# 5 Toward an economic theory of property in information

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## I. INTRODUCTION

In what sense is intellectual property property? In what sense should it be? These questions would be a lot simpler to answer if we had a good definition of property, before we try tackling the nature and purpose of property rights in information. In this Chapter, I argue that part of the controversy over intellectual property stems from inadequacies in the economic theory of property rights.

Most economists do not put much stock in labels, and 'property' is no exception. New Institutional Economics (NIE) is all about 'property rights,' but the definitions of property in NIE are surprisingly incongruent with traditional notions of property in the law. In this, both law-and-economics and the NIE tend to strip away what is distinctive about property. For many purposes this is just fine. For most economists, property rights are stable expectations of an ability to take certain actions with respect to a resource and to enjoy the return from these resource-centric actions.[1] Thus, someone who has rights to pick berries on Blackacre has property rights (as it happens, a right that would be called a 'profit' at common law). Someone who has fee simple title has property rights to Blackacre of a more sweeping sort. This larger package could, as some would have it, be regarded as a collection of specific rights: the right to collect berries, the right to plant crops, the right to build a house etc., etc. If so, then fee simple ownership of Blackacre differs from the berry-picking profit quantitatively: a fee simple owner has a larger set of expectations of acting and benefitting with respect to Blackacre. In this Chapter, I argue that this merely quantitative bundle-of-rights picture is not only an inadequate theory of property in general but falls especially short when it comes to property rights in information.

Instead I will argue that for reasons of information cost, a different view of property must be incorporated into the NIE and that this picture of property allows us to ask the right questions about intellectual property. To return to our Blackacre example, what the fee simple owner of Blackacre holds can alternatively be summarized by saying that A has a right to keep others generally (including B) off the land or to give permission, as A sees fit, coupled with a liberty to make use of Blackacre in a variety of largely unspecified ways. This definition of property differs from the quantitative bundle-of-rights view in two ways.[2] First, the set of activities or uses is generally not specified. Instead, a boundary is defined over which A is gatekeeper, and this set-up indirectly protects a collection of interests in use that usually need not be separately specified. Although extensionally this is equivalent to having a bundle of profits (for berries, corn) and other use rights, from the point of view of delineation it is not equally costly to set up. The former, boundary-based method is more cost-effective.

Second, the set of people who must respect this boundary or get permission from A is an open-ended one – the right is in rem. So again the set of dutyholders is equivalent to an enumeration of all the people in society (B, C, D, . . .), but capturing it as 'everyone else' is far cheaper.[3]

In both respects – interests in use and dutyholders – the indefinite approach is much cheaper in terms of information cost. The right to Blackacre is a black-box-like *module*, in the sense that what happens inside is of limited relevance to dutyholders who are told to simply keep off. Tortfeasors need not know who the owner is or what she is doing in order to know to keep off and so not to interfere. Likewise, one can navigate the world of personal property like cars in a parking lot by not taking any car one does not own, with no need to know who the owner is or how the car is being used.[4] Furthermore, the broad-brush approach in each case allows A to alter the configuration of rights to uses and the status of dutyholders. The owner also has the right within limits to alter the interface between this package of rights and the outside world as with covenants, easements and teases.[5] As long as the law's prescribed standard set of building blocks is preserved, the owner can subdivide and modify the duties by contract.[6]

It is the indirectness and indefiniteness of property that are crucial to the rationale for property rights in information.[7] Because information is usually nonrival there is no purpose to be served by exclusive rights to consume it. A wide variety of theories of intellectual property have been put forth, with varying degrees of relevance to specific areas of intellectual property, but these theories mostly do not depend on the allocation of rights that is emphasized on the bundle-of-rights view. Information per se does not call for exclusive rights. And to the extent some of these theories do call for limited rights, the quantitative expansion of them does not receive any justification. Instead, it is the need for appropriation of *rival* inputs surrounding the use of information, such as labor and lab space in discovering it and commercializing it, that call for property rights that feature the informational shortcuts – the indirectness in the set of interests protected and the indefiniteness in the set of dutyholders.

I will start by surveying briefly a variety of theories of intellectual property. Many of these theories do not particularly point to property rights in the traditional sense, as opposed to direct government rewards, auctions, and the like. I then turn to three approaches to the appropriation problem – contracting, unjust enrichment with tracing, and intellectual property rights. Each is used over some overlapping and shifting domains. An information cost theory of property based on modular rights and their interfaces allows us to capture some of the contours of rights regimes and partially explain their development over time.

## II. THEORIES OF INTELLECTUAL PROPERTY

Information can be valuable, but unlike many other valuable resources it usually exhibits both features of public goods: nonrivalness and nonexcludability. As for nonrivalness, one consumer can enjoy the plot of a play or practice a useful invention without preventing another from doing so. By contrast, if more than one person tries to eat the same apple or till the same soil, in both cases the two uses conflict. Because, by contrast, with many information goods additional consumption can occur at zero or near-zero

marginal cost, a competitive market will drive the price for a unit – a song file, for example – towards zero. One well-known problem is that the fixed costs in making this flow of marginal units possible need to be covered; these costs include the costs of creation and commercialization. Alternatively, people using rival resources (labor, lab space, and the like) as inputs will sometimes need some mechanism to appropriate the value from combining these resources with norival information.

As for non-excludability, it is possible to keep secrets, and to prevent people from acting in certain ways that relate to information – for example, patent liability for practicing an invention. But these forms of protection are difficult, and some uses of information are almost impossible to prevent.[8] For example, it would be prohibitively costly to prevent people from thinking about any idea without the 'idea owner's' permission. This difficulty with exclusion lies at the heart of Arrow's paradox of information: a seller cannot convince a potential buyer of the value of information without revealing it, but then the potential buyer has the information already and won't pay for it.[9] Methods of overcoming this paradox include not only intellectual property rights, but also reputation, ownership of physical assets (or one's own human capital) complementary to the information, warranties, and so forth. For example, a person with a reputation for having good ideas can offer an idea to another on the understanding that he will get paid if the other uses it. Without such a reputation this deal is not possible because the idea might be something the other already knew or could have found out easily. A simple contract by itself will not do. A partial substitute is the elaborate doctrine on idea submissions. Here usually some form of novelty is required, at least to the offeree, if not novelty in a more absolute sense.[10] Sometimes quasi-contract can apply based on the behavior of the parties, especially if the recipient solicited the idea. Thus for example, if someone proposes an idea for a tourist center near a pipeline, and the company proceeds with the project, a court will look for novelty in order to apply property-like remedies but may apply quasi-contract if the idea was solicited.[11]

Economic theories are not the only possible explanations or justifications for intellectual property rights – competitors include labor-desert theories and personhood – but the US intellectual property system, especially in its core aspects of patent and copyright, is conventionally thought to sound in either Lockean or utilitarian concerns.[12] Probably the most traditional theory and the one that potentially applies most widely across areas of intellectual property is the *reward theory* – that IP rights are rewards for creation of information goods. Intellectual property rights allow creators of information, especially authors and inventors, to reap a return, which in turn provides an incentive to create in the first place. Addressing the problem of nonrivalness, the idea is that the reward will cover the costs of creation (including the opportunity cost of the creator's effort) because a competitive market will not allow cost recovery from the sale of units at the competitive price, which would equal the zero or close-to-zero marginal cost of the additional use.[13]

The main problem with reward theory is that it tells us very little about what form rewards should take. An all-knowing and benevolent social planner could dole out rewards directly. Or the government could buy out patents or auction patents off but keep most of them.[14] On reward theories, the main issue is the *size* of the reward. In this they are reminiscent of the quantitative theory of property rights, only the quantity now is totally one-dimensional: the size of the monetary reward.

