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Private and Public Supply of Intellectual Property Rights

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Conventional analysis of intellectual property assumes that it is a precondition for extracting returns on innovation in the face of unauthorized imitation. This is false: public intellectual property rights issued by the state always coexist with private intellectual property rights. The presence of "private IP" complicates assessing the effects of "public IP" on propertization levels in innovation markets and, as a result, on firms' innovation incentives. Those effects differ as a function of firms' costs of substituting toward private IP. The effects of public IP are weakest in the case of large integrated firms, which are sheltered by economies of scale, brand capital, and other complementary assets that can capture value from innovation, and strongest in the case of younger, smaller and less integrated entrants, which do not have comparable access to those private IP alternatives. The differential effects of public IP as a function of firm size and scale imply that changes in public IP influence the set of feasible organizational forms in innovation markets. Strong public IP promotes entrepreneurial environments in which innovators can select from an unrestricted set of organizational forms. Weak public IP promotes hierarchical environments populated by a restricted set of organizational forms consisting of large integrated entities and governmental and philanthropic patronage institutions. These structural effects are illustrated by evidence from selected markets and the political-economic preferences of integrated and non-integrated firms.

Virtually all economic and legal analysis of intellectual property rights ("IP") is driven by a tradeoff between increasing innovation incentives, which demands more IP, and reducing access costs, which demands less. This tradeoff is based on two assumptions. First, IP rights intervene in an environment that is otherwise a public domain free from access restrictions. Second, IP rights determine "propertization levels" in that environment: that is, close off the portion of the stock of technological and creative goods that are subject to access restrictions while leaving the remainder in a public domain free from any such restrictions. Both assumptions are false and, in both cases, for reasons that derive from Yoram Barzel's functionalist definition of property rights as any means by which to consume, or extract value from, a good (Barzel 1997:90). Without those assumptions, the standard tradeoff is no longer a reliable guideline for positive and normative analysis of formal IP rights. The extent of propertization, and the resulting mix of innovation incentives and access costs, no longer moves in tandem with changes in formal IP rights. Even in the absence of state-issued IP rights (what I will call "public IP"), successful innovation environments develop private mechanisms (what I will call "private IP") that regulate access to innovation goods.[1] Just as economic historians have shown that the English commons was never open to all (Dahlman 1980), so too critical scrutiny shows that innovation markets deprived of public IP rights, at least those markets that are successful over time, are not open to all (Barnett 2010). Even if the state makes available public IP rights, those rights often indicate at best the approximate extent of propertization in the relevant market. Parties nominally entitled to those rights often find it too costly to enforce them or employ private IP instruments that waive, extend or otherwise alter those rights (Merges 1996). In general, the extent of propertization, and the implied size of the public domain, can only be reliably assessed by reference to both public and private IP—or more precisely, by reference to innovators' substitution between those two mechanisms for capturing returns on innovation.

A dynamic approach that takes into account innovators' ability to use private IP alternatives must discard the standard assumption that increases in public IP necessarily decrease the size of the public domain or that decreases in public IP necessarily increase it. Increasing public IP may reduce the size of the public domain as expected, leave it unchanged, or even increase it;

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1 By "innovation", I refer to all activities encompassed by the production, testing and commercialization of novel ideas, technologies and creative goods. Where necessary, I refer specifically to subsets of the innovation or commercialization process. This definition applies as well to "innovator", which can refer to an individual, firm or other entity, or "innovation asset" or "innovation good", which refers to the product of any innovation activity.

decreasing public IP gives rise to the same unbounded range of outcomes. Which of those outcomes is realized in any particular case depends on firms' relative cost of substituting toward private IP to extract returns from innovation. Changes in public IP will tend to have the greatest effect on propertization choices (and hence innovation choices) by firms that bear high costs in using private IP; otherwise, those changes will have little effect. In particular, changes in public IP have the greatest effect on propertization choices by smaller, younger and less integrated firms (which I will call "entrepreneurial" firms), who suffer from higher costs of substituting toward private IP, and the least effect on larger, older and more integrated firms (which I will call "hierarchical" firms), who face lower substitution costs. If the state eliminates or reduces public IP significantly, entrepreneurial firms bear escalating costs in regulating access through alternative instruments, expect reduced returns on innovation, and reallocate resources away from innovation. By contrast, hierarchical firms can substitute toward private IP alternatives at no or little cost and therefore are largely impervious to (and, for strategic reasons, often advocate for) reductions in public IP coverage.

Recognizing the abundance but unequal distribution of private IP both constrains and expands the incremental effect of changes in public IP on firms' innovation choices. First, a dynamic approach anticipates that changes in public IP will have different but approximately predictable effects on different firms' costs in capturing value from innovation. Those effects range from trivial to determinative as an inverse function of a firm's age, size and scale. Second, a dynamic approach anticipates that innovators will respond to changes in public IP by selecting an organizational type that minimizes expected appropriation costs (and thereby maximizes expected returns) given the level of protection available under public IP. Together those micro-level organizational choices at each stage of the innovation and commercialization pathway generate macro-level effects on market structure—what I call the "innovation environment".[2] Weak public IP skews organizational choices and promotes hierarchical environments populated by integrated firms protected by scale economies, brand capital, cost-of-capital advantages, and other private IP substitutes. Strong public IP enables innovators to select freely from the entire menu of organizational forms—including, importantly, the option of forming an independent firm

[2] The relationship between intellectual property, firm organization and market structure has received some attention in the economic, management and legal literature. The leading source is Prof. Ashish Arora and co-authors (in particular, Arora and Merges (2004), who explore the relationship between patent rights and firm structure, Arora (1997), who explores the relationship between patent rights and market structure, and Arora & Gambardella (1994), who explore the relationship between patent rights and supply chain structure). To my knowledge, the earliest contribution in this vein is Adelman (1982). For recent contributions in the legal literature, see Verztinsky (2012); Barnett (2011a, 2009a); Kieff (2006); Merges (2005, 2000); Heald (2005); Burk (2004). Other relevant contributions are cited subsequently.

outside any existing entity. As a result, strong public IP supports (but does not mandate) entrepreneurial environments populated by weakly-integrated firms that rely on contract to disaggregate some or all components of the innovation and commercialization process among a pool of least-cost providers.

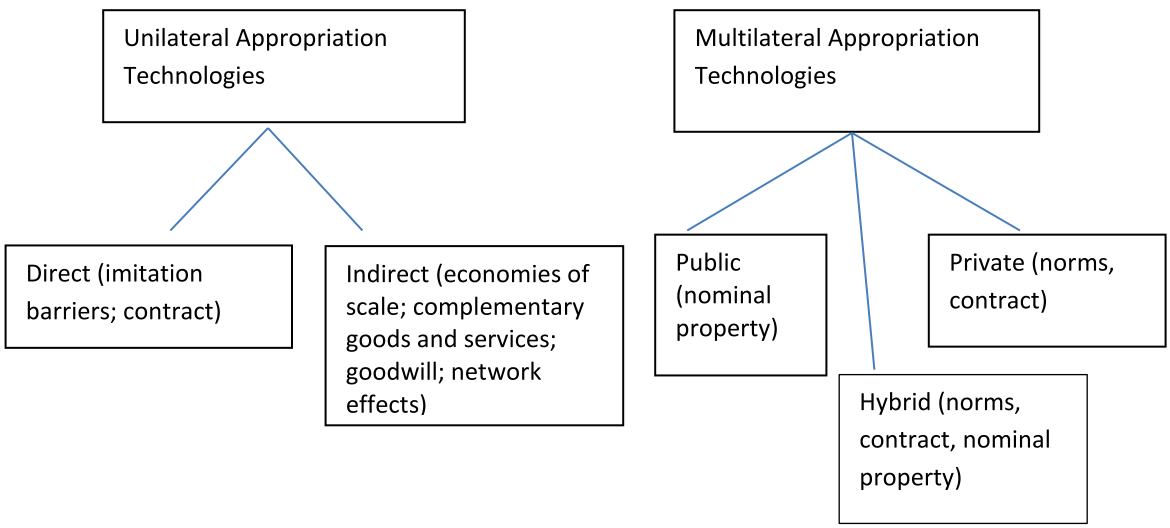
These structural effects on firm and market organization translate into efficiency losses whenever weak public IP compels organizational choices that inflate innovation and commercialization costs beyond the technological minimum that could be achieved under a stronger public IP regime. Those social losses may redound to the private advantage of integrated incumbents by erecting a barrier to entry by innovative but capital-constrained firms, which in turn potentially distorts the pricing, output and variety available to intermediate and end-users in the related product or services market. Two bodies of evidence preliminarily illustrate the effects exerted by changes in public IP on firm and market structure. First, I review selected markets in which patents appear to have enabled entrepreneurial firms to develop disaggregated supply chains that contest the dominant positions of integrated incumbents protected by scale economies and other private IP mechanisms. Second, I review evidence on political-economic behavior that is consistent with the proposed differences in the costs of adopting private IP across integrated and non-integrated firms. Outside of selected industries, large integrated firms tend to support relaxing public IP while smaller, non-integrated and R&D-intensive firms (and their financial backers) almost always take the opposite position.

Organization is as follows. In Part I, I provide a taxonomy of public and private IP rights. In Part II, I describe the firm-level and market-level structural effects of changes in public IP. In Part III, I discuss how these structural effects translate into efficiency effects. In Part IV, I review evidence from selected markets.

I. Intellectual "Property Rights": Redefinition and Reclassification

Legal and other commentary on IP naturally focuses on legal rights—patents, copyrights and other variants—that explicitly regulate access to a given stock of technology or creative assets. This exclusive focus on public IP can both (i) overstate economic rights in cases where legal rights are not well-enforced (a typical case); and (ii) understate economic rights in cases where holders of innovation goods have non-legal capacities by which to regulate access to, or otherwise extract value from, those goods (again, a typical case). Using a functionalist definition of property rights (Barzel 1997:90), public IP is properly understood as *a* member of the set of public and private mechanisms by which an innovator can capture returns on innovation. The set of public and private IP mechanisms—what the management literature calls "appropriation technologies"—can be broken down into two categories: (i) unilateral appropriation technologies; and (ii) multilateral appropriation technologies. The former technology does not require any coordination with other parties and can be implemented without any state intervention; the latter technology requires multi-party coordination and can be implemented with or without state intervention. The graphic below sets forth a taxonomy of these property rights in innovation markets.

Figure I: "Property Rights" in Innovation Markets



A. **Unilateral Private IP**

Innovators can draw on non-legal mechanisms to unilaterally limit access or otherwise extract value from innovation. These mechanisms fall into two categories: (i) direct mechanisms that secure exclusivity over the innovation good and extract value by regulating access over it; and (ii) indirect mechanisms that expose the innovation good to imitation but extract value by securing exclusivity over a complementary portion of the product and services bundle in which the innovation good is embedded. Direct mechanisms include: (i) imitation barriers, which are a function of technological characteristics inherent to, or added to, a particular good; and (ii) contractual agreements that impose restraints on use of the relevant good. Indirect mechanisms include: (i) production, testing, distribution and other efficiencies associated with economies of scale and accumulated know-how; (ii) cost-of-capital advantages; (iii) brand capital and associated goodwill; (iv) network effects and associated switching costs; and (v) the sale of complementary excludable goods or services.[3] Larger firms in some or even most industries rely primarily on these private appropriation technologies to extract value from innovation (Scherer et al. 1957; Taylor & Silberston 1973; Mansfield 1986; Levin et al. 1987; Cohen et al. 2002). Private IP provides a simple explanation for the otherwise anomalous fact that innovative output is often robust in markets in which public IP is weak, unused or absent.

B. **Multilateral Private IP**

Innovators often develop multilateral appropriation technologies that institutionalize exclusive rights to a certain pool of innovation goods. This can be accomplished by lobbying the state to provide legally enforceable property rights with respect to a given stock of innovation goods, resulting in a conventional public IP regime. But it can also be accomplished without (or with limited) state intervention. Any public or private IP regime consists of three basic components: (i) a set of rules that identify the set of protected innovations ("identification rules") and prescribe limits to the unconsented usage of those innovations ("access rules"); (ii) a mechanism for adjudicating disputes between alleged rights holders and alleged infringers; and (iii) a mechanism for enforcing those rules and dispute determinations. These private IP regimes can be situated along a continuum ranging from nearly private regimes that rely mostly on custom to hybrid regimes that rely on a mix of custom, contract, and public IP. The primary categories are as follows below; in each case, I include representative examples.

