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Intellectual Property as a Law of Organization

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Conventionally patents are understood to be critical instruments for supporting incentives to invest in innovation. But empirical support for this thesis is mixed across a range of markets, periods and jurisdictions.[1] In large part, those results may reflect the fact that firms often have access to alternative mechanisms by which to capture returns on innovation: take away patents and firms often can fill the gap by recourse to non-patent substitutes.[2] In this Article, I offer an alternative account of the patent system that explicitly recognizes the "IP-unfriendly" fact that patents are often not a unique instrument by which to capture innovation returns. In lieu of the traditional incentive thesis, I advance the "organizational thesis": namely, patent protection typically regulates innovation behavior to the extent it regulates the organizational structures among which innovators[3] select in order to generate and commercialize intellectual goods. Contrary to other attempts to provide a sounder basis for the patent system without reference to any incentive function[4], I exploit patents' organizational function—that is, patents' effects on transactional, firm and market structures—as a basis for reinvigorating the incentive thesis, as applied in mediated form to a selected but broad set of circumstances. Stated most generally, this thesis consists of a simple two-part proposition: (i) stronger or weaker levels of patent protection[5] sometimes influence the organizational forms that

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1 *See infra* note [12] and accompanying text.

2 For a detailed review of market substitutes for patents, see Jonathan M. Barnett, *Private Protection of Patentable Goods,* __ CARDOZO L. REV. __ (2004) [henceforth Barnett, *Private Protection*]. For an extended theoretical discussion of the indeterminate effects of intellectual property taking into account private-market substitutes, see Jonathan M. Barnett, *Is Intellectual Property Trivial?,* 157 U. PA. L. REV. 1691 (2009) [hereinafter Barnett, *Trivial*].

3 By "innovators", I refer broadly to any individual, entrepreneur, firm or other entity that is involved in generating and commercializing new technologies. This encompasses but extends beyond the traditional category of the inventor, who is not involved in commercialization.

4 *See* Paul J. Heald, *A Transaction Costs Theory of Patent Law,* 66 OHIO ST. L. J. 473 (2005) (arguing that patents reduce transaction costs of organizing and monitoring team production of R&D and other innovation assets); Clarisa Long, *Patent Signals,* 69 U. CHI. L. REV. 625 (2002) (arguing that, independent of any exclusionary function, patents perform a signaling function that relieves informational asymmetries, especially between firms and investors).

5 By "weak" or "strong" patent protection, I refer generally to the multiple factors that influence the strength of patent protection, including (among other things) duration, scope, cost of enforcement,

entrepreneurs, firms and other entities select in order to conduct the innovation and commercialization process and (ii) those organizational effects influence entrepreneurs', firms' and other entities' incentives to invest in innovation. Where this proposition is satisfied (which, I argue, is a typical but not universal outcome), it preserves an incentive function for patents even under the most adverse assumption that patents have no "added value" as a tool for constraining imitation in the goods market.

To develop this proposition, I pursue the intellectual equivalent of a pruning strategy: I remove decaying material in order to promote future growth. First, I intentionally overstate the empirical evidence by assuming that reverse-engineering barriers or other mechanisms always frustrate imitation in the goods market. Second, I severely cut back the scope of application of the incentive thesis to limited circumstances where patents enable innovators to accrue returns through weakly-integrated entities that contract with third parties to implement the commercialization process. That "zone of certainty" tracks a substantially accepted view that small firms and individual inventors most clearly depend on the patent system.[6] Third, I move beyond this limited proposition by arguing that these first-order effects over the innovation incentives of weakly-integrated entities can set off a sequence of higher-order effects over supply chain configurations, entry conditions and market structure that encompass a far broader range of firm types (in fact, all but perhaps the most highly-integrated entities). In particular, patents' localized incentive effects over R&D suppliers are symptomatic of a generalized bargaining process that continuously reallocates research, production, and other supply chain functions among the lowest-cost combination of external and internal providers, thereby minimizing innovation and commercialization costs. The specialization gains resulting from this division of labor in turn can yield socially attractive effects on market growth and formation that extend beyond the conventional link between "more IP" and

anticipated damage awards, etc. As Prof. B. Zorina Khan shows, even an apparently mundane element such as examination fees can exert a great effect on the "strength" of the patent system. *See* B. ZORINA KHAN, THE DEMOCRATIZATION OF INVENTION: PATENTS AND COPYRIGHTS IN AMERICAN ECONOMIC DEVELOPMENT, 1790-1920 (2005).

[6] On the role played by the patent system in supporting specialized R&D suppliers, see Ashish Arora & Robert P. Merges, *Specialized supply firms, property rights and firm boundaries,* 13 IND. & CORP. CHANGE 451, 454, 472 (2004); Barnett, *Private Protection, supra* note __; Robert P. Merges, *Intellectual Property Rights, Input Markets and the Value of Intangible Assets* (Working Paper 1999) [henceforth Merges, *Input Markets*]. On the role of small firms in the chemicals and biotechnology sectors, see *infra* Part II.C; and generally, *see infra* note [48].