Like the reward theory, many other economic theories of intellectual property focus on

some activity of the creator.[15] Some of these theories are mainly of relevance to patents. Thus, patents give an incentive to disclose an invention rather than keep it secret.[16] Patents allow inventions to be exploited commercially without keeping them secret. For useful information that *can* be kept secret, we need some other reason to give it patent protection (if nothing else, the difficulty of specifying which inventions could be kept secret and which couldn't). Others see patents as preventing a wasteful race to invent. Economists starting in at least the 1960s noticed that multiple potential claimants for the patent monopoly/reward could engage in wasteful competition (rentseeking).[17] The rent-seeking theories analogize patent protection to problems of first possession in regular property. The solution there is often to give rights where one claimant is in a much better position to claim (heterogeneity of claimants), and one view is that patent law prevents wasteful races by picking a clear winner early.[18] Conversely, some see patents as giving others an incentive to design around; the promotion of designing around counsels for narrow patents that encourage follow-on inventors.[19]

One activity that forms the basis for a theory with application to patent law and perhaps beyond is *commercialization*. A cluster of related theories stresses the similarity of patents and ordinary property in promoting commercialization. Judge Giles Rich theorized that rewards for inventors are not the centerpiece of patent law but rather that patents encourage those engaging in a wide range of activities to bring an invention – already created in the sense of invented – to market in useful products.[20] On Edmund Kitch's related prospect theory, a patent gives a right to develop an idea, but unlike Rich's commercialization theory, prospect theory emphasizes further inventive activity and the coordinating role of the inventor.[21]

Judge Rich cited the example of Herbert Spencer's 'invalid chair,' which Spencer deliberately did not patent but which no one would market without the exclusive rights of a patent.[22] The chair was invented, but according to Rich the commercialization would have taken place if someone had had a patent. In commercialization theory, private property plays its familiar role in delegating decisions to an owner who then can coordinate development of the invention. Property thus serves as a basis for further contracting.[23] The commercialization theory emphasizes the owner of the patent, who need not be the inventor. The inventor may well not be the one who can best develop or commercialize the invention, but the inventor can sell the patent or license it to others who can. These theories also have a strong entrepreneurial element. The 'entrepreneur' here may – but need not – be the inventor himself.

Inputs to commercialization are not all nonrival – that is, some *are* rival – and exclusive rights over inventions have to be compared with other methods of establishing property rights over inputs. In keeping with the emphasis on the similarities to regular property, commercialization theorists often assert that the patent monopoly often does not (or does not necessarily) give market power.[24] Commercialization theorists emphasize how many patents go into a 'product' as defined by consumer demand. If so, coordination and valuation become very difficult. Whether this leads to contracting or to a patent thicket (a form of anticommons) are empirical questions.[25]

Although commercialization theory is most often proposed for patent law, it is occasionally cited as a justification for copyright and trademark. In these latter areas the commercialization theory is much more controversial, but to the extent one accepts it, it does point to more property-like treatment. Consider trademark. The traditional

theory was the avoidance of consumer confusion, and more recently and controversially trademark dilution can lead to liability.[26] For example, the holder of the Kodak mark might object to its being used in connection with bicycles even though no one would be confused into thinking that the bicycles were made by the manufacturer of photographic equipment.[27] Anti-dilution calls for a more propertized view of trademark, and the idea is in part that the more blanket protection encourages not the development of new or inventive marks but their commercialization. The question here is whether commercialization is important enough and would be furthered enough through stronger trademarks to justify the increased cost of expanding liability.[28]

All of the above theories take as their starting points some benefit that intellectual property rights encourage – invention, commercialization, the promotion of good types of racing behavior, or the suppression of bad racing – but all intellectual property rights, like all property rights in general, come at a cost. Any prevention of access carries with it costs of foregone use, but this is particularly important in the case of a nonrival resource. And the more that use of information is interactive in the sense of benefiting from network effects and cumulative creation, the greater are these costs.

Considering these costs, one looks for some clear benefits on the other side that can only be supplied by intellectual property rights. But here is where the economists' thin definition of property becomes a stumbling block. If all property rights do is determine the size of a reward or allow owners to manage the variance in the returns from information, then buy-outs or auctions are theoretically better than intellectual property rights. They do less to impede access to nonrival information, and they provide the same quantitative rewards. Perhaps there is some administrative cost advantage in intellectual property rights over grants or auctions, but this is not obvious. And putting these administrative costs aside, auctions or liability rules look very attractive indeed, compared to NIE-style 'quantitative' property rights. If intellectual property rights are to receive a positive and normative explanation, quantitative rewards for creation cannot be the whole story.

## III. PROPERTY IN NIE AND LAW

The thin notion of property rights or entitlement does not follow necessarily from the assumptions of the New Institutional Economics. On the contrary, a more complete view of the costs and benefits of various entitlement structures carries the NIE further. An NIE that incorporates the information costs of entitlement delineation and enforcement can provide an explanation for the contours of rights and their changes over time. Interestingly, this more complete NIE-inspired account of property accords in a rough fashion with the legal detail of intellectual property regimes.

In the next Part, I will turn to some specific IP regimes, but to see how property rights in information work, it will be useful to compare three theoretically possible approaches, which are in fact used in various domains of activity involving valuable information. For transaction cost reasons, these three institutional frameworks – contracting, unjust enrichment with tracing, and property in the legal sense – have overlapping and shifting domains. It is the relative domains of these three methods for managing the complexity of interactive activities over information – which include

not just creation but also development, marketing, and follow-on invention – that need an explanation, which an NIE enriched with notions of bounded rationality and modularity can provide.

Traditional property law and its alternatives differ in their degree and type of modularity. All systems of interacting agents who face issues of appropriation and access form a complex system. A complex system is one in which internal interactions are many and multiplex such that is it difficult to infer the properties of the whole from the properties of its parts.[29] Any change to an element of the system can in principle affect any other element or combination of elements directly or indirectly. The number of possibilities rises at least exponentially (in the literal sense). So in a fully interconnected system change is so unpredictable through such ripple effects that change may not be an option, leading to rigidity. The choice, in other words, is between near-chaos and rigidity. One way out of this bind is to break up the system into semi-autonomous components (modules).

Modularization depends on the system being what Herbert Simon termed 'nearly decomposable.'[30] A nearly decomposable system consists of a pattern of interactions such that module boundaries can be drawn so that interactions are intense within the module but sparse and constrained between modules. This allows for information hiding: decisions in one module can be made largely without regard to what is happening in other modules, with the only constraint being the 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. By contrast in a nonmodular structure, any part could potentially impact every other, requiring superhuman efforts at acquiring and tracking information.

Property modules allow for bundling that is not captured by regarding a bundle as the mere sum of its constituents. In property, the exclusion strategy results in property being not just a bundle of sticks but something more – something that high transaction costs preclude us from accomplishing by contract. One of the functions of property is that it is a shortcut over all the bilateral contracts (or regulations) that would have to be devised for every pair of members of society in all their various interactions (A's right to grow corn on Blackacre as against B's trampling, same against C, etc.; A's right to park a car on Blackacre as against B, etc., etc). And intellectual property law provides a modular platform for the interactions of parties, especially when it comes to commercialization. Although exclusive rights have their costs – and because of the nonrivalness of information itself these costs are more apparent in intellectual property than in property – the modular bundling in intellectual property can serve to manage the complexity of coordinating rival inputs to commercialization.

