modules because the interactions between the teams are sparse, and except for the transfer of design requirements, the payment from cooks to smiths, and the transfer of the pot hook in the other direction, any of the other possible transfers can be sacrificed at little cost. In Simon's terms, the smith-cook system is nearly decomposable.[105] Other than the design parameters, the smiths need not worry about what goes on in the kitchen, and, as long as the transferred pot hook meets the stated requirements (on the interface between the smith module and the cook module), the cooks need not know anything about the process of manufacture. Each team can specialize informationally, which is like the specialization of labor but involves expertise and the crucial coordination of actors with different and incomplete information.[106] The actors can each exercise their options to undertake actions within their respective spheres without regard to the opinions or actions of the members of the other team. Transactions are limited to those allowed by the interface.

If in a zero-transaction-cost world not all transfers correspond to transactions, we can generalize this point to legal relations. In a zero-transaction-cost world all real options would be visible to the law and

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[104] Carliss Y. Baldwin & Kim B. Clark, *The Option Value of Modularity in Design: An Example from* Design Rules, Volume 1: The Power of Modularity (Harvard Negotiation, Orgs. & Mkts. Research, Paper No. 02-13, 2002), *available at* http://ssrn.com/abstract =12404.

[105] *See supra* notes 17-18 & 36-37 and accompanying text.

[106] BALDWIN & CLARK, *supra* note 18.

would correspond to a legal relation, at least as long as there were some positive benefit in doing so. Thus, even within the teams in the smith-cook example, one can think of the internal dealings of the smiths as the exercise of real options. For example, actions such as cleaning or replacing the forge, or creating new tongs, are all the exercise of real options. This would be true even if there were only one smith. In a world of zero transaction costs we might think of each of these actions and transfers as corresponding to some legal right that could be transferred or operated on in every way imagineable. But in a positive-transaction-cost world, these real options would be far too costly to serve as the basis for such fully articulated legal relations. Instead, legal relations also track a modular structure to economize on transaction costs.

Property is characterized by a large gap between the mechanisms that it employs and the interests that it serves. Thus, the right to exclude is not beneficial per se; only a fetishist would deem exclusion to be the interest to be served by property. Instead, people have interests in using (including preserving) assets, either directly or indirectly, through transfer. The trilogy of rights of possession, use, and transfer reflects more closely the interests that people have in resources rather than a theory of an unadorned right to exclude.[107] But when it comes to delineation, the information-cost theory suggests why exclusion is a starting point: it employs rough proxies that serve as a first cut at protecting a wide and indefinite set of interests in use. Because it is under- and (especially) overinclusive, the exclusion strategy is supplemented with governance regimes such as nuisance, covenants, zoning, the law of necessity, and various customs of access and responsibility. To those with an exclusive focus on the interests to be served by property, this emphasis on exclusion is an inconvenient obstacle. And it is difficult to understand the importance of exclusion without a theory of why the gap between means and ends produces any gains.

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[107] *See, e.g.*, United States v. Gen. Motors Corp., 323 U.S. 373, 377-78 (1945) (stating that a more accurate conception of property rights is an individual's right to possess, use, and dispose); 1 WILLIAM BLACKSTONE, COMMENTARIES *138-39 (discussing an individual's right of property as "free use, enjoyment, and disposal"); RICHARD A. EPSTEIN, TAKINGS: PRIVATE PROPERTY AND THE POWER OF EMINENT DOMAIN 22 (1985) (citing Blackstone's conception of property); Eric R. Claeys, Takings*: An Appreciative Retrospective*, 15 WM. & MARY BILL RTS. J. 439, 442 (2006) (discussing Richard Epstein's book and its idea of property rights as "possession, use, and control"); Adam Mossoff, *The Use and Abuse of IP at the Birth of the Administrative State*, 157 U. PA. L. REV. 2001, 2007-19 (2009) (discussing the bundling metaphors and exclusion conceptions of property).

The gap between delineation (means) and interests (ends) is even starker in intellectual property. Here, exclusion is costly because of the nonrival nature of information. If an additional person can use the information at zero marginal cost, excluding anyone from the information makes little sense in terms of direct interests.

An analogy to water rights is helpful: Like water, information is difficult to subject to property rights because it is costly to measure. And certain uses of water, such as power generation, have some public-goods characteristics.[108] Accordingly, riparianism has major common property elements.[109] However, I suggest a different analogy between water and intellectual property. In some areas, it was cheaper to delineate rights to water by owning the land around a water source, which afforded de facto rights over the water even if it was not technically susceptible to ownership claims.[110] In the case of intellectual property, the ability to delineate rights in the inputs to invention and commercialization is costly—especially against remote parties—and it appears that sometimes it is cheaper to delineate rights in related information in order to capture (indirectly) those inputs. The inputs are rival and are a good candidate for property rights on the benefit side, but they are not susceptible to narrowly tailored property rights on the cost side. One solution—albeit, with its own costs—is to give rights over the output (or some other related asset) as a proxy for the too-costly narrower rights to inputs. Here is where intellectual property potentially comes into play. Remote indirect rights to information look bad on their own terms because they incur the cost of exclusion from a nonrival resource, but they can be a cheaper stand-in for the right to the rival resources used as inputs to invention and commercialization.

In particular, patent law is a characteristic response to the limits of the traditional equity approach to property. For example, equity relied heavily on tracing rules,[111] and we conceivably could use such an

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[108] *See* Carol M. Rose, *Energy and Efficiency in the Realignment of Common-Law Water Rights*, 19 J. LEGAL STUD. 261, 291-92 (1990) (suggesting that eastern riparian law developed around an aspect of water use for power generation rather than for individual consumption).