1. *Nearly Private IP Regimes*

These regimes make little recourse to any state apparatus. Rather, they rely on reputational pressures and technological constraints to regulate access. The most extensive example is provided by the craft guilds that flourished in Western Europe for approximately five hundred years ending approximately at the start of the Industrial Revolution (Epstein 1998).[4] The guilds

[3] The business management literature emphasizes the "first-mover advantage" as a means of appropriating returns in the absence of any constraints on imitation (for a review, see Robinson et al. 1994). This refers to two distinct phenomena: (i) markets with short product cycles and limited imitation barriers that enable first-movers to capture value within the current product cycle; and (ii) markets with long product cycles but characterized by strong consumer inertia. In the first case, the first-mover advantage falls under the rubric of imitation barriers mentioned above; in the second case, the first-mover advantage falls (in part) under the rubric of brand capital mentioned above. Note that brand capital is not an entirely private mechanism insofar as it relies on trademark to protect name and logo.

[4] A purer variant of a private IP regime is provided by the "synthetic" copyrights that were recognized in the U.S. during the period prior to the extension of U.S. copyright protection to foreign authors in 1891. During that time, U.S. publishers developed a convention that recognized an exclusivity period for the publisher that had secured a "reprint" contract with an English author for the sale of his work in the U.S. market. These reprint rights were even transferable. Reputational pressures and the threat of

enforced a set of access rules governing members' use of innovations (Barnett 2010:1794-99; Merges 2004b) and were protected from outside imitators by a monopoly franchise granted by the sovereign. Guild members operated under norms that encouraged sharing technical knowledge within the guild (MacLeod 1988:83) but sometimes were permitted to keep secret certain innovations (Epstein 1998:693-95; Merges 2004b) or received side-payments for certain innovations (Foray & Perez 2006:245). The Stationers' Company, which held the equivalent of a collective copyright on virtually all printed materials in the United Kingdom from 1557 until enactment of the Statute of Anne in 1709 (regarded as the first modern copyright statute), falls under this rubric.

2. *Mostly Private IP Regimes*

These regimes are identical to nearly private IP rights regimes but rely on contract as the principal enforcement mechanism. Rule-promulgation functions are implemented privately by contract but rule-enforcement functions are delegated to the state as an adjudicative entity in any contractual dispute among the parties to this regime.[5] The most notable (and overlooked) example is the corporation, which can bind employees to invention assignment agreements, nondisclosure agreements (and, in some jurisdictions, noncompete agreements), and impose financial incentives (e.g., deferred stock options that discourage attrition), cultivate internal cultural norms and institute technological constraints that limit or discourage the use of innovation assets inside and outside the firm even in the absence of any public IP right. Interestingly, any corporation that achieves some degree of market power substantially replicates the private IP regime formerly implemented by the European craft guild.

3. *Hybrid IP Regimes*

These regimes use contract to regulate access by a large number of firms and other entities to a portfolio of innovation goods protected by public IP rights. This regime is illustrated by the

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pricing retaliation appear to have supported compliance with the system. For fuller discussion, see Khan 2005. Even this example is not an entirely private IP regime insofar as the author's incentives were predicated on the existence of copyright protection in the home UK market.

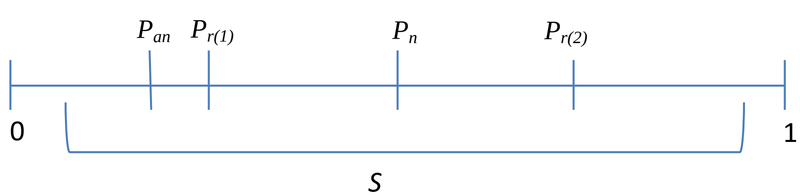
[5] A purer variant of this regime is a privately-administered adjudicative system for resolving contractual disputes. This regime was approximated by the Fashion Originators Guild of America ("FOGA"), a trade association active in the U.S. fashion apparel industry from 1932 to 1941. FOGA was a cooperative initiative by higher-end fashion manufacturers that obtained the contractual agreement of retailers not to purchase products produced by copyists. At its height, FOGA had penetrated more than 60% of the "high-end" and 38% of the "middle-end" U.S. women's apparel market. FOGA came to an end when it was ruled to be an implicit price-fixing scheme in violation of the antitrust laws (*U.S. v. Fashion Originators Guild of America* (S. Ct. 1942)).

extensive patent pooling and other multilateral licensing agreements in historical and contemporary technology and creative industries. Historical examples include: patent pools formed in the late 19th-century by steel producers (MacLeod & Nuvolari 2010) and sewing-machine manufacturers (Lampe & Moser 2009), "semi-automatic" cross-licenses in the 19th-century U.S. railway industry (MacLeod & Nuvolari 2010), international cross-licensing agreements among chemicals manufacturers prior to World War II (Arora 1997), tens of patent pools in manufacturing industries during the early 20th century (Merges 2001), and, continuing until the present day, the BMI and ASCAP copyright enforcement and licensing collectives in the music industry (Merges 1996). Today patent pooling and other multilateral licensing arrangements cover large portions of the semiconductors and consumer electronics industries (Layne-Farrar & Lerner 2007; Teece 2000:194-98; Grindley & Teece 1997:8-10).

C. Assessing Propertization Levels in Innovation Markets

Nominal propertization levels set forth in statutory and case law are at best roughly indicative of (and may sometimes be highly *un*indicative of) real propertization levels in any given innovation market. The real propertization level is a function of (i) public IP rights made available by the state; (ii) the actions undertaken by asset holders to enforce those public IP rights[6]; and (iii) any unilateral or multilateral private IP mechanisms used by asset holders to assert (or waive) exclusivity over the relevant stock of innovation goods. In greater detail, the following 3-step analysis can be used to describe real propertization levels in any particular market. This is represented graphically below, where P denotes the level of propertization, ranging from none at P = 0 to complete at P = 1, and S denotes the relevant stock of innovation goods.

Figure I: Propertization Levels in an Innovation Market



[6] Public IP regimes are typically enforced almost entirely by private action; by definition, the same is true of private IP regimes.

1. *Nominal Propertization*

The nominal propertization level, P_n, is a function of the identification and access rules set forth in the applicable public IP regime.[7] P_n denotes the percentage of the total attributes of *S* that are nominally closed to unconsented use as a matter of formal law.

2. *Adjusted Nominal Propertization*

Properly understood, P_n sets the maximal percentage of the total attributes of *S* that the holder of a public IP right can elect to close to unconsented use by making a sufficient investment in adopting and enforcing the right. The adjusted nominal propertization level, P_{an}, denotes the percentage of the total attributes of *S* that are actually closed by legal action (or the threat of legal action) to unconsented use on an expected basis. The value of P_{an} is a function of the investments made by rights holders in enforcing P_n, as discounted by the probability that any such action is successful. That probability value is a function of the avoidance actions undertaken by enforcement targets and the ideological bias of any state adjudicator or other enforcement agent.[8] The combination of significant application and enforcement costs in the case of most public IP entitlements[9] and the extreme skew in the commercial value of technological and creative output (Scherer & Harhoff 2000) means that the overwhelming majority of innovation goods eligible for public-IP protection are forfeited to the public domain. Real propertization levels therefore lag considerably behind nominal propertization levels. So in general $P_{an} < P_n$.

[7] It would be more precise to say that the nominal propertization level is a function of the lobbying efforts of interested constituencies, subject to the lobbying counterefforts of other interested constituencies, the ideological bias of state actors, and any extant technological constraints. I abstract away from that feature and, for simplicity, assume that the state sets some nominal level of intellectual property protection, which rights holders may then choose to enforce at a selected level of vigor.

[8] In the case of patents, the likelihood of successful enforcement of an intellectual property law right is currently no better than even and has sometimes been much lower. During the periods 1925-1954 (Federico 1956) and 1953-1978 (Koenig 1980), about 35% of litigated patents were found to be valid in court. By contrast, for the period 1989-1994, 56% of all litigated patents were found to be valid (Lemley 1994) and, for the period 1989-1996, 54% of all litigated patents were found to be valid (Allison & Lemley 1998). Note that these figures understate the likelihood that a patent is enforceable because a patentee will only prevail if the patent is found to be both valid and infringed.

[9] The lifetime costs of enforcing a public IP right are especially significant in the case of a patent: application costs (mostly legal fees) plus renewal fees can easily amount to several tens of thousands of dollars while litigation costs can amount to several million dollars in a full-blown litigation. Contemporary and historical data show that most patents are not renewed prior to the expiration of their full term (Moore 2005). The same was true of copyrights when they were still subject to renewal fees (Landes & Posner 2003), which is consistent with the extreme skew in the commercial value of innovation goods.

3. *Real Propertization*

To complete the analysis, it is necessary to identify the unilateral and multilateral private IP mechanisms employed by asset holders with respect to *S*. Any of these technologies can increase real propertization levels beyond the adjusted nominal baseline denoted by P_{an} or, in cases where the holder waives access controls in order to generate sales on a complementary good or service, can depress real propertization levels below $P_{an.}$[10] Taking into account all these actions yields P_r, the real propertization level of a given market. As shown by the two alternatives depicted above, the value of P_r may be higher or lower than the value of $P_{an.}$ Note that, even if $P_n = 0$, the value of P_r may be positive; and *vice versa*. For example, sound recordings enjoyed no formal protection under U.S. copyright law until 1971; however, prior to that date, they were protected against unauthorized replication at cost-equivalent and quality-equivalent levels by technological constraints (meaning, $P_r > 0$ but $P_n = 0$). Today the situation is approximately reversed: sound recordings enjoy robust formal protection under public IP, but significantly degraded protection as an effective matter given the widespread availability of low-cost and quality-equivalent reproduction and dissemination technologies (such that $P_n > P_r > 0$).

II. Dynamic Analysis of IP Rights

Both legal and economic analysis of IP rights follows the natural intuition that increases in public IP coverage always reduce the size of the public domain (and decreases in public IP coverage always expand it).[11] Put differently, this intuition assumes that $P_r = P_n$ (and therefore, if $P_n = 0$, then $P_r = 0$). This assumption does not survive a dynamic approach that takes into account innovators' ability to substitute toward private IP mechanisms in response to changes in the supply of public IP. The value of P_r can deviate significantly from the value of P_n. But this does not mean that changes in public IP exert random effects on propertization levels. Those effects can be approximately anticipated as a function of differences across markets and firms in the costs of using private IP as compared to the costs of using public IP. The net propertization

[10] Note that some indirect unilateral appropriation technologies may give away an innovation asset—that is, extend private IP protections or waive public IP protections—to accrue returns on a complementary excludable asset. Any such giveaway action would constitute a waiver of any applicable public IP rights and would be reflected in the value of $P_{r,}$.

[11] Any "increase" or "decrease" in public IP could take place with respect to any number of attributes of the relevant entitlement, including application fees and procedures, duration, subject matter, scope, available remedies, and enforcement costs. Unless specified more precisely, use of those terms in the following discussion can be construed as covering any of those attributes. For an attempt to map political-economic preferences with respect to multiple specific attributes of the patent system, see Kesan & Gallo (2009).

effects—that is the value of P_r—that result from the interaction of public and private IP often run counter to conventional intuitions.[12]

A. **General Analysis**

Suppose an innovation market that lacks any public IP (that is, $P_n = 0$). However, holders of innovation goods are able to capture returns on innovation through private IP (that is, $P_r > 0$). Now assume the state makes available a public IP right that entitles its holder to deter certain unconsented uses of the protected good. The holder will only adopt that right, and will only make efforts to enforce it, provided the cost of doing so yields an expected net positive gain. Most precisely: the holder will invest resources in enforcing a public IP right only to the extent that doing so delivers an incremental return on innovation at an expected net gain relative to investing those resources in a private IP mechanism or some other use. This decision rule generates stylized predictions of the effects of changes in nominal propertization levels on real propertization levels. Assuming no constraints on the supply of private IP, the effect of any change in P_n on the value of P_r simply depends on the cost difference between enforcing public and private IP rights. I will denote the cost per unit of return on innovation provided by a public IP right as C_{pu}, and the cost per unit of return provided by a private IP right as C_{pr}. For simplicity, I assume that (i) these per-unit costs are constant for any given IP right (that is, there are no diminishing returns to enforcement effort), and (ii) any private or public IP right covers the same set of attributes in the relevant stock of innovation goods (that is, there are no complementarities across different IP rights).