A thought experiment captures the role that modularity plays in the basic architecture of property and intellectual property. Legal relations are superimposed on a set of actors and activities. Let $M$ be the set of $m$ actors and $L$ the set of interactions between them. This can be modeled by a graph with nodes $M$ and links $L$. A world in which the legal system tracked every potential interaction would be modeled by the full graph, in Figure 5.1 for $m = 10$. Pick one node, say $m_{10}$. Compare the value of the least valuable link with the cost of the complexity it adds. The benefits of the link are likely to be linear, especially because other links can serve as substitutes. But from a complexity point of view, the

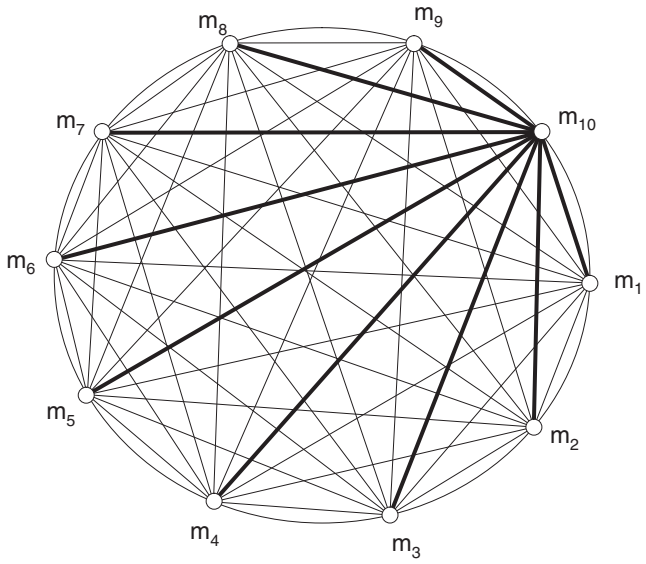


*Figure 5.1 Complete graph, m = 10*

last link, say ($m_{10}$, $m_5$), causes each of the nodes to link indirectly with every other node. Thus, as is familiar in modularity theory, the complexity costs are at least exponential.[31] In the complete graph (for the fully nonmodular system), each added node $m_n$ adds $n - 1$ links to the system, as illustrated in Figure 5.1 by means of the heavy lines for the links radiating from node $m_{10}$. This suggests that anything close to the nonmodular system will be far from optimal.

In many systems including the property-tort-contract-restitution system, i.e. basic private law, most links will not be very relevant, or will be weak. (Each link can be associated with a strength, but for simplicity's sake we assume for now that all links are of equal strength.) Although the level of modularity that is most suited to a system depends on empirical evidence that we only partially possess, as mentioned earlier there is a large literature on optimal modularization. Thus, in our example, if the system is nearly decomposable, we can group the system into modules. An easy case is illustrated in Figure 5.2. In this example all the nodes within each module are interconnected. As for relations between modules, they are much more sparse. Here the pattern of interactions indicates three modules with the interface between the left ($m_6$-$m_7$-$m_8$) and bottom ($m_2$-$m_3$-$m_4$-$m_5$) modules consisting of the link ($m_4$, $m_7$), the interface between the right ($m_1$-$m_9$-$m_{10}$) and bottom modules consisting of the links ($m_4$, $m_9$) and ($m_1$, $m_2$), and the interface between the left and right modules consisting of the link ($m_1$, $m_6$). If we wanted further modularization one or more of these four interface links would have to be suppressed, at some positive cost.

It is worthwhile to consider now how the complexity of actors' interactions in appropriation and access to information might be guided by three types of institutions: contracting, restitution with tracing, and property

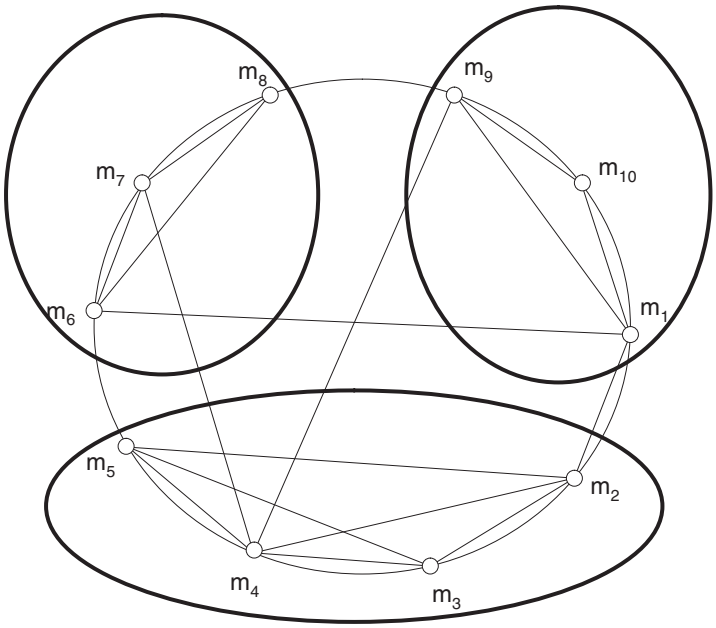


*Figure 5.2 Modular system, m = 10*

## A. Contracting

In accordance with Coase's thought experiment of the zero transaction cost world, it is customary to think of contracting as an alternative institutional arrangement.[32] It is true that in a zero transaction cost world any institutional arrangement that operates without costs would theoretically maximize wealth. But because the contract is a basic unit of analysis and the gains from trade are familiar, the full contracting environment is the conventional benchmark.

The idea of gains from trade is a familiar one, and bilateral contracts can be easily envisioned as exploiting gains from trade. Of course there are obstacles to achieving these gains because the costs of contracting are positive. In a positive transaction cost world, some of these contracts might not occur, making the initial setting of the 'entitlement' potentially relevant from a wealth-maximizing point of view.

In a world of no transaction costs all the necessary appropriation could occur with no sacrifice of access, all by means of consensual contacts. In such a world it would not matter what the initial entitlements were; everyone would bargain their way to the wealth-maximizing result given the initial entitlements. In the case of a nonrival resource like information, any value to be gained through additional access would occur through contracts. Perfect price discrimination, which would eliminate the deadweight loss, would be just one of the many possible costless contracts in the zero transaction cost world.

Moreover, other problems associated with the appropriation–access tradeoff would also be costlessly solved through contracts in the absence of transaction costs. Employees and their employers would contract for the optimal level of inventive efforts and

development, idea submitters would overcome Arrow's paradox of information and would costlessly bargain with those who can use their ideas, and in general any licensing that has any positive value would happen. Either full control of ideas by the originators or a universal public domain could be the starting point.

In a world of positive transaction costs, such contracts may or may not occur, and when they do they consume resources. This makes the institutional-choice question central. One issue with universal contracting in principle is its contribution to complexity. Consider the employee invention again. Without intellectual property rights, the set of all the inputs contributed by anyone in the firm might impact the value of any other. The problem of keeping separate what the employee contributed in her personal capacity versus as an employee would multiply. Contracts would have to sort out the claims to value made by any of the firm's stakeholders (and possibly persons further afield who claim to be idea submitters) on the value of the final output.