[109] *Id.*

[110] *See* George Cameron Coggins & Margaret Lindeberg-Johnson, *The Law of Public Rangeland Management II: The Commons and the Taylor Act*, 13 ENVTL. L. 1, 24-25 (1982) (noting that control of scarce water resources led to exclusion of others from adjacent public land).

[111] *See, e.g.*, DAN B. DOBBS, LAW OF REMEDIES: DAMAGES-EQUITY-RESTITUTION § 6.1 (2d ed. 1993) (discussing the necessity of tracing); Peter Birks, *Mixing and Tracing:*

approach to give the productive employers of rival inputs to invention and commercialization a return by tracing the beneficial effects into the assets and consumption of others. This system of allocation would be prohibitively expensive. One reason that tracing works in the context of equity and unjust enrichment is that the relation between the tracer and the tracee (including some of those to whom one can follow an equitable claim) is limited, and great attention is paid to ensure that the one against whom tracing (or following) is used is well aware of the claim. Often this is done by reserving these devices for use against clear wrongdoers and then making tracing easier by resolving questions against the wrongdoer. Consider one who wrongfully takes $100 and commingles it in a bank account already containing $400 belonging to the wrongdoer. If the wrongdoer then withdraws $100 and bets it successfully at the racetrack, winning another $200, the unjust enrichment claimant can claim $300. If on the other hand the horse (and wrongdoer) loses, the unjust enrichment claimant should receive $100 from the account. These harsh presumptions are appropriate where a sanction rather than a price is being implemented. But, if one were to use tracing-based, equity-style claims as a substitute for intellectual property, such draconian presumptions would usually be inappropriate. In actuality, the appropriate sphere, in terms of a nearly in personam relation, full information, and wrongdoing, would be the law of unfair competition and misappropriation, which are not coincidentally outgrowths of equity.

Thus while intellectual property may be consistent with a restitutionary impulse,[112] this is only indirectly true. Intellectual property bears only an indirect relation to restitutionary ends, because a more direct approach would be prohibitively costly. Intellectual property allows the exercise of real options involving rival inputs and the appropriation of the value of exercising those options by giving exclusion rights over downstream information assets.

There are two choices that we need to make to determine the proper mechanism. One is whether rights will be defined ex ante or

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Property and Restitution, *in* 45 CURRENT LEGAL PROBS. 69, 84 (1992) (exploring tracing in restitutionary claims); Peter B. Oh, *Tracing*, 80 TUL. L. REV. 849, 876 (2006) (examining remedial tracing in equity and at common law).

[112] *See* Wendy J. Gordon, *On Owning Information: Intellectual Property and the Restitutionary Impulse*, 78 VA. L. REV. 149, 157 (1992) (analyzing basic features of intellectual property through the lens of restitution).

ex post. In other words, should the rights be rules or standards?[113]
Another choice is whether to grant indirect or direct rights. And,
given the imperfection of proxies, often an indirect right must be
broader than a direct one. For a given rival input to commercializa-
tion, it is unlikely that a perfect indirect proxy can be found. For an
entire collection of such rival inputs, it is even more likely that no sin-
gle accurate proxy will be found and that any proxy will be broad if
one is to be used at all. These two choices provide a two-by-two matrix
as follows:

	Ex Ante	**Ex Post**
Direct	Trademark, Plant Protection, Anti-Plug-Mold	Unfair Competition
Indirect	Patent	*X*

Patent law is the solution to the problem that is ex ante and indi-
rect or broad. If it were narrower it would be similar to trademark,
plant protection, or anti-plug-mold statutes which are ex ante but
which make reference to much narrower information assets or to in-
dividual activities. By contrast, whereas patent law is ex ante and indi-
rect, the opposing area of law in both respects—ex post and narrow—
is unfair competition. Related areas of law such as copyright and
trade secret are somewhere in between. What we seem unable to find
are broad and ex post regimes. A very expansive reading of *Interna-
tional News Service v. Associated Press*[114] would be such a regime, because
in that (equity) case the Court employed commercial morality to de-
clare a quasi-property right against use of hot news by a competitor
news organization. A generalized version of this approach would pose
a number of related threats. First, the burden would fall on a large
class of dutyholders (in rem) without giving much guidance as to the
liability. Second, a broad version of *INS* would derogate seriously
from the public domain. In particular, if equitable notions of tracing
and resolving doubt in favor of the claimant carry over, the public

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[113] *See* Louis Kaplow, *Rules Versus Standards: An Economic Analysis*, 42 DUKE L.J.
557, 568-88 (1992) (analyzing rules versus standards in terms of the timing of decision
making).

[114] 248 U.S. 215 (1918).

domain is bound to lose. Indeed, such an approach suffers from the
problem of overexpansive equity that the common law lawyers and
their descendants have raised against equity itself, from the "Chancel-
lor's foot" onward.[115] The general question is the right mix of law and
equity. For present purposes, we must ask if patent law's combination
of a relatively ex ante delineation and indirectness between the
mechanism employed and the interests served makes sense.

III. APPLICATIONS

The information-cost theory allows us to draw out some implica-
tions of recent developments in the law regarding the licensing of in-
tellectual property, and patents in particular. It also suggests the na-
ture of the tradeoff presented by the choice between injunctions and
damages as remedies for patent infringement.

A. *Licensing*

Licensing has implications for the modular structure of intellec-
tual property. First, licensing is a way of modifying the interface be-
tween different actors. There is no guarantee that the off-the-rack
pattern of ownership of intellectual property assets is optimal.