1. *Conventional Case*

This is the standard case (and implicitly assumed to be the universal case in conventional analysis): $C_{pu} < C_{pr}$. Suppose again an innovation market without public IP. If the state makes available a public IP right, then the holder will invest resources in enforcement of public IP so long as doing so yields a positive expected return. Hence the real propertization level increases as would be conventionally expected following an increase in public IP: as the value of an entitlement increases, firms spend more resources on adopting and enforcing it. Conversely, if the state curtails public IP, then firms withdraw resources and the effective level of propertization falls. But even this outcome is not certain, depending on the elasticity of the innovator's demand for protection against unauthorized usage. Withdrawing public IP raises the costs that must be

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[12] Some of the following analysis consolidates and refines my earlier discussion of related topics in Barnett 2009b.

incurred by an innovator to maintain existing propertization levels. This increase in propertization costs may induce innovators to reduce efforts to block such usage, resulting in an increase in the size of the public domain as expected. Alternatively, the size of the public domain may remain unchanged if holders sufficiently value preserving existing propertization levels such that the gains from doing so exceed the increased costs of maintaining that coverage using more costly private IP substitutes.

2. *Neutral Case*

Assume that $C_{pu} > C_{pr}$. Even if the state increases the supply of public IP (and assuming no constraints on the supply of private IP), the holder declines to invest resources in enforcing the entitlement and the real propertization level remains roughly the same. This is a fairly common occurrence: public IP is often unused or underused by the target innovator population. A recent literature documents that much of 19th-century invention in the United Kingdom, the United States and Western Europe took place without any recourse to the patent system (for a brief review, see MacLeod & Nuvolari 2010, Moser 2005)—meaning, some innovators rejected use of the patent system in favor of (presumably less costly) private IP substitutes. On multiple occasions, Congress has introduced *sui generis* statutory protections that have proven unpopular in the target market.[13] The level of *real* propertization in the markets subject to these public IP rights remained largely unchanged. Even if those rights were now abolished, the real propertization levels in those markets would still remain the same.

3. Perverse Case

So far I have identified a conventional case where real propertization levels move in tandem with changes in nominal propertization and an indifference case where real propertization levels are indifferent to changes in nominal propertization. Under certain circumstances, a perverse case is realized: real propertization levels fall when public IP is introduced and increase when public IP is withdrawn. This case relies on the assumption that private IP rights deliver “lumpier” units of “exclusionary power” relative to public IP rights. Suppose a market without public IP but with a powerful but crude form of public IP. As a result, the holder of an innovation asset faces the choice between a zero level of exclusionary power (for example, releasing the

[13] These include a miscellany of underused public IP rights: the Vessel Hull Design Protection Act of 1998 (Olson 2007); the Visual Artists Right Act of 1990; the Architectural Works Protection Act of 1990; the Semiconductor Chip Protection Act of 1984 (Radomsky 2000); and, to a lesser extent, the Plant Variety Protection Act of 1970 (Janis & Kesan 2002) and the Plant Patent Act of 1930 (Stallman & Schmid 1987).

technology into the market without protection) or an extremely high level of exclusionary power (keeping the technology in a secret vault). Now assume the state releases a public IP entitlement that the innovator can use to achieve an intermediate level of exclusionary power at a cost that yields a net gain relative to the existing options of zero or complete exclusion. Intermediate levels of protection can be achieved either by adjusting enforcement efforts or by using public IP rights to tailor contractual provisions that finely regulate usage by a third party. But why would the innovator choose to *reduce* the real propertization level? It will do so whenever reducing the level of exclusionary power increases the innovator's expected revenues. This could occur for several reasons: increasing access makes the asset more attractive to potential buyers, gives buyers an implicit discount in the total cost of accessing the relevant bundle of product attributes, or induces sales of a complementary good in which the holder has a competitive advantage. A perverse (and virtuous) result ensues: increased public IP increases access to the protected good *and* increases the expected return on innovation. By implication, if the state withdraws public IP protection, then the innovator will be compelled to return to use of the more severe private IP right, resulting in a *decrease* in the size of the public domain and, perversely (but viciously), a decrease in the return on innovation.

B. Local Analysis: Market-Level and Firm-Level Effects

In this Part, I pursue the following proposition: the net propertization effects of changes in public IP can be approximately anticipated based on the differences in costs between using public and private IP to achieve returns on innovation.[14] The effect of changes in public IP on real propertization levels will be greatest in the case of firms that bear higher costs of capturing innovative return under private IP as compared to public IP; conversely, those changes will have little to no effect on real propertization levels in the case of firms with lower or comparable costs of capturing innovative return under private IP as compared to using public IP. More formally, changes in the value of P_n are most likely to change the value of P_r, and the implied size of the public domain, whenever the cost of securing a unit of innovative return using private IP exceeds the per-unit cost using public IP (that is, $C_{pu} < C_{pr}$). If using public IP is equally or more costly relative to using private IP (that is, $C_{pu} \geq C_{pr}$), then those changes make no difference with respect to real propertization levels. Assuming no constraints on the supply of private IP, no innovator

[14] For purposes of the following analysis, I exclude differences in "lumpiness" across public and private IP rights. However, as discussed subsequently, I identify additional circumstances in which perverse outcomes arise: that is, increasing public IP depresses real propertization levels, and *vice versa*.

would ever use the more costly public IP alternative (or would substitute indifferently between the two equally-costly IP rights).

1. *Market-Level Effects*

Markets that have different costs of substituting toward private IP will place different values on, and invest different levels of resources in enforcing, public IP. Empirical evidence is roughly consistent with this proposition. Technology markets that are populated by firms with relatively high costs of using private IP tend to make extensive use of patents; conversely, markets that are populated by firms with access to low-cost private IP tend to make little use of patents. Moser (2005) finds that the propensity to patent among late 19^{th}-century American and English inventors correlates inversely with reverse-engineering costs (a form of private IP): as those costs increase in a particular industry, the propensity to patent declines, and *vice versa* in other industries. Studies of contemporary markets find that patents tend to be most highly valued by large firms in the pharmaceutical and certain chemical industries (Taylor & Silberston 1973; Mansfield 1986; Levin et al. 1987, Cohen et al. 2000), which suffer from high invention costs and low reverse engineering costs—that is, private IP mechanisms are weak. Conversely, those studies find that patents are not highly valued by large firms in other industries, which rely on process technologies that are easy to defend through secrecy precautions or, even where reverse-engineering costs are low, can bundle an imitable technology with difficult-to-replicate reputational capital or production or distribution capacities—that is, private IP mechanisms are strong.

2. *Firm-Specific Effects*

Firms that have different costs of substituting toward private IP will place different values on, and invest different levels of resources in enforcing, public IP.[15] Hence, even within a single market, the effects of changes in public IP on firms' propertization choices (and hence, innovation choices) will differ across firms as a function of differences in their costs of using

[15] In the following analysis, I assume that all firms have identical per-unit costs of accessing public IP (but, as stated above, non-identical per-unit costs of accessing private IP). A more realistic analysis would take into account the fact that smaller entrepreneurial firms may be less able to bear the costs of public IP enforcement. However, the arguments above would still follow so long as the "per unit" costs borne by smaller entrepreneurial firms to enforce public IP rights are less than the "per unit" costs borne by those small firms to acquire the complementary assets that can act as a substitute private IP mechanism. That seems reasonable: funding a patent litigation is less expensive than funding a vertically integrated production and distribution infrastructure.

private IP as compared to public IP. Roughly speaking, those costs are an inverse function of a firm's age, size and scale.

a. *Hierarchical Firm*

Let's assume that, for firm A, $C_{pu} > C_{pr}$. Then firm A is indifferent to changes in public IP protection: firm A will always prefer to use private IP and, assuming no constraints on the supply of private IP, will never adopt public IP. To take an example, this roughly describes the reaction of large integrated financial services firms to the extension of patents to financial-method patents by the Court of Appeals for the Federal Circuit in 1998 (*State Street Co v. Signature Financial Group*, 149 F.3d 1368 (Fed. Cir. 1998)). Since that time, large financial services firms have not invested aggressively in obtaining or enforcing patents compared to other industries (Lerner 2008) and continue to rely on secrecy, branding, scale effects, and the sale of complementary goods and services to capture returns on developing new financial instruments (Hunt 2009). As I will discuss subsequently, they have made considerable efforts to limit the scope of that right.

b. *Entrepreneurial Firm*

Now assume that, for firm B, $C_{pu} < C_{pr}$ and, to illustrate the point most dramatically, let's assume further that C_{pr} is so large that firm B would exit the market if it had to bear that cost. In the financial services industry, this might describe a small firm that has no reputational capital, cost-of-capital advantages, or complementary excludable assets by which to capture its investment in a new financial-services product that can be replicated by larger competitors at little cost. Unlike firm A, firm B is extremely sensitive to changes in public IP protection. Any substantial reduction in public IP will compel firm B to exit the market (or, less dramatically, reduce its innovation investment) because it is too costly for it to use private IP. Not coincidentally, it was a small financial-services firm that initiated the patent infringement litigation against State Street Bank & Trust, a large financial-services incumbent, which ultimately led to the *State Street* decision extending patent protection to financial-method innovations. Since that time, small firms and individuals (or their assignees)—that is, firms with weak private IP substitutes—have tended to exhibit behavior virtually contrary to the behavior of large incumbents: they have aggressively adopted financial-method patents and account for a disproportionate percentage of the plaintiffs in infringement litigation relating to these patents (Hunt 2009; Lerner 2008).

c. *Another Perverse Case: Reducing Public IP Reduces the Public Domain*

The effects of changes in public IP on firms' propertization choices depend on firms' costs of substituting toward private IP in lieu of public IP. Firm A has zero or "negative" substitution costs and its propertization choices (and hence innovation choices) are therefore largely or entirely insensitive to changes in public IP; firm B has high substitution costs and its propertization choices (and hence innovation choices) are therefore sensitive to changes in public IP. But this point deserves some qualification. Suppose the state withdraws public IP and, due to the absence of any cost-feasible private IP substitute, firm B exits the market. Assuming no other competitive threats, firm A will then occupy the entire market and might elect to use private IP to increase access constraints over its innovation goods. To see why, consider that the extent to which a firm elects to control access to its innovation goods exerts pricing effects with respect to those goods. If a firm gives away a particular attribute of its innovation good (and does not increase the price of other attributes accordingly), then the price for that attribute is set at zero; if a firm regulates access to a particular attribute, then the price is explicitly set at some positive value determined by market pressures. In a competitive market, firms may be under pressure to give away certain valuable attributes at a zero price. That is the case in two-sided markets such as mobile and desktop computing markets, in which platform holders compete to provide developers with free access to "APIs" (application programming interfaces) for developing applications for the platform, or in search and social media markets, in which platform holders compete to provide users with zero-priced access (Barnett 2011a). In a monopolized market protected by the entry barriers implied by weak IP rights, firm A operates under reduced pressure to provide these implicit pricing reductions. Hence, another perverse outcome results: withdrawing public IP raises entry barriers and protects incumbents, which induces incumbents to implicitly raise prices by limiting access to the relevant innovation good, thereby reducing the size of the public domain. Conversely, if the state restored public IP in that market, firm B would re-enter, restoring competitive pressure and compelling firm A to implicitly lower prices by again forfeiting access to that same good, thereby expanding the size of the public domain.

III. Structural Effects of IP Rights

Any reliable assessment of the effects of nominal changes in public IP on real propertization levels demands a dynamic approach that takes into account firms' ability to use private IP to match or exceed the exclusionary force of public IP. Those substitution responses depend on firms' costs of adopting private IP as compared to public IP, which in turn depend on a firm's age, size and scale. But this approach is still insufficiently dynamic because it takes as given the existing distribution of firm types. Absent regulatory constraints, innovators are free to choose from the full range of organizational forms ranging from the most hierarchical to the most entrepreneurial. This includes the decision made by an individual innovator whether to form an independent firm or work for a larger corporate entity. If changes in public IP exert different effects on innovators' appropriation costs depending on organizational form, then innovators will respond to changes in public IP by adjusting their organizational choices to minimize appropriation costs and maximize expected returns. Generally, weak public IP tends to skew innovators' choices toward hierarchical forms as a private IP substitute while strong public IP imposes no such bias and permits innovators to select from the full range of organizational forms. In the aggregate, firms' organizational choices at each point on the innovation and commercialization pathway generate what I call the "innovation environment".