Returning to Figure 5.1, the links in the full graph could be interpreted as potential contracting channels. If so, one might ask whether the possibility of contracting keeps all the links alive and therefore makes the modularity-based theory inapplicable. To this it can be pointed out that the law of property does *not* allow unlimited contracting. One interpretation of mandatory standardization in property, through the *numerus clausus* and related devices,[33] is that property prevents contracting from undermining the basic modular architecture of the system.

### B. Tracing and Restitution

Another alternative to intellectual property would be a generalization of the law of tracing.[34] Tracing allows a plaintiff's claim to relate to a succession of assets and to follow the assets into remote hands. Thus if B steals A's car, sells it for $10,000 and puts the money in B's own bank account, A can claim the $10,000 in the account. Because B is a wrongdoer, presumptions work in A's favor. So if the bank account had $5,000 before 'A's' $10,000 was added, B adds the $10,000 and then withdraws $5,000 to bet at the racetrack, A can claim B's winnings. It is presumed that B used A's $10,000 to win at the track. If, however, B loses the $5,000 at the track, then we trace A's claim to the amount still in the account. Sometimes tracing claims can follow an asset in a transfer from B to C, for example if B stole A's car and gave it to C. American law with only a few exceptions enables A to claim the car back even if C paid for it, leaving C with a claim against B.[35] The law, however, does not allow unlimited tracing, and makes tracing available mainly where the primary actor involved is a wrongdoer.

We could imagine generalized tracing, where property claims were made in the narrowest fashion and the claims would float around, impacting those who interact with the assets in question. Thus, A might improve an object and have a lien that travels with the object into remote hands. We could imagine various liens interacting with each other, extinguishing each other, and so on. The more levels of tracing we allow and the more general the contexts in which we allow it, the closer we come to a property system that would look like the complete graph in Figure 5.1. In intellectual property, someone would on this hypothetical system be able to claim an inventive contribution – the light bulb is the famous example – and then 'trace' its effects to remote hands and make a claim against all remote beneficiaries.

Our property system is not like this, and it is worthwhile to consider why it is not. The full tracing system would be like coupling a tort law with no limits like foreseeability or duty constraints with an unlimited law of unjust enrichment.[36] Actual tort law places severe limits on which contextual variables are relevant,[37] and unjust enrichment is even more limited in its scope with respect to nonconsenting parties.[38] Property law limits interdependencies even more severely, as we have seen. Most of the possible interactions between any arbitrary pair of actors are weak or nonexistent. So ruling them out in principle is low cost. At the same time ruling such interactions out – simplifying the interface between modules – is likely to decrease complexity costs for the reasons discussed earlier.

### C. Property in Information and Rights to Things

What this thought experiment shows is that some (severe) limits on interdependencies are likely to be worthwhile and that the basic property element in property and intellectual property can be seen as serving this limiting function. What we still need is a theory of which modules and interfaces are (and should be) chosen, and how decentralized the modularization of the system should be. Work on community structure and optimal modularization can be a source of testable hypotheses. In particular, the application of network theory, community structure, and the notion of the strength of ties in social networks is well-established.[39] These theories, along with the organizational modularity literature, draw in turn on general modularity theory. These implications I leave for further work, but modularity theory provides some hypotheses about the tradeoffs in IP and some pointers to empirical evidence.

Intellectual property employs the same strategies as regular property, ranging from exclusion to governance, but because information is a special type of resource, the combinations of these strategies will differ from one IP regime to the next and from IP to regular property. Nevertheless, the same basic architecture of defining a modular thing and using on/off exclusion rights as a starting point, supplemented with rules of proper use, can be discerned even in IP. I will turn in the next section to how this approach to delineation allows for coordination of various parties who might commercialize information.

The economics of intellectual property tends to emphasize either one of two facets of the problem – the need for incentives or the nonrivalness of information – neither of which does much to explain the details of the delineation issues in a static or dynamic sense. As mentioned earlier, the need for creators to appropriate does not explain why 'quantitative' thin property rights (in the sense usually assumed in the NIE or 'entitlements' in law and economics) wouldn't suffice thereby obviating broad exclusion rights for owners of IP. On the other side, an exclusive focus on the nonrivalness of information, although likewise important, misses the benefits that modular exclusion based structures can provide in terms of managing the complexity of coordination. For example, the law of employee inventions and the establishment of joint ventures are facilitated though the asset-partitioning effect of IP rights.[40] Moreover, a regime such as patent in which uses are hard to delineate separately relies more heavily on exclusion than does the more tort-like copyright law, in which governance regimes like fair use loom much larger.[41] As we will see in the next Part, a simple model of the supply and demand for different delineation strategies can capture these differences as well as their

trajectory over time. A simple emphasis on either incentives or public goods faces great difficulties in this regard.

Like other resources that are hard to delineate and have public goods aspects, such as water and radio spectrum, intellectual property tends towards a mixture of public and private rights.[42] The modularity of exclusion can help deal with the problems of an information semicommons. In a semicommons, private and common property regimes overlap and interact. This interaction raises the potential for strategic behavior through the enhanced access from the overlap.[43] A tangible (and elaborate) semicommons was the medieval open field system in which the access afforded by throwing open the entire set of privately owned strips to common grazing during fallow periods and right after harvest allowed strategic behavior, such as favoring one's own parcel with manure or trashing others' with excessive trampling of sheep.[44] The benefits and costs of this type of access-through-overlap are more likely in the case of intellectual property: access to information is more difficult to prevent and impeding access to nonrival information is presumptively undesirable.[45] Doctrines like fair use in copyright can be regarded as an overlap between private rights and the public domain, and as a very complicated interface between the two.

But by relying on exclusion as well as governance, the interface conditions provided by intellectual property law make the complexity entailed by this multiple use easier to manage. As in regular property intellectual property helps contracting parties get together and to coordinate their inputs. For example, someone who commercializes an invention by using labor and lab space to make the invention more attractive to consumers or to producers of downstream products need only focus on her contribution and the claims of others (supplemented by whatever contractual license terms are considered worthwhile). Likewise, the owners of those claims need attend only to a subset of the information that the other input owners claim, supplemented by license terms. As in regular property, exclusion in intellectual property rights is not absolute. IP rights are meant to furnish notice to draw contracting parties together.[46] Nonetheless, any property system, including patent, copyrights, and the other branches of intellectual property law, must face the question of what combination of exclusion modules and governance interfaces will most cost-effectively bring parties together and allow them to engage not only in a division of labor but also in a specialization of information.

Which degrees of exclusion and governance are called for and how best to manage a semicommons are empirical questions. Recitation of the benefits of open access in terms of nonrivalness or the benefits of entitlements in terms of incentives tells us very little about the shape those entitlements should take or the forms of protection they should receive. If we are to have property rights, why are they not very thin sticks to engage in very specific uses? If someone invents a new compound, why would a patent cover all uses instead of pre-identified ones (fuel-additive, lubricant, etc.)? If the public domain is important why don't we specify the public rights stick by stick? Lumpiness in delineating rights has its advantages, and the on/off quality of the exclusion strategy allows complexity to be managed through modularity. Where necessary, governance can be used to tailor these solutions – to enrich the interface conditions between modules, as is the case with copyright fair use.

Modularity theory has the potential to be helpful in developing new empirical strategies for studying property. First of all, modularity theory provides an explanation for

why certain aspects of property have been more amenable to conventional economic analysis than others. Governance rules – such as covenants, casements, nuisance and zoning – are more like the rules of contracts and torts and impinge on identified persons. For this reason, we can try to connect variation in those rules with a micro theory of individual behavior. And the behavioral response to changes in the rules is likely described by some linear function. If so, some parts of property law are more susceptible to this approach than others. Thus, the refinements and extensions of the governance strategy can more easily be isolated, and regimes with and without them might present sufficient variation against a nearly constant (or at least unbiased) backdrop of the rest of the property regime.