Licensing supports and is supported by modular intellectual
property rights. Indirect intellectual patent rights allow transacting
parties to cooperate without delineating the rights to their inputs,
which is important in joint ventures. Each of the participants in a
joint venture can use its rival inputs to develop and commercialize a
combination of joint and individual projects at low delineation cost.
It is not that exclusive rights to information are useful per se. Rather,
the importance of the asset-partitioning function of intellectual prop-
erty is partly that related *rival* assets and inputs can be partitioned si-

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[115] *See* JOHN SELDEN, TABLE TALK xxxviii, at 43-44 (London, E. Smith, 1689) ("Eq-
uity is a Roguish thing: for Law we have a measure, know what to trust to; Equity is ac-
cording to the Conscience of him that is Chancellor, and as that is larger or narrower,
so is Equity. 'Tis all one as if they should make the Standard for the measure we call a
Foot, a Chancellor's Foot; what an uncertain Measure would be this. One Chancellor
has a long Foot, another a short Foot, a Third an indifferent Foot: 'Tis the same thing
in the Chancellor's Conscience."); *see also* Grupo Mexicano de Desarrollo, S.A. v. Alli-
ance Bond Fund, Inc., 527 U.S. 308, 332-33 (1999) (Scalia, J.) (holding that because
equity at the time of the Federal Judiciary Act of 1789 did not include issuing prelimi-
nary injunctions to freeze unrelated assets in cases claiming only money damages, fed-
eral courts do not have such power).

multaneously.[116] In this way the partitioning effect and the attribution of returns in a team-production-type problem are closely related.[117] As modularity promotes specialization in organizations and production teams generally,[118] there is evidence that intellectual property rights promote specialization in firms.[119]

The modular structure of exclusion-based intellectual property rights also makes other types of contracting more tractable. Robert Merges has argued that intellectual property rights facilitate contracting by making precontractual liability possible and enforcement more flexible.[120] Sometimes this is possible precisely because intellectual property rights serve as a convenient reference point, even prior to or apart from any need to delineate more accurate provisions relating to particular possibly unforeseeable (rival) inputs. For example, intellectual property rights can simplify the law of employee inventions.[121] If independent invention were a defense to patent law, it would be very difficult to allocate rights as between employers and employees without the constant threat of defection.

All of this is not to say that intellectual property rights are always necessary or desirable, or that stronger is always better. It does suggest that, in considering the empirical question of what kinds of rights make sense, the modular structure of intellectual property rights potentially carries benefits. Otherwise, the indirectness between the mechanism and its purpose—an indirectness even greater than the sometimes controversial indirectness in regular property—appears as

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[116] *See* Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473, 480-84 (2005) (arguing that patent registration lowers the costs of asset partitioning for certain information assets).

[117] *Id.* at 487-99 (discussing benefits of a patent registration system in addressing team production issues involving intellectual property).

[118] *See* BALDWIN & CLARK, *supra* note 18.

[119] *See* Ashish Arora & Robert P. Merges, *Specialized Supply Firms, Property Rights, and Firm Boundaries*, 13 INDUS. & CORP. CHANGE 451, 452 (2004) (arguing from model and suggestive empirical literature that strong intellectual property rights lead to specialization in firms); *see also* Daniel W. Elfenbein, *Publications, Patents, and the Market for University Inventions*, 63 J. ECON. BEHAV. & ORG. 688, 691 (2007) (finding in a study of university inventions that a patent is associated with a doubling of the likelihood of finding a licensing partner and arguing for the role of reduced risk of expropriation, lesser uncertainty, and inventor incentives).

[120] *See* Robert P. Merges, *A Transactional View of Property Rights*, 20 BERKELEY TECH. L.J. 1477 (2005) (arguing that intellectual property promotes transactions through its role as property).

[121] *See* Robert P. Merges, *The Law and Economics of Employee Inventions*, 13 HARV. J.L. & TECH. 1, 53-54 (1999) (explaining how intellectual property law solves problems in the employee invention context).

an unmitigated problem. And pointing to incentives does not provide a complete explanation. Going back to the NIE definitions of property rights, if we knew the mean return from assets and all options were known and could be valued, there would be far less reason to have a property rights system—rather than some system of direct rewards or restitution with tracing—for information at all.

One main issue here is notice and, in particular, the most cost-effective method of furnishing it. Although systematic and centralized property records often do provide effective notice (most notably in the case of land[122]), it is an empirical question as to how they stack up against other methods in any given situation.[123] Other methods include standardization, equitable doctrines of notice (which apply in personam and not in rem), and doctrines absolving from liability those who encounter rights. Where a legal device falls between in personam contract and in rem property, we should expect intermediate strategies to deal with the potentially large, but still limited, set of dutyholders.[124]

When notice is the issue, it is important to keep in mind that it is not information that is scarce but rather *attention*, as Herbert Simon pointed out a long time ago.[125] Thus, even where land records or notices printed on a product may give notice in some sense, there might still be reasons to force a standardized format (similar to, for instance, nutrition information, or the terms of consumer loans). Even the land records are not a "data dump" but limit the types and form of documents that are permitted to be recorded. Format can matter. For example, a rule that rent is incompatible with fee ownership means that once one knows that an interest is a fee simple, one can stop looking for information along this dimension. Similar problems

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[122] *Cf.* Alfred F. Conard, *Easement Novelties*, 30 CAL. L. REV. 125, 131-33 (1942) (arguing that enforcement of easements should not be objectionable on grounds of novelty as long as there is notice); Richard A. Epstein, *Notice and Freedom of Contract in the Law of Servitudes*, 55 S. CAL. L. REV. 1353, 1354 (1982) (arguing for freedom of contract in the area of covenants and easements as long as land records provide notice).

[123] *See* Merrill & Smith, *supra* note 99, at 43-45 (describing other methods of meeting third-party informational needs).

[124] *See* Thomas W. Merrill & Henry E. Smith, *The Property/Contract Interface*, 101 COLUM. L. REV. 773, 776-77 (2001) (discussing the differences in the legal doctrines associated with areas mixing contract rights and property rights due to the costs and benefits associated with different types of rights).