A. Differences in Private IP Costs

Many of the private IP mechanisms that can substitute for public IP are most easily available to hierarchical firms that are large in size, have a high level of integration, hold a rich stock of reputational capital, and hold a large diversified innovation portfolio. These firms tend to have lower costs in accessing private IP; by contrast, entrepreneurial firms that do not exhibit these characteristics tend to have higher costs in doing so.[16]

1. *Unilateral Private IP*

Consider some of the most powerful unilateral appropriation technologies: scale economies in production, testing, marketing and distribution; accumulated know-how; cost-of-capital advantages; network effects and associated switching costs; and brand name and associated goodwill. These all tend to be characteristics that are inherent to firms that have achieved a certain size, acquired ample internal capital (or hold collateralizable assets that reduce the cost of external capital), and have been in the market for a sufficient amount of time to acquire reputational capital. Even if an imitator can replicate the technological features of a given innovation, it will be unable to compete with the innovator if it cannot replicate the cost-efficiencies under which the product is financed, tested, produced and distributed or the reputational capital with which the product is marketed. These private IP substitutes are unavailable—or more precisely, are only available at a far higher cost—to smaller, younger and

[16] For a similar observation that small firms cannot easily rely on nonpatent mechanisms to appropriate returns on innovation, see Scherer (1980:448-49).

less-integrated firms. This is self-evident in the case of reputational capital, network effects, scale economies, and cost-of-capital advantages, all of which take time to accumulate.

It might be objected that, even in a weak public IP environment, an entrepreneurial firm could mimic the scale economies of a vertically integrated firm by contracting with external suppliers that have specialized competencies in the necessary set of complementary production and distribution functions. If that were the case, then both hierarchical and entrepreneurial firms would be indifferent to significant reductions or even eliminations of public IP: hierarchical firms would supply complementary inputs internally while entrepreneurial firms would acquire those inputs externally. But this objection runs into an obstacle. Absent a public IP right, an entrepreneurial firm might face expropriation risk to the extent it must disclose some part of its technology in interacting with outside providers of commercialization inputs (Arrow 1962).[17] This is an implied form of the familiar holdup problem. Once the innovator discloses its technology to a third party with the capacity to use that technology in a product or service that competes with the innovator's intended product, the technology has no or lesser value (meaning, no capacity to generate rents or, at least, to generate monopoly rents) for any other user. As a result, the third party can hold up the innovator for almost all its value (or at least, the difference in value between monopolistic and duopolistic pricing of the disclosed technology).[18] While reputation effects can ameliorate this disclosure risk, they have no force in the case of unfamiliar parties or one-shot transactions, and, even in repeat-play settings, become unreliable in the case of the highest-value ideas and technologies that invite defection.

To avoid that risk, the innovator can resort to a familiar but costly solution to holdup: namely, vertical integration. In environments characterized by weak reputational capital and extreme expropriation risk, the innovator must raise sufficient external capital to construct a stand-alone production and distribution infrastructure for commercializing an innovation good with minimal to no interaction with third parties. But external capital markets for funding R&D suffer from inherent imperfections. Providers of capital are discouraged by informational asymmetries while

[17] Contract is an even weaker mechanism for remedying "Arrow's paradox": at best, the recipient of a to-be-disclosed technology will rationally agree to a non-disclosure obligation (as distinguished from a "non-use" obligation). Any non-use covenant would expose it to the possibility of paying for (or agreeing not to use) a technology that it already possesses.

[18] The parenthetical refers to the fact that the innovator can threaten to disclose the innovation to a competitor of the recipient. In that case the recipient will rationally share a portion of the rents with the innovator, so long as the recipient is still left with expected profits that exceed the expected profits that would be enjoyed in duopolistic competition (Anton & Yao 2004). While this strategy forecloses complete expropriation, it still precludes the innovator from fully recovering the value of its innovation (or more precisely, recovering as much value as could be gained if the innovation were subject to an enforceable public IP right).

innovators are discouraged by disclosure risk and, in the absence of public IP and collateralizable assets or revenue streams, must pay an elevated premium (Harhoff 2011:57-58; Acs & Audtresch 1990:69-70). As a sheer function of magnitude, that is especially true in the most capital-intensive commercialization settings—for example, the multi-billion-dollar expenditures required to erect a fabrication facility in the semiconductor industry, develop a new microprocessor in the semiconductor industry, or the hundreds of millions of dollars required to test and market a new biopharmaceutical product. These contracting costs may explain why smaller firms in certain markets (especially, biotechnology, medical devices and information-technology hardware) place a high value on patent protection (Sichelman 2012; Graham et al. 2011; Graham & Sichelman 2008), which is roughly the opposite of the typical answer given by large firms in most markets in other survey studies (Scherer et al 1957; Taylor & Silberston 1973; Mansfield 1986; Levin et al. 1987; Cohen et al. 2000). Patents not only reduce the costs of contracting with outside providers by limiting disclosure risk but reduce the cost of capital by offering potential investors and lenders a collaterizable asset and a somewhat informative signal of technological value. The high value of public IP to smaller firms is reflected in their aggressive litigation behavior as compared to large firms[19], which may reflect the fact that those firms cannot feasibly secure innovation returns through private IP substitutes and therefore concentrate resources on securing and enforcing public IP protections.

2. *Multilateral Private IP*

It might be thought that smaller, R&D-intensive and unintegrated firms could overcome the absence of public IP by participating in multilateral private IP arrangements that enable innovators to capture value from innovation even in the absence of public IP. As I have described elsewhere (Barnett 2010), these knowledge-sharing arrangements are structured environments that enable participants to capture value on innovation investments by limiting admission to participants that meet certain "endowment" requirements or bundling the "open" innovation good with a "closed" complementary asset. Both those requirements are easier for large integrated incumbents to satisfy, as compared to smaller, R&D-intensive and unintegrated firms.

19 Allison et al. (2004) find that small firms file patent lawsuits about three times as often as large firms on a per-patent basis. Similarly, Ziedonis (2004) and Hall & Ziedonis (2001) find that small firms in the semiconductor industry litigate patents more aggressively as compared to larger firms.

a. *Endowment Homogeneity*

Multilateral arrangements for sharing intellectual goods often implement a reciprocity norm that ensures rough parity between a participant's contributions to the common knowledge pool and a participant's withdrawals from that pool (Barnett 2010). That norm requires that all participants meet a certain "endowment" threshold—that is, a certain observable stock of innovation goods. Small entrepreneurs are unlikely to hold the rich innovation portfolio maintained by large incumbents and therefore lack the currency to gain admission to these cooperative arrangements.[20] Knowledge-sharing practices in the semiconductor and electronics industries are consistent with this proposition. During the early history of the semiconductor industry, leading firms routinely exchanged technical information, agreed to "below-market" royalties in licensing agreements, and rarely initiated patent litigation (Angel 1994, Teece 2000:199-201). Continuing this pattern, current patent cross-licensing arrangements in the electronics and semiconductor industries are usually populated by larger firms with comparable patent portfolios (Graham & Sichelman 2008:3-4; Barnett 2009a:452-53). But there is an important type of firm that tends to be absent from these arrangements: namely, smaller R&D-intensive chip design firms. These firms have sometimes become embroiled in extensive litigation with leading patent pools in the electronics industry. Those younger and less-integrated firms' failure to participate in these cooperative arrangements, and their proclivity to litigate in order to defend their patent holdings, are in part attributable to endowment differences between larger and smaller firms in the semiconductor industry. While the former have access to a rich innovation portfolio that they can exchange for access to competitors' innovation portfolios, the latter do not and therefore vigorously defend the patent rights that secure their limited but valuable stock of innovation assets.

b. *Bundling Condition*

Firms rationally contribute knowledge assets to a common pool so long as they are able to compete independently on a complementary set of goods and services over which they are able to maintain some degree of exclusivity and earn positive returns. For this reason, cooperative arrangements to produce knowledge on an "open-access" basis tend to bundle that knowledge with a "closed-access" good to earn positive income somewhere else in the product/services

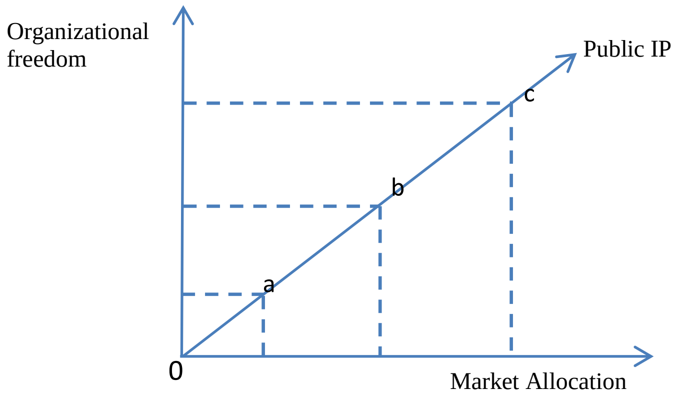
[20] Note that smaller R&D-only firms may sometimes have no rational interest in participating in these arrangements because their endowment is *superior* to that of incumbents, in which case participation would result in a net loss for the smaller firm. As I describe subsequently, this type of mismatch explains why the most talented artisans lobbied for public IP rights in order to escape participation in the guilds in the early modern period in Western Europe.

bundle. Consistent with this principle, most leading "open source" software projects—which are free to users, waive most formal IP protections, and are widely touted as a successful example of innovation "without IP"—depend on funding and personnel contributed by some of the world's largest hardware manufacturers, for whom zero-priced software is a complementary good to excludable goods or services in which they enjoy a competitive advantage (Barnett 2011a). This bundling condition, which requires that any firm enter the market on at least two levels, is easier for a large integrated firm to satisfy using its deep portfolio of difficult-to-replicate complementary assets and, by definition, cannot be satisfied by a smaller unintegrated firm that solely holds easy-to-replicate technological or creative assets.

B. Public IP, Organizational Form and Market Structure

Changes in public IP impact the relative costs and benefits of using certain organizational forms for conducting the innovation and commercialization process. Given that innovators are free to select from the range of organizational forms, we should expect that changes in public IP will influence innovators' organizational choices. All else being equal, innovators will select the organizational form that minimizes innovation and commercialization costs and thereby maximizes innovative return, *given* the existing level of public IP protection. In the aggregate, each innovator's organizational choices at each stage of the innovation and commercialization process generate the innovation environment in any given market. Three core types of innovation environments can emerge under different public IP regimes: (i) an *entrepreneurial* regime; (ii) a *hierarchical* regime; and (iii) a *bureaucratic* regime. Each regime is characterized by declining degrees of organizational freedom as public IP declines in force: an entrepreneurial regime emerges under the highest level of public IP and allows innovators to select from the full range of organizational forms; a hierarchical regime emerges under intermediate to weak levels of public IP and constrains the feasible set of organizational forms to large integrated entities; and a bureaucratic regime emerges under weak to zero levels of public IP and displaces the market allocation of innovation resources with a bureaucratic or philanthropic allocation. This relationship can be represented graphically as follows below: *a* denotes a bureaucratic regime; *b* denotes a hierarchical regime; and *c* denotes an entrepreneurial regime.

Figure II: Public IP and Innovation Environments



1. *Weak Public IP as Entry Barrier*

Prevailing views follow the natural intuition that strong IP rights act as an entry barrier that supports concentrated markets (for an example, see Wu 2005)—an intuition that drove judicial and regulatory hostility to patents starting in the New Deal, motivated aggressive antitrust prosecutions resulting regularly in compulsory licensing settlements throughout the 1940s and 1950s (which effectively expropriated 40,000-50,000 patents (Scherer 2007)), and only ended in the early 1980s. The widespread but differential distribution of private IP across firm types as a function of age, size and scale challenges that view. Any reduction in public IP inherently penalizes entrepreneurial firms that lack private IP substitutes at any reasonable cost and, as a result, drives innovators toward hierarchical forms that can feasibly replace public IP with private IP. Weak public IP tends to support hierarchical environments populated by large entities with rich sources of capital, rich reputational assets, rich innovation portfolios, and a rich set of complementary assets. In settings where public IP is weak and even large integrated firms cannot capture returns on innovation through private IP, the market allocation of innovation resources is replaced by a bureaucratic regime consisting of government procurement, tax-supported transfers, or private patronage institutions. Conversely, strong public IP tends to support entrepreneurial innovation environments populated by externally financed entities that bear high costs of accessing private IP and therefore rely on public IP to reduce the cost of outside capital and to protect against disclosure risk in interacting with outside suppliers of capital and commercialization inputs.