But what of the exclusion strategy? The bundle-of-rights view would regard this as one more feature that can be turned on or off, or dialed up or down. And in a narrow sense that is true. But if the exclusion strategy is a primary vehicle though which property attains a modular structure, we have to be on the look out for more systemic effects. These are not likely to be easy to isolate, for several reasons. There is a danger in isolating chunks of the property system that do not constitute a module. If we allow such pseudo-components to vary, we are either likely to mistake what true variation is or we are likely not to find anything interesting. On the flip side, modularity theory generates hypotheses about what constitutes a 'component' worth studying. In other words, the modularity-based theory gives us some handle on the granularity of the economic phenomenon.

Likewise, the information-cost theory directs us to potential case studies. One method for doing so is to look at smaller structures like business organizations and joint ventures to get a suggestive idea about larger property issues. This of course is fraught with perils relating to the scalability of the structures in question. But as one avenue of investigation, this is likely to be worthwhile. As a starting point, I turn to some comparative statics below.

More generally, we first need a theory that gives us candidates for what constitutes a component of the system in order to ask the right questions. All empirical work requires a theory, and I am suggesting that the theory needed in NIE to study property rights needs more of an architecture than suggested by the conventional view of property as an arbitrary collection of bare entitlements without much architecture.

Appropriation versus access is the central tradeoff in intellectual property. On the access side, exclusion rights are costly because they deny access to a nonrival resource. Consumption is being denied that would cover marginal cost. Intellectual property, like property and organizations, can be seen as the solution of a complex coordination problem of attributing outputs to inputs. In the intellectual property area, different actors combine inputs with something that can be said to belong to the public. As long as the innovator's or commercializer's rival input is valuable enough and the overall coordination problem of investment, appropriation, and consumption is complex enough, the theory of systems and our experience with human artifacts should lead us to expect a major role for modular solutions.

In this Part I have emphasized the benefits of modularity in terms of managing complexity. These benefits do not come without cost. Modularization may preclude interdependencies of some value or may overlook interdependencies that exist and cause unanticipated trouble.[47] Relatedly, conditions can change and call for a different modularization. Although under a wide variety of circumstances, modular systems

evolve more easily than nonmodular systems, modular systems can get stuck at local optima depending on how much modules can vary and whether variation is random or rationally selected.[48] Particularly promising are studies of modularity that allow for decentralized search and sporadic intervention by a control module (like official decisionmakers or other coordinating institutions) or special intermodular communication (like contracting) in order to improve the evolutionary path of the modular system under changing conditions.[49]

## IV. APPLICATIONS

As we have seen, the information cost theory shows how intellectual property rights could be part of the solution to the appropriation–access tradeoff. Whether and to what extent they are justified in these terms requires empirical analysis. The information cost theory of property leads to a number of testable propositions and helps explain the contours of the intellectual property system.[50] I first turn to some simple comparative statics which allow some rough predictions of the direction of change in IP systems. Next I turn in particular to the benefits of modular IP in terms of asset partitioning and coordinating inputs to developing information as a resource. Finally, I show how the information cost theory of modular IP also helps explain the law's response to the problem of IP compatibility

### A. Comparative Statics

The information-cost theory generates predictions about the likely direction of changes in property rights, in a Demsetzian sense.[51] We do not need to know the exact size of various quantities in order to be able to predict a move from exclusion towards governance or vice versa. Consider a simple model of exclusion and governance, and a few of the propositions that one can derive from it. A graphical version of this model with the cost structures of exclusion and governance can be illustrated as in Figure 5.3, with Wealth (W) depicted on the *y*-axis and precision (p) depicted on the *x*-axis:[52]

The marginal cost of exclusion (*MCE*) starts out low at low levels of precision, but increases rapidly. First cuts at defining a resource and preventing the most basic forms of theft by all sorts of pilferers and trespassers will use informational variables (proxies) with this cost structure. But fences and such measurement devices are not good at regulating uses in a finegrained way. By contrast, informational variables of the governance type start out with high marginal costs (*MCG*).

Dynamically, as marginal benefit shifts outward (inward) we expect, in Demsetzian fashion an increase (decrease) in property rights activity.[53] But because the supply curve is made up of components reflecting the various strategies, we can predict a shift from exclusion to governance (or in a more elaborate version of the model, a finegrained efforts at exclusion).[54] An example would be the increasingly stringent rules governing the use of grazing commons in medieval and early modern England before enclosure.[55]

Moreover, as the various components of the supply curve of property rights – the individual strategies – differ or change in cost, we can predict shifts in the relative reliance on exclusion and governance. For example, we can compare patent law and copyright law

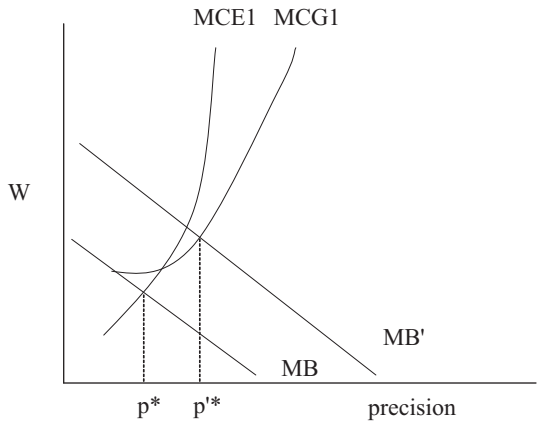


*Figure 5.3 Exclusion and governance for a resource*

in terms of the relative difficulty of setting up modular exclusion-style boundaries versus individualized governance-style rules of use, to explain why patent law is more property-like than copyright (as well as some changes in these areas over time).[56] Likewise, exclusion in the case of water is difficult and the high cost of modularization helps explain why water law has – both in its riparian and, more surprisingly, in its prior-appropriation versions – been more reliant on governance regimes than other areas of property.[57]

## B. Modular Intellectual Property and Asset Partitioning

Indirect intellectual property rights allow transacting parties to cooperate without delineating the rights to their inputs. This is important in joint ventures. Each of the participants in the 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. That is, the asset-partitioning function of intellectual property is important because it partitions the related *rival* assets and inputs at the same time.[58] In this way the partitioning effect and the attribution of returns in a team-production-type problem are closely related.[59] As modularity promotes specialization in organizations and production teams generally,[60] there is evidence that intellectual property rights promote specialization in firms.[61]

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.[62] Sometimes this happens precisely because intellectual property rights serve as a convenient reference point even in advance of or apart from any need to delineate more accurate provisions relating to particular possibly unforeseeable (rival) inputs. For example, intellectual property rights can make the law of employee inventions simpler.[63] 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[64] – appears as 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 for information at all, rather than some system of direct rewards or restitution with tracing.

One main issue here is notice, and in particular the most cost-effective method of furnishing it. Although systematic and centralized property records do often provide effective notice (most notably in the case of land),[65] it is an empirical question how they stack up against other methods in any given type of situation.[66] Other methods include standardization, equitable doctrines of notice (which apply in personam and not in rem), and doctrines absolving those encountering rights from liability. 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.[67]

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.[68] 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 (as in the case of 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 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.[69]

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 from some combination of statute and regulation.[70] 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 rather 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 by controlling rights to criticize) present information problems that normal governance regimes do not.