[125] *See* Herbert A. Simon, *Designing Organizations for an Information-Rich World*, *in* COMPUTERS, COMMUNICATION, AND THE PUBLIC INTEREST 37, 40-41 (Martin Greenberger ed., 1971) (noting that an abundance of information results in a scarcity of attention).

arise in contract, and are solved with a different mix of private and public solutions, such as making contracts shorter or enforcing reasonable consumer expectations.[126]

One reason that servitudes present a problem of informational detail is that they implement a governance strategy. Basic exclusion (e.g., "keep off" boundaries) is a platform upon which we can build governance regimes—i.e. rules of proper use. Governance rules refine and supplement the basic exclusionary regime when particular use conflicts are important enough. Governance rules in the law can be contractual, from common law, or some combination of statute and regulation.[127] Servitudes are a largely private governance regime. One possibility here is that courts have little problem with servitudes as long as they can be said to refine and supplement the basic exclusionary regime. Servitudes that are not refinements but are unrelated (e.g., the sale or lease of a shop partially in return for free haircuts), or more than a mere refinement (e.g., going outside the copyright baseline), present information problems that normal governance regimes do not.

Intellectual property servitudes arise in the context of licensing. An intellectual property license is like an easement in real property in that the default is nonrevocability. But, intellectual property servitudes are highly contractual. The question becomes what limits, if any, the law should impose on intellectual property servitudes, and why. The law has always been more suspicious of personal than real property servitudes, but this area of the law has been undertheorized.[128] Recently Molly Van Houweling has explored the "new servitudes" in intellectual property, examining how they implicate some of the traditional concerns with servitudes both more and less than do real and personal property servitudes.[129] In particular, she shows how licenses can conflict downstream, as in the cases of the GPL Version 2, under which the original Linux kernel was created and licensed, and

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[126] *See* Smith, *supra* note 83, at 1176 (discussing boilerplate language in contracts).

[127] For the role of governance regimes in intellectual property, see Smith, *supra* note 35, at 1782-98.

[128] *See, e.g.*, Zechariah Chafee, Jr., *Equitable Servitudes on Chattels*, 41 HARV. L. REV. 945, 977-87 (1928) (surveying case law and explaining objections to equitable servitudes on chattels); Zechariah Chafee, Jr., *The Music Goes Round and Round: Equitable Servitudes and Chattels*, 69 HARV. L. REV. 1250, 1254-56 (1956) (acknowledging the scarcity of authorities enforcing equitable servitudes on chattels). For a recent contractarian argument, see Glen O. Robinson, *Personal Property Servitudes*, 71 U. CHI. L. REV. 1449, 1449-55 (2004).

[129] Molly Shaffer Van Houweling, *The New Servitudes*, 96 GEO. L.J. 885, 924-50 (2008).

the Wikipedia GNU Free Documentation License.[130] These licenses mandate that further works incorporating the licensed material be made available on the same terms; the problem comes when these terms of openness are detailed and potentially conflict with later visions of openness. A later work may incorporate material that is licensed in two conflicting ways, which is a general problem with licenses that are meant to apply to somewhat remote and indefinite parties. The conflict is somewhat reminiscent of water law, in which property rights definition is difficult because it is desirable or unavoidable that water rights interlock tightly (the return-flow issue in first appropriation is a dramatic example).[131]

In both IP servitudes and water law, the difficulty of delineating rights with respect to the resource leads to complex interfaces between modules. We need refinements (governance) for a variety of purposes, which complicates this interface when uses interact (e.g., nuisance and servitudes). One difference among land, chattels, and intangibles is that the exclusion strategy is easier to carry out for tangible property. The baseline is clearer: in the case of land, there is a physical bubble that corresponds to the module that the exclusion strategy provides. In intellectual property, by contrast, attempts at exclusion are necessarily artificial. Thus, it is easier for servitudes in intellectual property to lack reference to an exclusion baseline. Admittedly, some have reference to a relatively clear ex ante baseline, as with the Creative Commons licenses favoring use within the scope of the copyright.[132] But some licenses do not use this baseline and, instead, go beyond it (as where rights to criticize are contracted away).[133] The conflicting-license issue would not arise if intellectual property were more naturally modularized; the problem is that, in principle, these servitudes can be about anything and can interact in any way with each other. The modularity of land rights through spatially defined exclusion limits the extent to which servitudes will conflict. Owners will be aware of what a servitude will "cover" (almost literally)

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[130] *Id.* at 941-43.

[131] *See supra* note 103 and accompanying text.

[132] Van Houweling, *supra* note 129, at 938-39.

[133] *See id.* at 938 (providing Microsoft's Vista EULA as an "example of a license that in fact imposes limitations that exceed the baseline restrictiveness of copyright").

in the case of land.[134] Unlike land, software as a resource does not en-
sure this awareness.

Complex interfaces can reduce transferability, as in the case of wa-
ter. In some kinds of property, those setting up property desire li-
quidity, providing more than enough incentive for standardization
(many financial instruments are an example).[135] In other cases, idio-
syncratic rights (fancies) may "pollute" the general informational at-
mosphere, increasing information costs for others.[136] The resulting
general need for others to be on the lookout for additional types of
information in no predetermined format can present an externality
that exceeds the benefits of the idiosyncrasy to the transacting par-
ties.[137] The private incentives for liquidity and the size of the external-
ity, therefore, partly determine the need for standardization. More-
over, as long as the state is involved in enforcing property rights, there
can be economies of scope in the state's taking on the standardization
function.[138]

Many of the issues raised in this Article manifested themselves in
Quanta Computer, Inc. v. LG Electronics, Inc.,[139] a case recently decided
by the U.S. Supreme Court. In that case, the Federal Circuit had
taken a wholly contractarian approach, concluding that the patent-
exhaustion doctrine did not apply to a method patent, thus allowing
the patent holder to license a firm without at the same time licensing
that firm's customers.[140] The Supreme Court, however, reversed, hold-
ing that patent exhaustion was mandatory and that servitudes on intel-
lectual property, including patent-related restrictions on use down-
stream from a licensee, would not run.[141] These problems of
servitudes perched between property and contract suggest intermedi-
ate possibilities. Van Houweling, for example, suggests that the dis-
tinction made in earlier Supreme Court cases between commercial
producing entities and individual consumers (the latter of which may
have more of an everyday expectation of permission to use a physical

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[134] If, however, we followed the legal realists and asserted that there is no core to
the bundle of sticks of rights in land, the situation would be much more similar to the
one that Van Houweling identifies for information goods.