Hierarchical firms' preference for weak public IP, and entrepreneurial firms' preference for strong public IP, follows from a simple difference in those firms' costs of accessing private IP. In any market where the costs of accessing private IP fall as firm age, size and integration increase, any reduction in public IP coverage tends to protect the positions of large integrated incumbents against threats by smaller, younger, less integrated, and less richly-endowed competitors. In markets without public IP, the hierarchical firm's cost-advantages in accessing substitutes for public IP (or the bureaucratic institution's cost-advantages by virtue of taxpayer-funded subsidies) mitigates or neutralizes competition from entrepreneurial innovators. Schnaars (1994) and Teece (1987) identify cases where large firms have exploited weak public IP to replicate novel products released by small firms and then used their superior economies of scale, accumulated know-how and brand capital to produce, market and distribute the product at a lower cost, thereby depriving the innovator of part or all of the return on its investment.[21] As Schnaars (1994) emphasizes, apparent first-mover successes are often *second*-mover cases in which a large firm "cherry picks" the successful efforts of entrepreneurial entrants. This has an important implication: the first-mover advantage that is often touted as a substitute for public IP sometimes is merely a strategy by which incumbents can protect against competitive threats by entrants with superior innovation, but inferior commercialization, capacities.[22] Even in markets where some firms can substitute private IP for public IP to capture returns on innovation, other firms cannot do so at even an approximately comparable cost. Compelling the market to rely solely on private IP to support innovation often rewards the well-resourced imitator at the expense of the poorly-resourced innovator.

2. *Innovation Environments*

The interaction between public IP and private IP yields three core types of innovation environments. Those environments are distinguished by the degree of organizational freedom and the extent to which innovation resources are allocated by external market forces rather than internal allocation by a firm or political allocation by the state.[23]

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21 Tripsas (1997) finds a similar sequence in the typesetter industry, where the incumbent is found to have survived repeated challenges from innovative entrants by imitating the entrant's innovation and then using its superior complementary production and distribution capacities to outmatch it on price and other produce and service features.

22 This begs the question of why large firms would simply refrain from imitation and purchase the technology held by the small firm. There are two responses: (i) where reverse-engineering costs are low, the large firm may find it cheaper to imitate than purchase the technology; and (ii) even if the large firm would wish to purchase the technology, the large firm and small firm cannot safely negotiate the terms of any such purchase in the absence of a public IP right, which would enable the large firm to credibly commit against expropriation once the technology had been fully disclosed.

23 The following typology does not include "free appropriation" or "commons" environments that have received some attention in the recent management and legal literature. That is because, as I have argued elsewhere (Barnett 2010) and as I noted above, outside of non-commercial or non-capital-intensive settings (e.g., amateur creative production or hobbyist inventors), these environments tend to be structured

a. Entrepreneurial Innovation

Entrepreneurial firms have two reasons to place an especially high value on public IP: (i) it provides a tool to protect a novel technology when it is disclosed to financing and contracting partners in the commercialization process; and (ii) it provides a tool to protect a novel technology when it is released into the end-user market. The dependence of individual and small-firm innovators on the patent system—in particular, for the purpose of securing outside financing—is a constant throughout the history of modern technology markets. In the United Kingdom, an increase in courts' willingness to honor patents in the 1830s resulted in the emergence of a class of professional inventors who sold inventions into a secondary market of manufacturers and assignees (Dutton 1984:122-74). Buyers of inventions generally required a patent as a condition to purchase (Dutton 1984:124) and financiers of inventive enterprises generally demanded a patent as a condition to invest (Dutton 1984:151). Strong enforcement of U.S. patent rights following the Civil War supported the emergence of an independent class of individual inventors, who used patents to secure financing from a network of outside investors or to monetize patented technology through assignments to third parties (Khan 2005; Khan & Sokoloff 2001; Sokoloff & Khan 1990; Lamoureaux & Sokoloff 2002). The historical linkage between patent protection and external financing of inventive activity is replicated by today's venture-capital-backed startups, which are often expected to have secured patent protection as a virtual precondition for seeking external funding (Sichelman 2012; Graham et al. 2009:1280). It seems hardly coincidental that the rise of the venture-capital industry coincided with the increase in patent strength consequent to the establishment of the Federal Circuit: as patenting rates increased starting in the mid-1980s, so too did venture capital investment, which invested a total of $550 billion in U.S.-based start-ups from 1980 through 2007 (Ziedonis 2008).[24] The result is an innovation environment that deviates sharply from the incumbent-dominated technology markets of the patent-skeptical decades immediately following World War II.

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settings in which some exclusionary constraint is used to control access at some point on the total product/services bundle. As I have shown with respect to open source software (Barnett 2011a), even the most well-developed forms of "collective invention" tend to rely on direct or indirect support from revenues generated by excludable complementary assets. Hence, these collective invention environments are best characterized as an implicit variant of "hierarchical innovation" in which innovators either collaborate within the framework of a semi-closed multilateral arrangement or operate under the implicit umbrella of a hierarchical firm. This point is especially obvious if one considers that the guild, a government-sanctioned monopoly franchise, is the historical antecedent of modern examples of collective invention.

[24] Of course, the causality could be inverted, as Kortum and Lerner (1998) claim: that is, the rise in venture capital funding induced increased patent applications by small-firm innovators.

b. Hierarchical Innovation

AT&T's Bell Labs illustrates how weak public IP fosters hierarchical organizational forms for conducting innovation. During its tenure as a national telephone monopoly (roughly from 1949 until 1982), AT&T was required by judicial order to make all its patented innovations available at a reasonable cost—essentially, a modified form of a compulsory license that can be construed as a low level of public IP since it limited AT&T's ability to extract income from its technological assets. AT&T did not cease innovation as a result of this constraint; to the contrary, its research arm, Bell Labs, produced a slew of remarkable innovations. Bell Labs could support innovation under a weak public IP regime because it had access to a powerful appropriation technology that was available to no other firm. Thanks to the government-granted monopoly, AT&T received an assured stream of revenues on complementary goods and services in a protected market (telephone communications and equipment), which provided a steady cash stream to support R&D investment. But Bell Labs' innovative vigor may have masked the implicit disappearance of less integrated entities during a period characterized by weak public IP. Without strong public IP, no innovator would undertake (and no outside investor would share in) the risk of starting a stand-alone R&D-intensive firm whose sole asset would be exposed to expropriation in the commercialization process or at market release. Given Bell Labs' remarkable performance, this organizational effect clearly did not have catastrophic effects on innovative output; however, it most likely shifted innovation resources toward hierarchical organizations that had lower-cost access to the private IP mechanisms required to make up for the shortfall in public IP. Ironically, as the Bell Labs story suggests, a lax patent policy designed to open up the intellectual commons can have precisely the opposite effect by compelling innovators to either exit the market entirely or remain in the market as employees of large integrated enterprises.

c. *Bureaucratic Innovation*

In the most extreme case, the absence of any robust public IP protection replaces market-financed innovation with the most advanced form of an integrated and self-financing entity: namely, the state.[25] This is a practically important mode of financing innovation (although, tellingly, it has declined in importance as patent protection has increased in strength): as of 2008, federal government funding represented about 30% of all R&D expenditures in the U.S. (and industry funding represented almost 70%); as of 1983, the federal government and private

[25] Williamson (2005:54 n.12) suggests a similar view of the state as the highest form of integrated organization (with the lowest-powered incentives and most extreme bureaucratic constraints).

industry shared roughly equal percentages of national R&D expenditures; and, as of 1966, federal government funding represented almost 70% and industry funding represented approximately 30% of national R&D expenditures (National Science Foundation 2010). Bureaucratic innovation will be most prominent in environments where (i) public IP is absent or weak, and (ii) vertical integration or some other form of private IP is not a feasible device for capturing the value generated by the relevant type of innovative activity.[26] In those cases, capital-intensive innovation in the absence of public IP can only proceed on the basis of tax-funded transfers to innovation entities, which may be organized as private firms, nonprofit research institutes, or, in the case of direct procurement, governmental instrumentalities. It is not accidental that this is the principal mechanism for funding innovation in pure science fields that produce knowledge that is generally ineligible for patent protection due to the prohibition on patenting abstract ideas, naturally occurring physical phenomena, and mathematical formulae.[27] The same pattern holds true in creative markets. In the period prior to the advent of copyright protection, musical composition in Western Europe tended to take place under a patronage system in which composers were dependent on subsidies from ecclesiastical institutions, royal benefactors or philanthropic foundations (Scherer 2004). When public IP is weak, and there is no adequate and cost-feasible private substitute, neither an entrepreneurial regime populated by less integrated firms nor a hierarchical regime populated by more integrated firms is feasible. Rather, innovation must take place under a bureaucratic regime governed by administrative fiat. The competitive pursuit of private resources for innovation is replaced by the competitive pursuit of private resources coercively redistributed by the state or altruistically forfeited by the wealthy.

III. Do Structural Effects Matter?

As a normative matter, the organizational effects of changes in public IP on firm and market structure—together, the innovation environment—might be dismissed as merely aesthetic. That is, different levels of public IP support different types of innovation environments—Bell Labs v.

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[26] Note that these conditions would be satisfied in an environment where (i) the courts were hostile to the enforcement of patents (or other public IP rights) and (ii) the government imposes antitrust constraints on the ability of firms to fully achieve economies of scale, whether through acquisitions or internal growth. In that case, absent philanthropy, no private-market mechanisms could support capital-intensive innovation, which would either wither or have to be funded by the state. Interestingly, the postwar period during which courts were hostile to patents was generally also a period during which the courts and federal agencies aggressively enforced antitrust constraints on firm size and growth.

[27] It is also the principal mode for supporting scientific research by the military, an important component of the U.S.'s innovation infrastructure. This too is expected: both military use and pure scientific research are paradigm examples of public goods that require some coercive non-market mechanism to fund adequately

Silicon Valley v. National Institutes of Health—but the resulting effects on total innovative output are indeterminate or negligible. In this Part, I argue that these effects are significant and overlooked by arguments that have been widely adopted in both legal and economic analysis of intellectual property. Ironically, taking into account the ubiquity of private IP clarifies the efficiency gains uniquely attributable to strong public IP.

A. The Unique Value of Public IP

Setting aside contemporary fashions in the business management literature, it could fairly be argued that there is no intrinsic social interest in preserving a "startup culture" in which innovation takes place in smaller and disaggregated organizational structures, rather than a hierarchical culture in which engineers typically work as paid employees within a large corporate enterprise, or a bureaucratic culture in which scientists typically work as paid employees within a government bureaucracy. Absent any such interest, the abundance of private IP implies a presumption against strong forms of public IP. If the market can develop adequate models for supporting innovation without public IP, or the state can coerce redistributive transfers for the same purpose (or the good-hearted wealthy are willing to forfeit sufficient resources), then there is no reason to incur the deadweight losses and transaction costs associated with strong public IP regimes. Legal and some economic commentators sometimes draw this conclusion based on the widespread presence of non-legal strategies by which to capture returns on innovation and the apparent lack of any noticeable decline in output in markets in which public IP is constrained or absent (Boldrin & Levine 2009, Breyer 1970). Based on the existence of a market that appears to support a reasonable level of innovative output without public IP, it is concluded that public IP is an unnecessary and artificial intervention by the state that imposes a tax on the many for the benefit of the few.