### C. Intellectual Property Compatibility

Licensing has implications for the modular structure of intellectual property. Licensing occurs at the interfaces between IP modules and, through licensing, transactors can modify those interfaces.

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 of the license. 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 property servitudes than in real property, but this area of the law has been undertheorized.[71] 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 real and personal property servitudes do.[72] 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 the Wikipedia GNU Free Documentation License.[73] 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 licensed in two conflicting ways. This 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).[74]

In both IP servitudes and water law, the difficulty of delineating with respect to the resource leads to complex interfaces between modules. For a variety of purposes, we need refinements (governance), which complicate 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.[75] But some licenses do not use this baseline and instead go beyond it (as where rights to criticize are contracted away).[76] The conflicting license issue would not arise if intellectual property were more naturally modularized: the problem is that these servitudes can in principle be about anything and interact in any way with each other. The modularity of land rights through spatially defined exclusion limits the extent to which servitudes will come into conflict. Owners will be aware of what a servitude will 'cover' (almost literally) in the case of land.[77] Unlike land, software as a resource does not ensure this.

Complex interfaces can reduce transferability, as in the case of water. In some kinds of property, those setting up property desire liquidity, and this is more than enough incentive for standardization (financial instruments are sometimes an example).[78] In other cases, idiosyncratic rights (fancies) may 'pollute' the general informational atmosphere, increasing information costs for others.[79] 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 parties.[80] The private incentives for liquidity and the size of the externality, therefore, partly determine the need for standardization. Moreover, as long as the state is involved in enforcing

property rights, there can be economies of scope in the state taking on the standardization function.[81]

Many of the issues raised in this Chapter manifested themselves in *Quanta Computer v. LG Electronics, Inc.*,[82] 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, allowing the patent holder to license a firm without at the same time licensing that firm's customers.[83] The Supreme Court, however, reversed, holding that patent exhaustion was mandatory and that servitudes on intellectual property, including patent related restrictions on use downstream from a licensee, would not run to remote purchasers.[84] But these problems of servitudes perched between property and contract suggest intermediate possibilities. Van Houweling, for example, suggests that the distinction made in earlier Supreme Court cases between commercial producing entities and individual consumers (the latter of whom may have more of an everyday expectation of permission to use a physical article) is potentially a good rule of thumb.[85] For one thing, those manufacturing under a license are a more expert audience with more at stake than consumers.[86] Accordingly, there is less reason for the law to worry about the processing costs of closer, more expert duty holders, particularly those with actual notice.

## V. CONCLUSION

The New Institutional Economics employs a thin notion of property under which most expectations of deriving value from a resource count as 'property rights.' Under these definitions the prospect of a government reward or rights arising under a contract to transfer information would be property rights. Without more, the NIE definition of property is very similar to the bundle of rights picture of property that legal theorists have inherited from the legal realists. In other words, any right that the NIE would label a property right would count as a bundle and could be labeled an 'entitlement' or 'property.' By contrast, the traditional motion of property as a right to a thing good against the world focuses attention on certain aspects of property as being architecturally important. The basic architecture of modular exclusion and interfaces of governance rules manifests itself in dynamic changes in intellectual property, in the asset-partitioning function of intellectual property, and in the issue of the compatibility of intellectual property rights. It is these architectural features that result from the information costs involved in the appropriation/access tradeoff that bring property and intellectual property closer together – rather than simply quantitative rewards.

## NOTES

1. See, e.g., 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.').
2. For present purposes, I am not distinguishing between rights and privileges. The exclusion strategy based on the right to exclude protects many interests in use without further delineation, making them look like

privileges or liberties. But when a given use comes into view in an important resource conflict, it may be singled out as a right.

3. Wesley Hohfeld tried to analyze in rem rights as a collection of in personam rights. Wesley Newcomb Hohfeld, Fundamental Legal Conceptions as Applied in Judicial Reasoning, 26 Yale L.J. 710 (1917), reprinted in Wesley Newcomb Hohfeld, Fundamental Legal Conceptions as Applied in Judicial Reasoning and Other Legal Essays 65–114 (Walter Wheeler Cook, ed. 1923). Others have emphasized that 'in rem' means availing against not only a large but also an indefinite set of dutyholders. See, e.g., Albert Kocourek, Rights in Rem, 68 U. Pa. L. Rev. 322, 322 (1920); Thomas W. Merrill & Henry E. Smith, The Property/Contract Interface, 101 Colum. L. Rev. 773, 783–86 (2001) (breaking notion of in rem legal relation into elements of numerosity and indefiniteness of dutyholders).
4. See, e.g., J.E. Penner, The Idea of Property in Law 29–30, 71 (1997).
5. Henry E. Smith, Intellectual Property as Property: Delineating Entitlements in Information, 116 Yale L.J. 1742 (2007).
6. Thomas W. Merrill & Henry E. Smith, Optimal Standardization in the Law of Property: The *Numerus Clausus* Principle, 110 Yale L.J. 1 (2000); Smith, this volume.
7. Henry E. Smith, Institutions and Indirectness in Intellectual Property, 157 U. Pa. L. Rev. 2083 (2009).
8. R. Polk Wagner, Information Wants To Be Free: Intellectual Property and the Mythologies of Control, 103 Colum. L. Rev. 995 (2003).
9. 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 ed., 1962) ('[T]here is a fundamental paradox in the determination of demand for information; its value for the purchaser is not known until he has the information, but then he has in effect acquired it without cost.').
10. See Mary LaFrance, Something Borrowed, Something New: The Changing Role of Novelty in Idea Protection Law, 34 Seton Hall L. Rev. 485 (2004). New York now takes an intermediate approach under which novelty in general (to all) is required for misappropriation but only novelty to the defendant is require in quasi-contract. Apfel v. Prudential–Bache Securities Inc., 81 N.Y.2d 470 (1993); see also Nadel v. Play-By-Play Toys & Novelties, Inc., 208 F.3d 368 (2d Cir. 2000).
11. See Reeves v. Alyeska Pipeline Service Company, 926 P.2d 1130 (Alaska 1996).
12. See, e.g., Robert P. Merges & Jane C. Ginsburg, Foundations of Intellectual Property 21 (2004) (noting that the ''utilitarian' view of intellectual property is widely held to be the intellectual foundation for U.S. intellectual property law'); Justin Hughes, The Philosophy of Intellectual Property, 77 Geo. L.J. 287 (1988) (analyzing Lockean justifications close to Founders' vision and more European-style Hegelian theories).
13. On the problems of marginal cost pricing as a benchmark for subsidies, see John F. Duffy, The Marginal Cost Controversy in Intellectual Property, 71 U. Chi. L. Rev. 37 (2004).
14. See, e.g., Michael Abramowicz, Perfecting Patent Prizes, 56 Vand. L. Rev. 115, 123–24 (2003); Steven Shavell & Tanguy van Ypersele, Rewards Versus Intellectual Property Rights, 44 J.L. & Econ. 525, 534–45 (2001).
15. For a summary of a wide range of theories of patent law, see A. Samuel Oddi, Un-Unified Economic Theories of Patents – The Not-Quite-Holy-Grail, 71 Notre Dame L. Rev. 267 (1996).
16. See, e.g., Rebecca S. Eisenberg, Patents and the Progress of Science: Exclusive Rights and Experimental Use, 56 U. Chi. L. Rev. 1017, 1028–30 (1989).
17. Yoram Barzel, Optimal Timing of Innovations, 50 Rev. Econ. & Stat. 348 (1968); Jack Hirshleifer, The Private and Social Value of Information and the Reward to Inventive Activity, 61 Am. Econ. Rev. 561 (1971); see also Mark F. Grady & Jay I. Alexander, Patent Law and Rent Dissipation, 78 Va. L. Rev. 305 (1992).
18. Dean Lueck, The Rule of First Possession and the Design of the Law, 38 J.L. & Econ. 393, 399–403 (1995).
19. State Indus. v. A.O. Smith Corp., 751 F.2d 1226, 1236 (Fed. Cir. 1985) ('One of the benefits of a patent system is its so-called 'negative incentive' to 'design around' a competitor's products, even when they are patented, thus bringing a steady flow of innovations to the marketplace.'); F. Scott Kieff et al., Principles of Patent Law 70–71 (4th ed. 2008).
20. See Giles S. Rich, The Relation Between Patent Practices and the Anti-Monopoly Laws, 24 J. Pat. Off. Soc'y 159, 177–81 (1942) (arguing that promoting the commercialization of inventions is the most important function of patent law); see also F. Scott Kieff, Property Rights and Property Rules for Commercializing Inventions, 85 Minn. L. Rev. 697 (2001) (arguing for commercialization theory).
21. Edmund W. Kitch, The Nature and Function of the Patent System, 20 J.L. & Econ. 265, 276–77, 284 (1977) (discussing, inter alia, the role of patent prospect in giving 'the patent owner . . . an incentive to make investments to maximize the value of the patent,' including investments in manufacture, distribution, and market development).