[135] Merrill & Smith, *supra* note 99, at 47 & nn.168, 169.

[136] *See id.* at 26-34 (differentiating the information costs for originating parties, po-
tential successors in interest, and other market participants).

[137] *Id.* at 31-33.

[138] *Id.* at 51.

[139] 128 S. Ct. 2109 (2008).

[140] *Id.* at 2115.

[141] *Id.* at 2113.

article) is potentially a good rule of thumb.[142] For one thing, those manufacturing under a license have more expertise and more at stake than consumers.[143] Accordingly, there is less reason for the law to worry about the processing costs of closer, more-expert dutyholders, particularly those with actual notice.

B. *Remedies*

The question of remedies in patent law is now in considerable flux. Until recently the Federal Circuit made injunctions almost automatic for infringement. In *eBay Inc. v. MercExchange, L.L.C.*, the U.S. Supreme Court reversed the Federal Circuit, holding that courts deciding whether to award injunctive relief for disputes arising under the Patent Act must use a four-factor test said to be used traditionally in equity courts.[144] The majority opinion does not give much guidance as to how this equitable analysis should be applied. Chief Justice Roberts's concurrence suggests that it should usually lead to an injunction.[145] Justice Kennedy's concurrence, on the other hand, emphasizes the desirability of denying injunctions when granting them would not be in the public interest and suggests that nonpracticing entities and holders of patents covering complex products might well be denied injunctive relief.[146] Since *eBay*, lower courts have denied injunctions in more cases than before, but injunctions still seem to be widely available.[147] Nonetheless, there is widespread disagreement on when an injunction should be denied.[148]

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[142] *See* Van Houweling, *supra* note 129, at 932-39 (evaluating the different notice and information costs of licensing practices).

[143] *See* Smith, *supra* note 32, at 1173-77 (examining specialized audiences in various areas of intellectual property).

[144] 547 U.S. 388, 390 (2006). For a discussion of how the four factors and the notion of "tests" do not fully accord with the traditional standard for injunctive relief, see John M. Golden, *The Supreme Court as "Prime Percolator": A Prescription for Appellate Review of Questions in Patent Law*, 56 UCLA L. REV. 657, 695-98 (2009).

[145] *See id.* at 395 (Roberts, C.J., concurring) (acknowledging that while historical practice "does not *entitle* a patentee to a permanent injunction or justify a *general rule* that such injunctions should issue," it is unsurprising that "courts have granted injunctive relief upon a finding of infringement in the vast majority of patent cases").

[146] *Id.* at 396-97 (Kennedy, J., concurring).

[147] *See, e.g.*, Transocean Offshore Deepwater Drilling, Inc. v. GlobalSantaFe Corp., No. 03-2910, 2006 U.S. Dist. LEXIS 93408, at *2 (S.D. Tex. Dec. 27, 2006) (granting injunction); Smith & Nephew, Inc. v. Synthes (U.S.A.), 466 F. Supp. 2d 978, 981 (W.D. Tenn. 2006) (granting injunction); z4 Techs., Inc. v. Microsoft Corp., 434 F. Supp. 2d 437, 444 (E.D. Tex. 2006) (denying injunction); *see also* Benjamin Petersen, *Injunctive*

Much of the worry about injunctions stems from so-called troll behavior, in which an entity purchases weak patents, waits for reliance on them (especially as a minor component of a larger project that is only now crucial because it is difficult to design around ex post), then engages in holdup, demanding compensation greatly out of proportion to the contribution of the patent.[149] Defining trolls has been difficult because the broadest definitions seem overly broad: they would include any nonpracticing entity (NPE)—a company that does not itself manufacture products using the patented invention. Upstream nonmanufacturers do not seem problematic in the way that a firm that purchases weak patents for the purpose of bringing a nuisance lawsuit does. For those most suspicious of intellectual property, trolls are everywhere, and something close to a compulsory license is the answer. If any nonpracticing entity is treated as a troll and is unable to get an injunction, specialization in R&D versus manufacturing is problematic. If nonpracticing and nonlicensing entities are per se problematic, this also gives the first potential licensee a lot of leverage. If the problem is weak patents, the question is whether weeding them out would be better than weakening the remedies, the latter of which could potentially affect stronger patents as well. Perhaps business-method patents, whatever their merits, are inadvisable because they drive courts in the direction of compulsory licenses in general. *eBay* itself involved a software-based business-method patent.[150]

The information-cost theory can help us get a handle on these remedial questions. First, the value of an injunction is not in the intrinsic benefits of exclusion (not that there is any such benefit in regular property). The real question is how much, and in what ways, the injunctive remedy contributes to the option-maximizing and complexity-managing modularity furnished by patent law. With every attempt

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*Relief in the Post-*eBay *World*, 23 BERKELEY TECH. L.J. 193 (2008) (describing trends in patent-injunction cases post-*eBay*).