This is an old argument made by skeptics of the patent system from its inception.[28] It suffers from a basic defect. Namely, it implicitly assumes that the social costs of private substitutes for public IP are always lower than the social costs of public IP. The social costs of relying solely on private IP to support innovation are subtle but significant and there is no reason to believe they do not exceed the social costs engendered by public IP. The costs attributable to private IP derive from the simple fact that private IP mechanisms are not available at a uniform cost to all organizational types and, in particular, tend to be available at a lower cost to incumbents. Weak public IP restores the expropriation risk inherent to contracting over innovation assets, which

[28] Machlup & Penrose (1954:18) describe the same argument having been made in debates over the patent system in the late 19th century.

compels firms to use integrated structures to control knowledge leakage, thereby potentially inflating innovation and commercialization costs, reducing the return on innovation ex post and depressing innovation incentives ex ante. This is especially punishing to younger entrepreneurial firms for which expected returns may fail to cover costs in the absence of strong public IP. It is perhaps no accident that the postwar markets that appeared to support innovation without a strong patent regime were dominated by both a weak patent regime and, in many cases, small numbers of large integrated incumbents. These were the organizational types that could survive best in a market that compelled innovators to use costly private IP substitutes to compensate for large shortfalls in public IP coverage. Hence, economists who adopted the "Schumpeterian" view (for the original, see Schumpeter 1950:106) that large firms were best-suited to support R&D due to the "natural" entry barriers provided by large size and economies of scale[29] may simply have been drawing a conclusion about relative innovation capacities across firm types that is only true *given* weak public IP coverage.

Public IP has a singular advantage over private IP as a device for supporting private investment in innovation: it is organizationally agnostic. Public IP mitigates the contracting costs attendant to transacting over innovation assets in the absence of reliable reputational constraints and thereby enables innovators to freely select from the entire menu of organizational forms at each stage of the innovation and commercialization process.[30] To appreciate this argument in some more detail, assume that we know nothing about the efficient form of organization for conducting innovation and commercialization activities in any given market. Hence the organizational set ranging from extreme disaggregation of the innovation and commercialization process among large numbers of small-scale entities to complete integration of that process in a single entity is open. But there is no need to make any choice. Absent entry barriers, market pressures will drive innovators to select the most efficient form along that organizational range. The market will punish innovators that select non-cost-minimizing organizational forms—either excessively or insufficiently integrated—while rewarding innovators that select cost-minimizing forms. Reducing public IP coverage impedes that selection process by foreclosing (or, at least,

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[29] For a review of this literature, see Penrose 2009:204 and Acs & Audretsch 1991:39-40. For an example, see Galbraith 1956:87-88.

[30] Adelman (1982) first argued that the patent system allows the market to conduct innovation under any organizational structure without regard to expropriation risk. More recently, Arora and Merges (2004) have argued that intellectual property can efficiently shift the location of technological innovation by allowing it to take place outside vertically integrated firms. Similarly, Barzel (2002:72-73) observed that the extension of patent protection to financial innovations allowed innovation to move outside the framework of vertically integrated firms. For further discussion, see Barnett (2011a, 2009a); Bar-Gill & Parchomovsky (2009).

increasing the cost of adopting) incompletely integrated forms of organization. The result: weak or zero public IP markets only support the most integrated forms that can replace public IP with difficult-to-replicate scale economies, accumulated know-how, cost-of-capital advantages, and reputational capital. In any market where weakly-integrated forms provide the least-cost mechanism at even one stage in the innovation and commercialization process, any deviation from complete public IP coverage necessarily compels firms to select a non-cost-minimizing combination of organizational forms. In the most extreme case, firms cannot bear the cost of integration and, given the prospect of knowledge leakage, elect to exit the market, "sell out" at a discount to a larger integrated firm[31] (assuming not all information must be disclosed to the buyer for valuation purposes), or, in the case of individuals, to seek employment with a larger integrated firm.

Overintegration punishes all firms, regardless of age, size or scale, by replacing external markets for technology financing, transfer and commercialization with internal markets. Put differently: activities that "should" take place in the market are compelled to take place inside the firm, which therefore adopts a level of integration that is inefficiently high relative to the technological optimum that could be achieved under stronger public IP. Even a larger integrated firm will be injured under a weak IP regime to the extent that it would have selected a lower level of integration—for example, it would have contracted with a third-party provider—at any point on the supply chain to minimize its innovation and commercialization costs. Large firms widely use patent rights to engage in "horizontal" contracts with competitors to share knowledge assets, or to enter into "vertical" contracts for innovation and commercialization services from smaller upstream and downstream providers (Kieff 2006, Merges 2005). By definition, those are efficient transactions that result in a positive joint surplus.[32] Without patents, those efficient transactions are precluded in environments in which reputational protections against expropriation risk are insufficient. Like a small entrepreneurial entrant, a large hierarchical firm may be forced under a

[31] An example from patent history nicely illustrates this effect. In the 19th century, German patent law required that patent holders "work" the patent within three years after its being granted, either by manufacturing the patented product or using the patented process in Germany. Large incumbents used the clause to extract favorable licenses from small-firm or individual patentees. The requirement apparently promoted concentration in the German dye industry (Murmann 2003:86 n.99).

[32] One potential caveat should be noted. It is possible that a patent-sharing transaction may be privately but not socially efficient if it is entered into solely for the sake of avoiding litigation. But that is only true if a higher social surplus would have been achieved under a lower level of patent protection, which depends on the innovative output, net of transaction costs, that would have been generated under that alternative regime. Moreover, contrary to theoretical concerns expressed by the "anti-commons" literature, large repeat-players in real-world technology and creative markets often exhibit strong incentives and capacities to enter into cooperative arrangements that preclude mutually destructive overinvestment in patent acquisition and litigation (Barnett 2009a).

weak public IP regime to operate under an overintegrated structure in which it is compelled to internalize innovation or commercialization functions that could be performed at a lower cost by outside providers.[33] Oxley (1999) and Anand & Khanna (2000) provide evidence consistent with this expectation, showing that firms tend to choose more hierarchical structures (for example, subsidiaries or acquisitions) when transferring technology to jurisdictions with weak intellectual property protections and less hierarchical structures (for example, joint ventures or arm's-length licensing) in jurisdictions with strong intellectual property protection.[34]

B. *A Caveat: Unproductive Entrepreneurship*

The argument set forth above generates a presumption in favor of the state providing an unlimited level of public IP that extends over the full range of attributes embodied by any innovation good. Under that regime, organizational choices would be undistorted and innovations would be delivered to market at the lowest feasible cost, resulting in higher returns for innovators, greater entry opportunities, and improved innovative output, as measured by price, volume and variety. But that normative implication does not track even the strongest forms of observed public IP regimes. Hence some explanation is required to explain why public IP regimes always impose some cap on the protection provided to rights holders. There are two reasons. First, as will be discussed subsequently, integrated incumbents may exert political-economic force to limit public IP and thereby discourage or preclude entry by unintegrated firms that may lack easy access to any private IP substitute. Second, as I will now discuss, strong public IP can induce patent-based entrepreneurship that is "unproductive" in the sense that it consists solely or primarily of rent-seeking *legal* innovations that detract from the social product.[35] A cap on public IP can generate social gains by deterring unproductive forms of patent-dependent entrepreneurship that exceed the social losses incurred by deterring productive forms of patent-dependent entrepreneurship. This principle best accounts for observed limitations

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33 For a similar argument, see Kieff (2006:362-63). This assertion is consistent with my later argument that large integrated firms strategically support weak public IP regimes in order to raise entry costs for less-integrated rivals. The large integrated firm may maximize profits in a market where entry by less-integrated providers is precluded, even though it could achieve lower innovation and commercialization costs in a market in which it was exposed to greater entry. In short: the pie is smaller but the incumbent's slice is larger in absolute terms.

34 In a related contribution, Branstetter et al. (2006) find that technology transfer to, and R&D spending by, affiliates of multinational corporations increases when the affiliates' local jurisdictions increases the strength of patent rights. While this evidence does not address integration choices, it demonstrates the manner in which strong public IP facilitates transfers even among affiliated parties. Zhao (2006) finds that multinational firms who conduct R&D in emerging markets with weak public IP protections protect against knowledge leakage by confining knowledge production within the firm.

35 On the distinction between productive and unproductive entrepreneurship, see Baumol (1990).

on public IP (and the recent adoption of reforms to the patent laws motivated in large part by an attempt to frustrate precisely these types of unproductive patent-based entrepreneurs); however, it is weaker than the traditional reasons relied upon for justifying such limitations.

1. *Conventional Reasons for Limiting Public IP*

The social costs attributed to any increase in public IP are well-known: (i) the deadweight losses inherent to positive pricing of a nonrivalrous good having low to zero variable costs, and (ii) the transaction costs of increased licensing, dispute-avoidance and dispute-resolution activities inherent to a public IP system. In any case where those social costs exceed the social gains attributable to any incremental increase in public IP protection on an expected basis, then that increase should be avoided and any political-economic activity in its favor can be dismissed as unproductive rent-seeking. (Conversely, in any case where those social costs likely do not exceed the social gains attributable to any incremental increase in public IP protection on an expected basis, then that increase should be promoted and any political-economic activity in opposition to it can be dismissed as unproductive rent-seeking.) That possibility implies that the optimal level of public IP coverage follows an "inverted-U" curve, where increased levels of public IP result in diminishing net social gains until an inversion point is reached, after which increasing levels of public IP result in net social losses and should therefore be avoided.

But those countervailing social costs may not be as large as is commonly thought to be the case. If that is true, then the social returns to increased public IP would diminish more slowly and the inversion point would be reached at a higher level of public IP coverage than may otherwise be anticipated. The reason is logical, not empirical: the social costs normally attributed to public IP only "count" to the extent that they represent *incremental* costs relative to the deadweight losses and transaction costs that would *still* exist in a market with weaker or zero levels of public IP. Conventional analysis implicitly sets those preexisting costs at zero because it assumes that a market without public IP is free of any access constraints. If, however, innovation markets without public IP still operate under private IP that constrains unauthorized usage, then that assumption must be discarded and the costs attributed to any increase in public IP must be appropriately discounted to identify the incremental portion of those costs. Transaction costs will exist in markets without public IP whenever innovators employ technological, contractual and other private IP strategies to regulate access. Deadweight losses will arise whenever innovators are successful in doing so and impose access restrictions that block usage by third parties willing to cover the variable (and often trivial) costs of production and distribution of the relevant innovation good. In any successful innovation market without public IP, both those costs necessarily must be positive—as is illustrated by the fact that many multilateral private IP arrangements have cartel-like features that generate monopoly rents for participants in those arrangements.[36] Without those rents, innovators would have no incentive to invest and the market would fail to produce robust innovative output.

2. *A Better Reason for Limiting Public IP*

This observation has an important (and, to my knowledge, overlooked) normative implication. *If deadweight losses and transaction costs have positive values even in markets without public IP, then there is no assurance that any proposed increase in public IP will increase the deadweight losses and transaction costs borne by users in the relevant market or, conversely, that any proposed decrease in public IP will reduce those costs.* Just as the standard incentives/access tradeoff fails to provide a reliable positive account of the propertization effects of changes in public IP, so too it fails to provide a reliable normative account of the efficiency effects of those changes. Given that inherent indeterminacy, the standard reasons for limiting public IP in order to reduce deadweight losses and transaction costs is unsatisfactory as a general guideline. Nonetheless, there remains a robust ground for limiting the level of public IP made available by the state. This is supported by one type of transaction cost that is unique to public IP. As public IP increases in strength, it induces entry not only by productive forms of patent-based entrepreneurship that add value to the social product but unproductive forms of patent-based entrepreneurship that detract value from the social product. Practically speaking, this mostly refers to entities that engage in socially wasteful *legal* innovation by accumulating patent holdings, whether by application or acquisition, in order to support actual or threatened litigation against cash-rich incumbents with high costs of designing around technologies that are claimed to be covered by those patent holdings and therefore rationally avoid litigation by settling quickly for large payoffs in the form of a licensing or other type of agreement. This form of unproductive patent-based entrepreneurship depends on a combination of a sufficient likelihood of judicial error (magnified potentially by the use of juries and certainly by treble damages for willful

[36] The European craft guild discussed previously is the most dramatic example. Consider some more examples: (i) the industry-generated rules governing the allocation of credit to writers in Hollywood film and television production, which are set forth by the Writer's Guild of America, the writers' union and enforced as a result of collective bargaining agreements between the union and the small number of large studios and networks (Fisk 2006); (ii) the Fashion Originators Guild of America, which discouraged copying of fashion designs in the 1930s and 1940s through contractual arrangements with retailers; and (iii) the *Chambre Syndicale de la Couture Parisienne*, an organization founded in Paris in 1868, which limits use of the *haute couture* label to members that meet a detailed set of requirements, including minimum investments in design, marketing and production for biannual fashion shows and prohibitions on mass production (Barnett et al. 2010).

infringement), sufficiently high litigation costs, and no custom of shifting collectible legal costs to losing litigants. This is a specified transaction cost that derives largely from the inherently imperfect match between verbal language in a legal entitlement and the underlying innovation. It is therefore entirely attributable to public IP[37], rather than to the generic combination of deadweight losses and transaction costs that could arise in equal, greater or lesser amounts under both public and private forms of IP.