"more innovation". For the incentive thesis, less is more. Initially confining the thesis to the firm categories and market settings where it is most robust ultimately reinstates it as a compelling account of the manner in which patents can exert far-reaching effects over firm and market structure, which in turn yield incentive effects consistent with the standard rationale and market growth effects that go beyond it.

This project builds upon allied bodies of work by legal scholars, business management scholars and economic historians—in particular, Prof. Robert Merges in the legal literature, Prof. Ashish Arora in the management literature and Profs. Kenneth Sokoloff and Naomi Lamoreaux in the economic history literature—who have pioneered inquiry into the interactions between intellectual property, transactional design, firm boundaries and market structure.[7] Consistent with these empirically-grounded lines of scholarship, I anchor my arguments in two foundational observations. First, firms must commercialize innovations in order to realize any payoff on their R&D investment (and, more generally, for everyone else to realize a social payoff on the firm's R&D

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7 *See* ASHISH ARORA ET AL., MARKETS FOR TECHNOLOGY: THE ECONOMICS OF INNOVATION AND CORPORATE STRATEGY (2001); LEARNING BY DOING IN MARKETS, FIRMS AND COUNTRIES (eds. Naomi Lamoreaux et al.) (1999); Arora & Merges, *supra* note 6; Robert P. Merges, *A Transactional View of Property Rights*, 10 BERKELEY TECH. L. J. 1477 (2005) [henceforth Merges, *Transactional View*]; Merges, *Input Markets, supra* note 6. In particular, Profs. Arora & Merges have argued that intellectual property rights can exert incentive effects indirectly by supporting the viability of specialized R&D firms that enter into supply contracts with larger integrated firms. *See* Arora & Merges, *supra* note __, at 454, 472. For other contributions in the legal literature on the relationship between intellectual property and firm structure, see Oren Bar-Gill & Gideon Parchomovsky, *Firm Boundaries in Technology-Intensive Markets,* 157 U. PA. L. REV. 1649 (2009), and Dan. L. Burk & Brett H. McDonnell, *The Goldilocks Hypothesis: Balancing Intellectual Property Rights at the Boundary of the Firm,* 2007 U. ILL. L. REV. 575, and, on the relationship between intellectual property and market structure, see Martin J. Adelman, *The Supreme Court, Market Structure and Innovation: Chakrabarty, Rohm and Haas,* 27 ANTITRUST BULL. 457 (1982). For other contributions in the economic history literature, see *infra* notes [75-77]. Inquiry into the relationship between intellectual property and firm structure ultimately traces back to contributions by: David J. Teece, *Firm Organization, Industrial Structure and Technological Innovation*, 31 J. ECON. BEHAV. & ORG. 193 (1996); David J. Teece, *Profiting from technological innovation: Implications for Integration, Collaboration, Licensing and Public Policy,* 15 RESEARCH POL'Y 285 (1986) [hereinafter Teece, *Profiting*]; David J. Teece, *Economies of scope and the scope of the enterprise,* 1 J. ECON. BEHAV. & ORG. 223 (1980). This Article seeks to advance these bodies of scholarship in three principal respects: (i) it views specialized R&D suppliers (the focus of much of the existing literature) as a subset of a general case where intellectual property rights enable the efficient allocation of innovation and commercialization functions among least-cost providers throughout the supply chain, (ii) it provides a consolidated structure that identifies links between the entry of upstream R&D suppliers, the unraveling of downstream portions of the supply chain and the formation of secondary markets in supply chain functions and inputs, and (iii) it exploits these relationships in order to isolate the circumstances where patent coverage exerts incentive effects on innovation behavior as well as positive feedback effects on market growth that extend beyond an incentive-based framework.

investment), which in turn necessitates implementing capital-intensive and skill-intensive activities to reach market release. Any practically compelling theory of intellectual property must therefore show how it supplies incentives to fund the commercialization process. Second, as Kenneth Arrow observed long ago, innovators face an inherent obstacle in commercializing new technologies. That is because bargaining over an intangible resource is frustrated by a "chicken and egg" problem: negotiation to agree upon valuation necessitates disclosing the invention, which allows the listener to seize it at will.[8] That means that innovators who have an "idea" may have difficulty bringing it to market: expropriation threats preclude outsourcing commercialization functions without risking forfeiture of the innovation. Any practically compelling theory of intellectual property must address this obstacle to market release.