[148] *Compare* Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 2037-38 (2007) (arguing that injunctions systematically overcompensate), *and* Gerard N. Magliocca, *Blackberries and Barnyards: Patent Trolls and the Perils of Innovation*, 82 NOTRE DAME L. REV. 1809, 1809-12 (2007) (analogizing the patent-troll problem to nineteenth-century "patent sharks"), *with* Vincenzo Denicolò, *Do Patents Over-Compensate Innovators?*, 22 ECON. POL'Y 679 (2007) (finding little evidence of overcompensation), *and* John M. Golden, Commentary, *"Patent Trolls" and Patent Remedies*, 85 TEX. L. REV. 2111 (2007) (critiquing the case for overcompensation).

[149] *See, e.g.*, Mark A. Lemley, *Are Univeristies Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 613-14 (2008) (describing the rise of patent holdup, or the "troll problem").

[150] 547 U.S. at 390.

to second-guess a patent owner's behavior—in terms of (non)practicing, (non)licensing, who to deal with, and so on—patents are less modular. We have partially withdrawn the delegation of development and commercialization decisions from the owner and built additional context into the law's interface between the actors.

Nevertheless, the information-cost theory, particularly in its somewhat unexpected parallels to regular property, suggests limits on injunctions consistent with the traditional approach to equitable relief. The basic limits, familiar from regular property, are based on a combination of detrimental reliance and lack of notice. Interestingly, notice and reliance in the presence of the danger of opportunism were at the heart of traditional equity. I will argue that the information-cost theory of property provides a rationale for equitable analysis as the correct safety valve for enriching the interface between otherwise quite modular rights. In this sense *eBay* can be read as a call for this property-style approach and should, I argue, be given a chance to work as a safety valve before moving, through new legislation or otherwise, further toward compulsory licenses.

Much of the problem with injunctions comes from the fear that the infringer did not know and reasonably could not have known about the patent before engaging in detrimental reliance. As a result, a patent holder can capture a portion of the ex post costs of designing around the patent.[151] If, before the accused infringer's investment, the patent is cheap to design around, but is expensive to design around ex post, the patent holder can wait for a share of the lower of (a) the ex post costs of designing around, and (b) the value of the investment. This need not bear any relationship to the patentee's contribution. Denying an injunction removes this holdup power but at the cost of the benefits derived from delegating decisions to the patentee in the first place and also at the cost of valuing the contribution judicially.[152]

Although the troll problem is seen as a problem peculiar to patent law, this is only true in part. The problem is greater in patent law than in real property because patent boundaries are harder to delineate and because patents, especially in software and business methods,

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[151] *See* Vincenzo Denicolò et al., *Revisiting Injunctive Relief: Interpreting* eBay *in High-Tech Industries with Non-Practicing Patent Holders*, 4 J. COMPETITION L. & ECON. 571 (2008).

[152] *See* Smith, *supra* note 7.

are not considered to be serving their notice function well.[153] But the basic structure of the problem occurs with some regularity in property law, most prominently in building encroachments. In regular property, building encroachments, which have been analogized to infringement, have seen a move towards damages rather than injunctions, partly in the name of avoiding the waste and huge leverage that an injunction would afford.[154] Similar to the concern over trolls in patent law, the problem with building encroachments is that a known boundary is much easier to bargain around ex ante than ex post.[155] Land boundaries are often treated as unproblematic compared to those in intellectual property,[156] but it should not be forgotten that surveying is an art subject to mistakes—especially in the "metes and bounds" system, dependent as it is on markers, angles, and lengths.[157] Importantly, it is not socially optimal to achieve absolute certainty about land boundaries, and innocent mistakes remain. As Stewart Sterk has shown, the private incentive to measure a boundary can exceed the social benefit where property rules give great leverage ex post to the encroached-upon party.[158] Although he notes that pervasive use of liability rules can inadequately protect property, Sterk endorses the use of *eBay* to remove excess leverage and hence oversearching in patent law.[159] But *eBay* is not simply an exhortation to

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[153] *See, e.g.*, JAMES BESSEN & MICAHEL J. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS, AND LAWYERS PUT INNOVATORS AT RISK 29-72 (2008).

[154] *See* THOMAS W. MERRILL & HENRY E. SMITH, PROPERTY: PRINCIPLES AND POLICIES 50-56 (2007) (providing older and newer cases and explaining that "most American courts today would probably deny injunctive relief and award only damages" when encroachment is unintentional and minimal and the hardship to the defendant would be great if removal were required).

[155] For an illustration with a numerical example, see *id.* at 62-67.

[156] *See, e.g.*, BESSEN & MUERER, *supra* note 153, at 53-55 (discussing the difficulties of mapping boundaries of technology in comparison with land); David W. Opderbeck, *Patent Damages Reform and the Shape of Patent Law*, 89 B.U. L. REV. 127, 171-72 (forthcoming 2009), *available at* http://ssrn.com/abstract=1213160 ("A patent is not like a real property deed, which contains a precise ex ante statement of the metes and bounds of the entitlement."); *see also* Corning Glass Works v. Sumitomo Elec. U.S.A., Inc., 868 F.2d 1251, 1257 (Fed. Cir. 1989) ("A claim in a patent provides the metes and bounds of the right which the patent confers on the patentee to exclude others from making, using, or selling the protected invention.").

[157] *See, e.g.*, WILLIAM B. STOEBUCK & DALE A. WHITMAN, THE LAW OF PROPERTY § 11.2, at 820-21 (3d ed. 2000) (noting that "metes and bounds" descriptions are "often lengthy, cumbersome, and rife with potential for error" and that "they must be used with the greatest care," and detailing complications).

[158] Stewart E. Sterk, *Property Rules, Liability Rules, and Uncertainty About Property Rights*, 106 MICH. L. REV. 1285 (2008).

[159] *Id.* at 1333-34.

deny injunctions in cases of "excess" leverage. I argue that the specific content of traditional equitable analysis is keyed to the holdup situation and provides a narrow safety valve that does less damage to the modular exclusion regime than would a more unstructured, pure liability-rule regime of full-blown compulsory licenses.