22. Giles S. Rich, The Relation Between Patent Practices and the Anti-Monopoly Laws, 24 J. Pat. Off. Soc'y 85, 179 (1942).
23. See, e.g., F. Scott Kieff, Coordination, Property, and Intellectual Property: An Unconventional Approach to Anticompetitive Effects and Downstream Access, 56 Emory L.J. 327 (2006); Robert P. Merges, A Transactional View of Property Rights, 20 Berkeley Tech. L.J. 1477 (2005); Paul J. Heald, A Transaction Costs Theory of Patent Law, 66 Ohio St. L.J. 473 (2005).
24. See, e.g., Edmund W. Kitch, Elementary and Persistent Errors in the Economic Analysis of Intellectual Property, 53 Vand. L. Rev. 1727, 1729–31 (2000); see also Herbert Hovenkamp, Federal Antitrust Policy: The Law of Competition and Its Practice §10.3c (2d. ed. 1999) (``[M]ost patents confer absolutely no market power on their owners.'); but cf. Mark A. Lemley, The Economics of Improvement in Intellectual Property Law, 75 Tex. L. Rev. 989, 1048–67 (1997) (arguing for importance of market power with respect to improvers).
25. See, e.g., Eric G. Campbell et al., Data Withholding in Academic Genetics: Evidence from a National Survey, 287 J. Am. Med. Ass'n 473, 477 (2002) (reporting that 47% of academic geneticists said that another academic had refused at least one of their requests for data or materials associated with a published article at least once in the preceding three years); Stephen Hilgartner & Sherry I. Brandt-Rauf, Data Access, Ownership, and Control: Toward Empirical Studies of Access Practices, 15 Knowledge 355, 359, 363–66 (1994) (discussing strategic issues involved in decisions to grant access to data); Fiona Murray & Scott Stern, Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis, 63 J. Econ. Behav. & Org. 648 (2007) (finding modest effect of property rights on flow of information); Carl Shapiro, Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting, in 1 Innovation Policy and the Economy 119 (Adam B. Jaffe et al. eds., 2001); John P. Walsh et al., Effects of Research Tool Patents and Licensing on Biomedical Innovation, in Patents in the Knowledge-Based Economy 285 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) (noting that a survey of industry participants found that patents on research tools generally have not caused much breakdown or even restricted access as anticommons theory would suggest, and documenting various solutions to the fragmentation problem, including licensing, inventing around, infringing, public disclosure, and litigation); John P. Walsh et al., Patents, Material Transfers and Access to Research Inputs in Biomedical Research 2 (Sept. 20, 2005), http://tigger.uic.edu/~jwalsh/WalshChoCohenFinal050922.pdf. Problems seem to be greater in the case of materials transfer than sharing of data. John P. Walsh et al., View from the Bench: Patents and Materials Transfers, 309 Science 2002, 2002 (2005); see also Rebecca S. Eisenberg & Arti K. Rai, Harnessing and Sharing the Benefits of State-Sponsored Research: Intellectual Property Rights and Data Sharing in California's Stem Cell Initiative, 21 Berkeley Tech. L.J. 1187, 1200 n.47 (2006) (discussing studies surveying geneticists on sharing of data and materials).
26. See, e.g., Rochelle Cooper Dreyfuss, Expressive Genericity: Trademarks as Language in the Pepsi Generation, 65 Notre Dame L. Rev. 397 (1990); Stephen L. Carter, The Trouble with Trademark, 99 Yale L.J. 759 (1990).
27. See Eastman Kodak Co. v. Kodak Cycle Co., 15 Rep. Pat. Cas. 105 (1898).
28. The dilution theory has been criticized for overpropertizing trademark. See, e.g., Jessica Litman, Breakfast with Batman: The Public Interest in the Advertising Age, 108 Yale L.J. 1717 (1999).
29. Herbert A. Simon, The Sciences of the Artificial 195 (2d ed. 1981) (1969).
30. Id. at 195–98 (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 (2000); Managing in the Modular Age: Architectures, Networks and Organizations (Raghu Garud et al. eds., 2003).
31. Here they are factorial. See generally Modularity in Development and Evolution (Gerhard Schlosser & Günter P. Wagner eds., 2004); Lauren W. Ancel & Walter Fontana, Plasticity, Evolvability, and Modularity in RNA, 288 J. Experimental Zoology 242 (2000); Günter P. Wagner & Lee Altenberg, Complex Adaptations and the Evolution of Evolvability, 50 Evolution 967 (1996); John J. Welch & David Waxman, Modularity and the Cost of Complexity, 57 Evolution 1723 (2003).
32. See R.H. Coase, The Problem of Social Cost, 3 J.L. & Econ. 1 (1960).
33. See Merrill & Smith, supra note 6; Smith, This Volume.
34. See, e.g., Peter Birks, Mixing and Tracing: Property and Restitution, in 45 Current Legal Problems 69, 84 (1992) (exploring tracing in restitutionary claims); Dan B. Dobbs, Law of Remedies: Damages-Equity-Restitution §6.1 (2d ed. 1993) (discussing the necessity of tracing); Peter B. Oh, Tracing, 80 Tul. L. Rev. 849, 876 (2006) (examining remedial tracing in equity and at common law).
35. See, e.g., Joseph William Singer, Introduction to Property § 16.2.5 (2d ed. 2005). Other legal systems favor good faith purchasers in more circumstances. See, e.g., Saul Levmore, Variety and Uniformity in the Treatment of the Good-Faith Purchaser, 16 J. Legal Stud. 43 (1987). Purchasers with notice are generally not protected. See generally Benito Arruñada, Property Enforcement as Organized Consent, 19 J.L. Econ. & Org. 401 (2003).