IV. Empirical Evidence

It might be questioned whether the distortions attributed to weak levels of public IP in skewing innovators' choices toward hierarchical organizational forms yield any significant effect on efficient investment in innovation that warrants incurring the incremental social costs—in particular, the growth in unproductive patent-based entrepreneurship—attributable to any increase in public IP. In this Part, I review two bodies of empirical evidence that suggest that those organizational distortions can result in significant harm to innovation investment and conversely, that the organizational freedom that results from strong public IP can result in significant gains for innovators and the users of innovations. Contrary to common assumptions, reductions in public IP are often not best understood as publicly-interested reforms to "protect" the public against rent-seeking interests. Rather, efforts to promote those reforms are sometimes themselves rent-seeking efforts by incumbents to secure dominant positions anchored in a difficult-to-replicate portfolio of private IP instruments.

A. The Social Value of Entrepreneurial Innovation

Whether larger or smaller firms are best suited to undertake R&D in general has attracted considerable empirical attention without a single definitive answer across markets or even within a single market (Acs & Audtresch 1990, Ch. 3; Mansfield 1968:107-110, Scherer 1980:431-38). Viewed in the aggregate, however, much of that literature supports a nuanced view that smaller and younger firms are disproportionately responsible for the most radical early-stage forms of technological innovation (Baumol 2002:21; Acs & Audretsch 1991, Scherer 1980:437-38) while

[37] This observation can be construed as an extended application of Barzel's more general argument that measurement costs place an inherent limit on the feasible set of market-based transactions (Barzel 1982). In this case, measurement costs limit the socially optimal extent of public IP by influencing the error cost of enforcing public IP. Error costs require limiting the awards available to public IP rights holders in order to tradeoff the efficiency gains normally attributed to increasing property-rights coverage against the efficiency losses that arise as a result of erroneous issuance and enforcement of formal property rights. That in turn limits the set of innovation goods that can be traded efficiently through market exchange (rather than produced internally within a single firm).

larger established firms tend to focus R&D resources on later-stage incremental improvements to existing (and especially, process) technologies (Mansfield 1968:92-93; for a review, see Bhide 2000).[38] Various strands in the theoretical economics literature support the view that small firms are particularly well-suited (and large firms are particularly unsuited) to undertake the highest-risk forms of innovation[39] whereas larger firms have an inherent bias toward undertaking low-risk and capital-intensive innovation projects (Bhide 2000). If entrepreneurial firms are uniquely positioned to pursue the most disruptive forms of technological innovation, then reductions in public IP may impose significant social costs by shifting the locus of innovation inefficiently downstream to large hierarchical firms that are inherently focused on incremental improvements to existing design and technological paradigms. Conversely, increases in public IP reverse those effects by enabling small-firm innovators to enter markets through disaggregated networks of contractual relationships that exploit the competencies of outside providers of commercialization services, thereby avoiding having to assemble the funding and personnel required to establish a fully integrated firm structure running from lab to market. In a preliminary effort, I pursue this proposition below by examining the apparent effects of public IP on organizational structures in four selected markets.

1. *Craft Guilds: Coerced Integration*

Let's return to the European craft guild. As discussed previously, this can be understood as a private IP mechanism in a market that lacked public IP rights. The guild created a low transaction-cost zone for the exchange of knowledge among the guild's members—facilitated by reputational norms that promoted knowledge-sharing (Epstein 2004, Perez 2007:232, 256-57)—and possessed market power that generated revenue streams to reward guild members' collective

[38] Small firms outperform large firms on various measures of innovative contribution, including patenting per employee and citations per patent (CHI Research 2003). This is subject to the usual disclaimer that patents are an imperfect proxy for innovation. A study commissioned by the Small Business Administration confirms tendencies toward a vertical bifurcation of innovation and commercialization tasks: as industries place greater emphasis on R&D and technical functions, the distribution of small new private fast-growth firms and large established fast-growth public firms shifts in favor of the former; as industries place greater emphasis on production functions, that same distribution shifts in favor of the latter (Small Business Administration 2006).

[39] Various theoretical reasons are consistent with the claimed small-firm advantage in high-risk innovation: (i) the incentive intensity required for the most creative types of innovation declines in bureaucratic large-firm organizations due to defects in monitoring and compensation mechanisms (Williamson 2005); (ii) agency costs in large corporations discourage disruptive innovations that place management under high risk of reputational penalties in the case of failure (Holmstrom 1993) or require modification of existing structures, protocols and commitments (Henderson & Clark 1990); and (iii) large-number conditions give rise to diseconomies of scale as a result of increasing communication and coordination costs (Teece 1996; McAfee & McMillian 1995).

investment in producing that knowledge. This regime relied on two exclusionary constraints. On the "supply side", it employed an apprenticeship process to cultivate sufficiently talented and productive members and thereby maintain a common innovation endowment among guild members (Epstein & Prak 2007:7-9), who would otherwise be wary of contributing assets to the general knowledge pool. On the "demand side", it enjoyed a monopoly franchise from the sovereign, which generated rents to reward the innovation investments of the guild's members. But this otherwise successful substitute for public IP had a critical defect. Without an external market pricing mechanism, the most talented artisans were not appropriately compensated (Perez 2008:262) for forfeiting especially valuable technologies to the guild's knowledge pool. This can explain why the most innovative artisans sometimes extracted a portion of the value of their inventions through side-payments from the guild or collectively-administered reward systems (Foray & Perez 2006:245, Perez 2008:243-45), permission from the guild to keep certain inventions secret (Epstein 1998:693-95; Merges 2004), or "privileges" or other benefits given by sovereigns or guilds in competing jurisdictions (MacLeod & Nuvolari 2010:5; Trivellato 2008:222). For the same reason, these artisans sometimes advocated for the state issuance of IP rights (while the guilds resisted those reforms (MacLeod 1988:188)), which would enable innovators to recoup returns outside the guilds system. As regional and national markets expanded, the guild could not make sufficient side payments to cover the artisans' opportunity costs. Consequently, those artisans left (or refused to join) the guild (Foray & Perez 2006:245; Perez 2007: 247-51, 258-62, Perez 2008:262-63), which in turn expanded those external markets and increased demand for public IP rights that could protect free-standing innovation. The structural effect is clear: the extension of patent rights enabled individuals to fund innovative effort outside the hierarchical regime constituted by the guilds.

2. *Biotechnology: Integration by Contract*

In 1982, the Supreme Court upheld the patentability of genetically engineered microorganisms (*Diamond v. Chakrabarty* (447 U.S. 303)) and, in 1991, the Court of Appeals for the Federal Circuit's upheld the patentability of sufficiently isolated genetic material (*Amgen, Inc. v. Chugai Pharmaceutical Co.*, 927 F.2d 1200 (Fed. Cir. 1991)). These (and other) decisions secured the extension of patent rights to biotechnological innovations. Since that time, patent rights have supported the growth of vertically disaggregated transactional structures in which R&D-intensive start-ups can bargain safely with established pharmaceutical firms that have difficult-to-match advantages in capital-intensive testing, marketing and distribution functions (Lerner and Merges 1997; Pisano 1989). The result is a vertical division of labor that allocates innovation and commercialization functions to the entities that have the strongest capacities to execute each function (Arora & Gambardella 1994). Without public IP, those transactions would be fraught with expropriation risk, upstream innovators would have difficulty raising sufficient capital to integrate forward independently, and large integrated pharmaceutical firms would be compelled to integrate backward into upstream research functions.[40] Given that all these organizational options are currently available but tend to be declined in favor of vertically disaggregated structures, it appears that strong public IP has enabled the market to make an efficient organizational choice that drives down innovation and commercialization costs, thereby maximizing the social value generated by the innovation process.

3. *Semiconductors: Interrupted Integration*

Historically, leading firms in the semiconductor industry maintained vertically integrated structures but exchanged technical information on a regular basis, extracted "below-market" royalties in cross-licensing agreements, and rarely initiated patent litigation (Teece 2000:199-201, Angel 1994). The aggressive adoption and enforcement of patent rights by smaller unintegrated design-oriented firms starting in the 1990s has upset this *status quo* and supported the emergence of an alternative to the vertically integrated model. These "fabless" firms have strong R&D capacities but lack manufacturing capacities and enter into agreements with third-party suppliers for that purpose, subsequently recovering the fabricated chip for distribution to the intermediate-user market (Teece 2000; Hall & Ham 1999). Patent rights enable these upstream design-specialist firms to detour around the immense scale and cost-of-capital advantages enjoyed by incumbents such as Intel in the chip fabrication process (for which a new plant must be constructed at a cost of several billion dollars). Absent strong public IP, those difficult-to-replicate competencies would either bar entry entirely or discourage entry by shifting to incumbents the lion's share of the profits derived from any new chip design. As in the biotechnology sector, patent rights facilitate secure bargaining by mitigating expropriation risk among unrelated parties, and, as a result, promote an efficient division of labor that allocates tasks among firms with the strongest capacities in R&D, design, production, distribution and other functions required to deliver a product to market. This explains why chip design specialists are especially intensive users of the patent system, as indicated by the vigor with which they pursue

[40] To be clear, strong public IP is a necessary but not a sufficient condition to enabling interfirm technology transactions in high expropriation-risk environments. An important additional condition in some markets is modularity: for example, R&D functions can only be performed separately from manufacturing functions if the unit performing R&D does not require intimate and ongoing knowledge of the manufacturing process.

patent applications and, relative to large integrated firms, enforce patents against alleged infringers (Ziedonis & Hall 2001; Ziedonis 2003). This aggressive enforcement behavior is simply a rational response to the fact that these firms have few scale economies, no cost-of-capital advantages, and few complementary excludable assets by which to recover returns on innovation.

4. Innovation-Only Entities: Complete Disintegration

Recent legal and popular commentary on technology markets has focused heavily on the phenomenon of the "patent troll": that is, an entity that opportunistically acquires and litigates patents in order to extract hold-up licensing fees from cash-rich integrated enterprises that rely on the technologies claimed by those patents. That phenomenon has been the implicit or explicit impetus behind several recent judicial and legislative changes that have curtailed patentees' rights. While this recent focus on unproductive forms of patent-dependent entrepreneurship certainly has merit, it has deflected attention from a structurally related class of *productive* forms of patent-dependent entrepreneurship. These entities (which include the technology transfer office of a research university) engage in significant R&D but lack any downstream operational capacities, derive virtually all revenues from licensing patented technologies to downstream manufacturers and other entities, and are therefore entirely dependent on public IP.[41] Without a strong form of public IP by which to exclude imitators (or some form of public or private bureaucratic support), these innovation-only entities have no feasible appropriation mechanism and could not exist without integrating downstream into capital-intensive and labor-intensive manufacturing and distribution functions.[42] Two social losses—at least as a gross matter[43]—

[41] Some notable examples include: (i) specialized engineering firms, such as Universal Oil Products (acquired in 2005 for an estimated $1.6 billion), that have historically supplied patented engineering technology to the chemicals and petroleum industry, including in particular smaller. firms that lack the internal R&D capacities of larger firms (Arora 1997); (ii) a handful of large private R&D-only entities, such as the Battelle Corporation (approximately $4.9 billion in revenues in 2010), which have specialized in developing patentable applied technologies that are widely licensed to product manufacturers (Battelle 2011); (iii) Qualcomm Corporation (NASDAQ: QCOM, approximately $15 billion in revenues in 2011, market capitalization of $104.72 billion as of May 2012), which holds over 11,000 patents and licenses those patents to manufacturers of CDMA-based mobile telephone handsets (Qualcomm 2008); and (iv) Dolby Corporation (NYSE: DLB, approximately $309 million in revenues in 2011, market capitalization of $4.75 billion as of May 2012), which holds over 2,300 patents and licenses those patents to manufacturers of home audio systems, televisions and personal computers (Dolby 2011).

[42] The university is not an exception to this rule: it recovers income through coerced transfers from taxpayers and revenues earned through sales of a complementary asset, education.