Before turning to the structure of the equitable test, the use of damages rather than injunctions in continuing trespass is limited to those acting in good faith—those with no knowledge of the other's rights. A bad-faith improver (i.e., one who knows that she is violating the other's rights) still faces an injunction no matter how "wasteful" the injunction would be. Likewise, other exceptions to the stringent application of trespass are keyed to good faith. For example, in open-range areas, animals wandering onto unenclosed land are not considered to be trespassing, but animals directed by their owner to invade another's land are.[160]

How does this apply to patent law? The vagaries of the current willfulness standard are beyond the scope of this Article. The information-cost theory, however, suggests that injunctions should be offered routinely against bad-faith infringers but that, because of the difficulties with notice, this safety valve should be somewhat more expansive than in boundary-encroachment law. A patent that is very unclear or difficult to find, particularly if a result of the patentee's deliberate lack of clarity, could be a factor weighing against an injunction. For example, I have suggested elsewhere that one possible rule would be that infringement only under the doctrine of equivalents, which extends the literal claims to cover a penumbra of hard-to-foresee additional invention space, would result only in damages and not an injunction.[161] Further, a patent owner can ensure that the other party infringes in bad faith by providing individualized notice.

Particularly in light of the special notice problems in patent law, another possibility would be to borrow and strengthen the notion of equitable estoppel in the patent infringement context.[162] If the patent

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[160] *See* Light v. United States, 220 U.S. 523, 537 (1911) (noting that fencing-out rules "are intended to condone trespasses by straying cattle; they have no application to cases where they are driven upon unfenced land in order that they may feed there").

[161] Smith, *supra* note 35, at 1818-19; *see also* Timothy R. Holbrook, *Equivalency and Patent Law's Possession Paradox*, (Chicago-Kent Intellectual Prop. & Tech., Research Paper No. 09-010, 2009), *available at* http://ssrn.com/abstract=1330688.

[162] Currently, for equitable estoppel to apply, the patent holder must make some representation upon which the accused infringer reasonably relied or must otherwise procure the infringer's reliance. *See* Wang Labs., Inc. v. Mitsubishi Elecs. Am., Inc., 103 F.3d 1571, 1581 (Fed. Cir. 1997) (asserting that equitable estoppel "focuses on

owner knows of infringement and waits until reliance occurs, she could be estopped from getting an injunction. This could also be viewed as an application of the clean-hands maxim—although it goes beyond the uses of estoppel in contract, property, and patent law—because some affirmative act or representation is usually necessary in order to estop the party. Current laches doctrine already covers some of this problematic waiting on the part of the patent holder for reliance by an innocent infringer.[163]

Nonetheless, if taken seriously, the traditional equitable test is narrow and structured and is not an invitation to engage in a case-by-case policy analysis dressed up in the four factors. The factors are not really tests but a structured inquiry.[164] First of all, although potentially disappointing to the proponents of compulsory licenses, the order of the factors in the test—irreparable harm, inadequacy of damages, balance of hardships, and public interest—is no accident. In equity, the inadequacy of the legal remedy (here damages) because of irreparable harm was jurisdictional.[165] With the fusion of law and equity this is no longer as important (except for jury trial) but it does potentially serve to cabin equitable analysis to a defined sphere, in which it would act in personam rather than on the world at large. In doing so, equity thus circumscribed poses less of an informational burden and threat to stability than a more free-floating equity would. In this way, equity respects the modular structure of property more than it seems to at first glance.[166]

'misleading' conduct suggesting that the patentee will not enforce patent rights"); Bandag, Inc. v. Al Bolser's Tire Stores, Inc., 750 F.2d 903, 925 (Fed. Cir. 1984) ("One common thread in cases in which equitable estoppel applies is that the actor committed himself to act, and indeed acted, as a direct consequence of another's conduct." (quoting Stickle v. Heublein, Inc., 716 F.2d 1550, 1559 (Fed. Cir. 1983))).

[163] *See* Odetics, Inc. v. Storage Tech. Corp., 185 F.3d 1259, 1272-74 (Fed. Cir. 1999); Sterk, *supra* note 158, at 1334.

[164] Sometimes this structure takes the form of presumptions, as we will see. For a discussion of how *eBay* has confused the issue of the role of rebuttable presumptions in patent injunction cases, see Golden, *supra* note 144, at 696-98.

[165] *See generally* DAN B. DOBBS, 1 LAW OF REMEDIES: DAMAGES-EQUITY-RESTITUTION § 2.11(2) (2d ed. 1993). Although it takes us beyond the scope of this Article, some of the skepticism voiced by Dobbs and even more forcefully by Laycock about the content of the irreparable-injury requirement, DOUGLAS LAYCOCK, THE DEATH OF THE IRREPARABLE INJURY RULE (1991), and the fact that one can point to cases showing all sorts of injuries as irreparable, may reflect more of the discretionary nature of the decision making than a lack of any bite in the standard.

[166] Interestingly, one of the main innovations of equity, the trust, allows complexity to be walled off and largely confined to the parties to the trust, rather than third parties. *See* Merrill & Smith, *supra* note 124, at 849; Smith, *supra* note 32, at 1165-66.