36. Here we are considering the law of unjust enrichment as a mechanism for appropriation. On restitution as an interest in intellectual property, see Wendy J. Gordon, On Owning Information: Intellectual Property and the Restitutionary Impulse, 78 Va. L. Rev. 149 (1992).
37. See James M. Anderson, The Missing Theory of Variable Selection in the Economic Analysis of Tort Law, 2007 Utah L. Rev. 255.
38. Andrew Kull, Rationalizing Restitution, 83 Cal. L. Rev. 1191, 1196 (1995); Emily Sherwin, Restitution and Equity: An Analysis of The Principle of Unjust Enrichment, 79 Tex. L. Rev. 2083 (2001); but cf. Hanoch Dagan, The Law and Ethics of Restitution (2004) (arguing for an expansive role for restitution).
39. See, e.g., Aaron Clauset, M.E.J. Newman & Christopher Moore, Finding Community Structure in Very Large Networks, 70 Phys. Rev. E 70, 066111 (2004); M.E.J. Newman, Modularity and Community Structure in Networks, 103 Proc. Natl. Acad. Sci. USA 8577 (2006). For a discussion and an application to community custom, see Henry E. Smith, Community and Custom in Property, 10 Theoretical Inquiries L. 6 (2009).
40. See infra notes 58–63 and accompanying text.
41. Smith, supra note 4.
42. Henry E. Smith, Governing Water: The Semicommons of Fluid Property Rights, 50 Ariz. L. Rev. 445, 475–77 (2008).
43. See Henry E. Smith, Semicommon Property Rights and Scattering in the Open Fields, 29 J. Legal Stud. 131, 131–32, 138–44 (2000).
44. See id. at 134–38, 144–54.
45. See, e.g., Robert A. Heverly, The Information Semicommons, 18 Berkeley Tech. L.J. 1127 (2003); Lydia Pallas Loren, Building a Reliable Semicommons of Creative Works: Enforcement of Creative Commons Licenses and Limited Abandonment of Copyright, 14 Geo. Mason L. Rev. 271 (2007); Smith, supra note 5, at 1765–66; Henry E. Smith, Governing the Tele-Semicommons, 22 Yale J. on Reg. 289, 291–96 (2005); Smith, supra note 43, at 131–32, 138–44, 166–67; Peter K. Yu, Intellectual Property and the Information Ecosystem, 2005 Mich. St. L. Rev. 1, 11–12.
46. See F. Scott Kieff, On Coordinating Transactions in Information: A Response to Smith's Delineating Entitlements in Information,' 117 Yale L.J. Pocket Part 101 (2007). Much recent criticism has focused on failures in the notice-giving function of patent law. James Bessen & Michael J. Meurer, Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk 29–72 (2008). Giving discretion to examiners and judges to deny more patents eliminates the notice problem along with the patents that are denied, but for those that remain the property rights may wind up more unclear than ever. Part of the problem may be solved by using damages as an alternative to injunctions as a limited equitable safety valve. See Smith, supra note 7, at 2125–32.
47. See Oliver Baumann, Coordinating Search in Modular Systems: The Value of (Temporary) Integration (Munich School of Management Draft Mar. 21, 2008), available at SSRN: http://ssrn.com/abstract=1113174.
48. See Stefano Brusoni et al., The Value and Costs of Modularity: A Problem-Solving Perspective, 4 Eur. Mgt. Rev. 121 (2007) (exploring tradeoff between speed of search through modularity and lock in to sub-optimal solutions); Luigi Marengo et al., Decomposability and Modularity of Economic Interactions, in Modularity: Understanding the Development and Evolution of Complex Natural Systems 835 (Werner Callebaut and Diego Rasskin-Gutman eds., 2005). Baldwin & Clark, supra note 30, assume a rationally designed search.
49. Baumann, supra note 47.
50. This Part draws on material from Smith, supra note 7.
51. Henry E. Smith, Exclusion Versus Governance: Two Strategies for Delineating Property Rights, 31 J. Legal Stud. S453, S477–78 (2002).
52. For a discussion of how to operationalize precision, see Smith, supra note 51, at S467–79.
53. See, e.g., Terry L. Anderson & P.J. Hill, The Evolution of Property Rights: A Study of the American West, 18 J.L. & Econ. 163 (1975); Harold Demsetz, Toward a Theory of Property Rights, 57 Am. Econ. Rev. 347 (1967) (Papers & Proc.); Smith, supra note 51.
54. Smith, supra note 51, at S464–78.
55. Id. at S478–83.
56. Smith, supra note 4, at 1799–1819.
57. Smith, supra note 42.
58. See Paul J. Heald, A Transaction Costs Theory of Patent Law, 66 Ohio St. L.J. 473, 480–84 (2005) (arguing that intellectual property has an asset partitioning function like organizational law).
59. Id. at 487–99 (discussing team production issues in involving intellectual property).
60. See Baldwin & Clark, supra note 30.
61. 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, 690 (2007) (discussing intellectual property marketplaces and selectivity issues).
62. See Robert P. Merges, A Transactional View of Property Rights, 20 Berkeley Tech. L.J. 1477, 1479 (2005) (stating that specific aspects of property law 'encourage the making of real-world deals').
63. Robert P. Merges, The Law and Economics of Employee Inventions, 13 Harv. J.L. & Tech. 1, 21 & n.69 (1999) (recognizing a greater emphasis on teamwork and cooperative tasks in patent law).
64. See Henry E. Smith, mind the Gap: The Indirect Relation between Ends and means in American Property Law, 94 Cornell L. Rev. 959 (2009).
65. See 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).
66. See Merrill & Smith, supra note 6, at 43–45 (describing other methods of meeting third-party informational needs).
67. 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).
68. 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).
69. See Henry E. Smith, Modularity in Contracts: Boilerplate and Information Flow, 104 Mich. L. Rev. 1175, 1176 (2006) (discussing boilerplate language in contracts).
70. For the role of governance regimes in intellectual property, see Smith, supra note 4, at 1784–98.
71. See, e.g., Zechariah Chafee, Jr., Equitable Servitudes on Chattels, 41 Harv. L. Rev. 945, 977–87 (1928) (surveying the 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 addressing 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).
72. Molly Shaffer Van Houweling, The New Servitudes, 96 Geo. L.J. 885, 924–50 (2008). Incompatibility of intellectual property can sometimes be remedied by modularity. See, Smith, supra note 7; Joachim Henkel & Carliss Baldwin, Modularity for Value Appropriation: Drawing the Boudnaries of Intellctual Property (Harvard Business School Finance Working Paper No. 09-097), available at SSRN: http://ssrn.com/abstract=1340445.
73. Id. at 941–43.
74. See supra note 57 and accompanying text.
75. Van Houweling, supra note 71, at 938–39.
76. See id. at 938 (providing Microsoft's Vista EULA as an 'example of a license that in fact imposes limitations that exceed the baseline restrictions of copyright').
77. 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 Van Houweling identifies for information goods.
78. See Merrill & Smith, supra note 6, at 47–48. But moral hazard in financial contracting is possible under certain circumstances, and this can provide a rationale for mandatory standardization. See Ayotte & Bolton, This Volume.
79. Id. at 26–34 (differentiating the information costs for originating parties, potential successors in interest, and other market participants).
80. Id. at 31–33.
81. Id. at 51.
82. 128 S. Ct. 2109 (2008).
83. Id. at 2113.
84. Id.
85. Van Houweling, supra note 71, at 932–39 (evaluating the different notice and information costs of licensing practices).
86. Henry E. Smith, The Language of Property: Form, Context, and Audience, 55 Stan. L. Rev. 1105, 1173–77 (2003) (examining specialized audiences in various areas of intellectual property).