[43] The qualification is important. As I note above, strong public IP also induces entry by *unproductive* entrepreneurs who accumulate dubious patents for the purpose of socially wasteful litigation and hold-up of entities that are reliant on the claimed technology. The optimal legal rule would distinguish

would result from this outcome. First, all hypothetical downstream licensees would be compelled to engage in duplicative effort to replicate the technology that could not be securely licensed from (and therefore, by anticipation, would not be developed by) a stand-alone upstream provider. If those replication costs are not feasibly borne by all firms, then some of those hypothetical licensees would never enter the market, resulting in reduced competition in the end-user or intermediate-user segment. Second, there would be no possibility of an external market in intellectual goods, which could only be traded safely—or, at least, at the lowest risk of expropriation—within the confines of a single entity. Both effects produce a potentially perverse result from reducing public IP. Rather than protecting the market against a "patent tax", withdrawing public IP compel innovators to adopt integrated structures that internalize all innovation and commercialization functions, potentially resulting in higher access costs, reduced entry opportunities, increased pricing power, and, ultimately, reduced innovative output.

B. *Political Economy: Incumbents (Usually) Prefer Weak Public IP*

Political economic behavior provides some of the strongest evidence for the proposition that hierarchical firms tend to be sheltered by weak public IP regimes whereas entrepreneurial firms tend to rely on public IP to enter concentrated markets. The former often oppose expansions of public IP, while the latter often resist curtailment of those rights. That behavior is fully consistent with the theoretical arguments set forth above: reducing public IP protects incumbents against both productive and unproductive forms of patent-dependent entrepreneurship. Note that in the first case, incumbents' private interest is misaligned with the social interest; in the second case, those interests are aligned. This pattern appears with remarkable frequency. Two bodies of evidence support this view.

1. *Historical Evidence.* Since the inception of modern patent systems through the present, large incumbents tend to resist extensions of patent protection with remarkable consistency. Even in creative markets, large firms that hold complementary assets sometimes vigorously resist extensions of copyright or similar types of protections. The following examples are illustrative.

    a. *Mid-to-Late 19th-Century (European "Patent Controversies").* Chambers of commerce and trade associations supported substantial relaxation or reform of German patent laws

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between unproductive and productive forms of patent-based entrepreneurship, discourage the former and encourage the latter. Unfortunately, the criteria for doing so are largely unavailable.

(Penrose 1954:4). The same was true in England, where abolition of the patent laws was supported by members of the Board of Trade and representatives of manufacturing districts (Penrose 1954:3). The same was again true of textile and chemicals companies in Switzerland, which blocked the adoption of patent laws in that country until 1907 (Moser 2005).

b. *Late 19th Century (U.S. Railroads).* The U.S. railroad industry was one of the chief proponents of curtailing patent coverage, disclosed technical knowledge to limit the patentable subject matter available to individual inventors, and collectively financed defensive litigation against third-party infringement suits (Usselman 1991).

c. *Late 1930s (New Deal).* The congressional Temporary National Economic Committee considered proposals to constrain patentees' rights (including, at the Roosevelt administration's suggestion, widespread compulsory licensing), which purportedly contributed to market concentration. Outside of the pharmaceutical and chemicals industries, the response of leading firms was tepid or even cooperative. The president of Bell Labs declared that Bell Labs had grown so large that "it cared little about patents anymore" (Owens 1991: 1078 n.5, citing Hearings Before the Temporary National Economic Committee 1969). Ford Motor Company executives supported the proposed reforms and stated that patents were not particularly important in supporting R&D (Machlup 1962:168, citing Hearings Before the Temporary National Economic Committee 1940).[44]

d. *1960s/1970s (Software Patents).* The Patent Office began to issue patents for software innovations, despite ambiguity as to whether these innovations fell within patentable subject matter. This elicited a policy debate in which IBM and other leading hardware manufacturers (who bundled proprietary software with their hardware product) opposed the extension of patents to software (Allison et al. 2007).

e. *Early 1990s* (*Gene Patents*). Genomics firms and other entities sought to patent isolated fragments of genetic materials ("expressed sequence tags"). In the ensuing policy debate over the patentability of these materials, several large pharmaceutical companies lobbied successfully for elevated standards for gene patent applicants (U.S. Patent Office 2001)

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[44] Edsel Ford, the then-CEO of the Ford Motor Co. declared his support for the proposed reforms and, together with the company's legal counsel, reported that Ford offered its patents to "any applicant" at no charge and abstained from enforcing its patents against parties who failed to enter into a license (Hearings Before the Temporary National Economic Committee 1938:182, 257-58).

and sought to preempt patenting by developing open-access databases of genetic materials.

f. *Late 1990s* (*Financial Method Patents*). In 1998, the Court of Appeals for the Federal Circuit extended patent protection to financial-method innovations (*State Street Co v. Signature Financial Group*, 149 F.3d 1368 (Fed. Cir. 1998)). Since that time, large financial services firms have lobbied (principally through a consortium known as the Financial Services Roundtable), mostly successfully, to restrict the scope of this decision (Barnett 2009a:424-26).[45]

g. *1990s-Present (Information Databases).* The Bloomberg Corporation, the leading firm in the financial information industry, has successfully opposed efforts in Congress to enact *sui generis* intellectual property rights for information databases (Band & Kono 2001). Notably, firms that sell information without any complementary products or services (unlike Bloomberg, which provides access through proprietary terminals) tend to support these proposals.

h. *Present (Information Technology).* Currently large information technology firms, acting through consortia such as the Business Software Alliance and the Information Technology Industry Council, have been the leading proponents of changes to the patent laws that make it harder to obtain a patent and harder to enforce a patent and obtain a large damages award. These changes were partially implemented by the America Invents Act of 2011.

i. *Present (Digital Content).* Currently search and distribution intermediaries, as well as hardware manufacturers, in the internet and information technology markets are among the most vigorous opponents of enhancing liability for indirect infringement of the copyright laws (most recently, with respect to the proposed and defeated "SOPA" legislation). These firms' services and technologies facilitate mass infringement of copyright by individual users.

2. *Empirical Evidence*

Empirical studies on firms' lobbying behavior with respect to intellectual property laws find evidence that is consistent with incumbents' tendency to support constraints on public IP,

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[45] These reforms have included: (i) legislative changes in 1999, which immunized prior secret users of financial methods against infringement claims brought by subsequent patentees of those methods (American Inventors Defense Protection Act, 35 U.S.C. §122(b)), and (ii) changes made by the PTO in 2000 to institute a "second look" review of business method applications (U.S. Patent & Trademark Office 2000).

whereas smaller firms tend to take the opposite view. With the exception of the pharmaceutical and content industries[46], large public corporations have tended to support legislative and judicial reforms that limit patentees' ability to pursue infringement actions and damages. In a recent study of amicus briefs filed at the Supreme Court involving patent-related cases during 1989-2009, it was found that public corporations filed briefs favoring the patentee only *32*% of the time; by contrast, universities favored patentees 75% of the time and patent holding companies favored the patentee virtually all of the time (Chien 2011). The opposition to strong patent protection is most pronounced in the case of large information technology companies, which have lobbied to reduce patent damages, limit the patentability of business method patents, raise the threshold for obtaining patent protection, limit the ability to obtain injunctive relief, and expand opportunities for third parties to challenge issued or pending patents (Kesan & Gallo 2009). The aforementioned study of Supreme Court amicus briefs confirms this tendency: among all amicus briefs filed by high-technology and financial services companies, only 36% favored the position of the patentee (Chien 2011). These proposed reforms to patent law (which have been partially adopted[47]) have been opposed by the biotechnology industry, the "fabless" segment of the semiconductor industry, the venture-capital firms that back those innovators, and patent-holding firms (Barnett 2009a, Barnett 2011b).[48]

[46] These exceptions do not contradict my general thesis. Both types of firms suffer from a large difference between invention and imitation costs, such that even large firms do not have access to adequate protection technologies without public IP. Additionally, content companies sometimes have few complementary excludable assets by which to extract the returns on creative production. The same is not true of large integrated technology manufacturers and media distribution intermediaries, which would happily give away content in order to increase the value of the device on which that content is played (or, in the case of search companies, to increase the value of advertising slots, the positively-priced complementary good). Therefore these companies vigorously oppose all legislative and judicial efforts to increase the legal penalties for, and lower the costs of prosecuting, copyright infringement.

[47] Several recent Supreme Court decisions have restrained patentees' right. These include: *Quanta Computer v. LG Electronics*, 553 U.S. (2008) (upholding patent exhaustion doctrine); *KSR Int'l v. Teleflex, Inc.*, 550 U.S. 398 (2007) (relaxing standard for finding a patent to be invalid as nonobvious); *Medimmune v. Genentech*, 549 U.S. 118 (2007) (expanding circumstances under which patent licensee may seek declaratory judgment that the licensed patent is invalid); *eBay v. MercExchange LLC*, 547 U.S. 388 (2006) (holding that, even if patent is found valid and infringed, injunctive relief only issues subject to traditional 4-factor test). Additionally, in 2011, the Federal Circuit issued a decision that raises the evidentiary threshold to obtain damages (*Uniloc USA v. Microsoft* (Fed. Cir. 2011), and Congress enacted the America Invents Act, which (among other things) raises the evidentiary threshold to obtain a patent and expands opportunities to oppose issuance of a patent.

[48] Another recent study of political-economic behavior in the patent system is Kesan & Gallo (2009), who observe lobbying behavior in Congress by constituencies affected by changes in various attributes of the patent laws. While a full description is beyond this paper's space constraints, they generally find that large information technology firms push for weaker patent protections while pharmaceutical and biotechnology firms, as well as small inventors, tend to push for stronger patent protections.

3. *Evaluation*

The revealed political-economic preferences of integrated and non-integrated firms, as shown by historical and empirical evidence, largely track those firms' differences in the costs of adopting private IP instruments as compared to public IP. As those costs increase, firms' demand for public IP increases, and *vice versa*. At the same time, firms that enjoy the lowest costs in accessing private IP tend to suffer the highest costs in defending against opportunistic litigation brought by claimed holders of public IP. The rationale is transparent. Integrated firms' lower-cost access to the complementary assets that function as private IP substitutes implicitly advantages hierarchical firms in any environment in which public IP is weak and entrepreneurial competitors cannot acquire those same assets at the same cost. Hierarchical firms therefore support reducing public IP to raise potential or actual rivals' entry costs, while entrepreneurial firms oppose any such action for the same reason. This has an important normative implication. Contrary to conventional assumptions, reducing public IP can distort market pricing even further away from competitive conditions, resulting in *more* deadweight losses and *greater* access restrictions relative to a weaker public IP regime. Consistent with my earlier discussion, there is no assurance that increasing public IP increases *incremental* deadweight losses and transaction costs—the markets discussed above suggest that those costs can fall *on net* as public IP rights are more widely adopted and enforced and non-integrated firms are able to enter the market independently. In those markets, a perverse result can again ensue from reducing public IP: dominant incumbents are shielded from entry and use their market power to increase the extent of propertization through private IP mechanisms, with a resulting reduction in the size of the public domain.

Conclusion

Intellectual property law is commonly viewed as a device for providing property rights in markets that do not have any other mechanism by which to defend investments in innovation against capture by free-riders. This assumption is false: intellectual property law always intervenes in markets that already have some other private source of property rights. The effects of changes in public IP on aggregate propertization levels is a function of a firm's costs of substituting toward private alternatives to public IP. In general, weaker public IP tends to advantage more integrated firms that have lower costs of adopting private IP substitutes; conversely, stronger public IP protects less integrated firms that have high costs of adopting private IP. As a result, public IP tends to expand the set of organizational forms from which innovators may select, which supports open and flexible markets populated by unintegrated firms with stand-alone R&D capacities, while private IP tends to restrict that set, resulting in closed markets dominated by integrated firms that hold complementary R&D, production and distribution capacities. The firm-level and market-level organizational differences that emerge under different levels of public IP protection are not merely aesthetic. Public IP preserves firms' ability to select the most efficient organizational form for capturing returns on innovation, which drives innovation and commercialization costs to the technological minimum, reduces entry costs for younger, smaller and less integrated firms, and maximizes the net social value generated by innovation. Reducing public IP reverses all those effects, although it does mitigate unproductive forms of patent-based entrepreneurship. Rather than entrenching incumbents, intellectual property is often a tool by which to unseat them; and, rather than promoting competition, withdrawing intellectual property is often a tool by which to suppress it.

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