The remaining factors—balance of the hardships and public interest—are also best understood as narrow safety valves. First of all, there is balancing and then there is balancing. The balancing called for in the traditional equitable test is not full-blown cost-benefit analysis or an even weighing of hardship on both sides. Instead, traditional equitable analysis asked whether someone otherwise entitled to an injunction should not get one, in the judge's discretion, in light of a grossly disproportionate hardship on the defendant.[167] Because equity incorporated a standard of behavior and an injunction implements a sanction rather than a price, it is not surprising that decision making here is not a matter of equipoise but rather a rough matter of avoiding egregious errors in an otherwise robust system of injunctive relief.[168] Not surprisingly, writers sensitive to this aspect of the equitable test have suggested that disproportionate hardship should be the standard in building encroachments[169] and, interestingly, in patent law itself.[170]

Likewise, the public interest standard in equity is not an invitation to try to measure social welfare on a case-by-case basis. Rather, it is another safety valve in which a case otherwise eligible for an injunction would pose a major harm to third parties. In patent law this most often has been associated with the public health.[171] There is little support for comprehensive cost-benefit analysis under the traditional public interest test. It is quite doubtful that judges are up to that

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[167] *See, e.g.*, 42 AM. JUR. 2D *Injunctions* § 35 (2005) ("Even if the wrongful acts are indisputable, an injunction may be denied if the payment of money would afford substantial redress and if the injunction would subject the defendant to grossly disproportionate hardship." (footnote omitted)).

[168] Robert Cooter, *Prices and Sanctions*, 84 COLUM. L. REV. 1523, 1523-37 (1984).

[169] *See* Richard A. Epstein, *A Clear View of* The Cathedral*: The Dominance of Property Rules*, 106 YALE L.J. 2091, 2102 (1997) ("[E]ssentially the appropriate solution is to allow injunctive relief when the relative balance of convenience is anything close to equal, but to deny it (in its entirety if necessary) when the balance of convenience runs strongly in favor of the defendant. The usual presumption is that the exploitation risk is greater than the holdout risk. This presumption can be reversed by a showing of the dramatic difference in values . . . .").

[170] Herbert F. Schwartz, *Injunctive Relief in Patent Infringement Suits*, 112 U. PA. L. REV. 1025, 1045-46 (1964) (suggesting a "grossly disparate hardship" standard); *cf.* Doug Rendleman, *The Trial Judge's Equitable Discretion Following* eBay v. MercExchange, 27 REV. LITIG. 63, 85 (2007) ("However, disagreeing with the Supreme Court in *eBay*, I think that balancing the hardships should be a defendant's affirmative defense to an injunction rather than an element of an injunction in plaintiff's case-in-chief.").

[171] *See, e.g.*, City of Milwaukee v. Activated Sludge, Inc., 69 F.2d 577 (7th Cir. 1934) (dissolving an injunction against an infringing sewage-disposal system).

task,[172] and this Article argues that any significant move in that direction carries the costs of undermining the modular structure of entitlements that allows actors to deal with options in a decentralized fashion.

Finally, traditional equitable analysis also used the flexibility built into injunctive relief to moderate hardship.[173] Thus, injunctions can be tailored to the harm and can be delayed in order to give an innocent infringer time to design around.[174]

More speculatively, the information-cost theory of property and intellectual property suggests one source of the controversies over licensing and remedies. In an earlier time, equity served as a safety valve in a strictly defined domain.[175] In that domain, the discretion afforded to judges permitted them to combat opportunism without a widespread weakening of property rights—or so went the theory. In any event, in our legal-realist-inspired era, after the fusion of law and equity, we tend to get a polarization of approaches: either everything should be ex post and equitably based on policymaking, or the legal rules should be ex ante and across the board without exceptions. Both sides in the controversies over intellectual property can invoke either of these approaches, although the intellectual property skeptics are more likely to prefer the equitable approach given the current state of per se rules.

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[172] It is instructive here that even in areas of law like nuisance that are said to involve more even-style balancing, courts do not often engage in true balancing, much less cost-benefit analysis. Smith, *Exclusion and Property Rules, supra* note 7, at 990-1007. Even in the face of obvious waste as in the context of oil fields, limited judicial competence has probably prevented much intervention by courts to prevent waste. *Id.* at 1027-37.

[173] Epstein, *supra* note 169, at 2101, cites *Quinn v. American Spiral Spring & Manufacturing Co.*, 141 A. 855 (Pa. 1928), as an example.

[174] *See* Lemley & Shapiro, *supra* note 148, at 2037-38.

[175] For instance, equity would act in personam and would "follow the law," especially with respect to property rights. *See, e.g.*, 1 JOSEPH STORY, COMMENTARIES ON EQUITY JURISPRUDENCE AS ADMINISTERED IN ENGLAND AND AMERICA §§ 26-27, 30, 64 (Melville M. Bigelow ed., Fred B. Rothman & Co. 13th ed. 1999) (1853) (differentiating between courts of law and equity and explaining the various interpretations of equity "follow[ing] the line"); Howard W. Brill, *The Maxims of Equity*, 1993 ARK. L. NOTES 29; Charles M. Gray, *The Boundaries of the Equitable Function*, 20 AM. J. LEGAL HIST. 192, 202-06 (1976) (illustrating how courts of equity were prohibited from addressing real estate disputes); Roger Young & Stephen Spitz, Essay, *SUEM—Spitz's Ultimate Equitable Maxim: In Equity, Good Guys Should Win and Bad Guys Should Lose*, 55 S.C. L. REV. 175, 177 (2003) (exploring nine equitable principles used by the South Carolina courts, including "[e]quity follows the law" and "[e]quity acts in personam, not in rem").

CONCLUSION

The information-cost theory points to some benefits from the modularity of intellectual property stemming from the structure that it shares with regular property: a base of modular exclusion and an interface of governance rules. Because information is nonrival, the benefits of modularity must be weighed against the costs of exclusion. Key to its operation, however, are the indirectness between the mechanism and the interests that modularity serves, in terms of the appropriation and contracting over returns from rival inputs to invention and commercialization. By contrast, legal-realist-style definitions of property in the NIE, sounding in risk rather than information costs and uncertainty, have trouble explaining why exclusion-based intellectual property rights make any sense at all.