The shift in focus to the commercialization stage that lies between invention and market release is the key to identifying the role that patents can play in influencing certain firms' configuration of the supply chain by which innovations reach market, which in turn promotes those firms' innovation incentives consistent with the conventional thesis. Recall the starting assumption: an "IP-unfriendly" environment where reverse-engineering barriers or other extra-patent mechanisms substantially delay imitation in the goods market. That state of affairs would appear to threaten patents with redundancy. But expropriation risk can still persist at any point at which innovators must disclose information to external providers of the functions that must be implemented in order to deliver an innovation to market. It is precisely at this stage—post-invention but pre-release—that patents can play a unique role. Without patents, expropriation risk induces an organizational response: innovators integrate forward so as to implement commercialization independently and minimize interaction with third parties. That would appear to resolve the expropriation threat (which would *again* appear to threaten patents with redundancy). However, it is critical to appreciate that integration can impose a subtle but important cost. Where expropriation risk compels an innovator to select higher levels of integration than it otherwise would have preferred, the innovator must forfeit specialization gains that could have been accrued by allocating one or more

[8] *See* Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, in THE RATE AND DIRECTION OF INVENTIVE ACTIVITY 614-16 (1962). The idea is repeated subsequently, see KENNETH J. ARROW, THE LIMITS OF ORGANIZATION 152 (1974).

supply chain functions to lower-cost providers. In the extreme case, those specialization losses are so great that entry is no longer cost-feasible. Patents mitigate expropriation risk and therefore enable innovators to select freely among organizational forms in order to capture specialization gains through relationships with lower-cost providers. That in turn maximizes innovation profits and incentives consistent with the conventional rationale.

In short: transactional, firm and market structures sometimes look much different under stronger or weaker forms of patent protection and these organizational effects sometimes matter for the underlying objective of supporting innovation. This is not to say that strong forms of patent coverage do not give rise to transactional burdens, opportunistic litigation and other social costs that may ultimately recommend against it "on net" in any particular market. The organizational thesis is ambitious as a positive statement but modest in its normative aspirations. It simply identifies on a "gross" basis an important set of social gains—much of which is overlooked in legal and policy discussions of intellectual property—generated by the bargaining processes secured by patent rights. These social gains fall into two categories that encompass but extend beyond the R&D suppliers that are most obviously dependent on the patent system. First, the same specialization logic that drives upstream R&D suppliers to outsource downstream production functions can induce—actually, by competitive pressure, it will compel—ongoing adjustments throughout the remainder of the supply chain. Integrated firms exit the research portion of the supply chain, specialized entities enter at the production, testing or other portions of the supply chain, "virtual" firms exit all portions of the supply chain except for marketing and distribution, and so on. This continuously adaptive division of labor exerts positive feedback effects by reducing costs and expanding output, which in turn increases the size of the market, and induces further entry by suppliers of technological and production inputs at all points on the market supply chain. Second, breaking up the supply chain among least-cost providers forms the basis for assembling the transactional infrastructure required to support a "market in ideas" that has the potential to operate akin to a trading market in tangible goods. Disaggregation multiplies supply chain providers and inputs, which gives rise to informational complexities that induce re-intermediation by transactional entrepreneurs who match buyers and sellers of technological inputs, which (if successful) can be expected to yield the efficiency gains associated with mature markets in tangible goods.

These complex relationships between intellectual property on the one hand and supply chain configurations, firm scope, and market structure and formation on the other hand extend intellectual property analysis toward both "micro-level" issues of operational design and "macro-level" issues of market growth that have received little attention in legal scholarship on intellectual property. The virtuous sequence of strong patents, adaptive supply chains, specialization economies and market expansion certainly does not tell the "whole story" of the patent system. But it represents an important part of the story that is rich in both research potential and policy guidance. To illustrate these relationships in close detail, I provide a case study of the "fabless" segment of the semiconductor market, which develops designs for customized chips used in data processing, transmission, and storage technologies. Over roughly the past 15 years, this multi-billion dollar and patent-intensive market has migrated from almost exclusive reliance on integrated supply chains to substantially disintegrated structures where "fabless" firms that specialize in chip design contract out "fabrication" functions to third-party "foundries" that specialize in the production process. Consistent with specialization logic, the fabless/foundry model has induced entry by intermediaries that provide design tools, standardize design interfaces and aggregate design portfolios for licensing purposes. This transformation of firm and market structure offers an uncharacteristically robust (if still incomplete) realization of a "market in ideas", which has otherwise largely remained the subject of theoretical design. Importantly, it provides a counterfactual to the frequently asserted (but infrequently documented) claim that widespread patenting, and the resulting fragmentation of intellectual resources, impedes innovation and entry in technology markets. To the contrary: the fabless chip market, and the challenge it has mounted to powerful incumbents, almost certainly would not exist without it.

Organization is as follows. In Part I, I situate the innovation process within the market supply chain and explore the extent to which firms can mitigate expropriation risk through contractual, reputational and organizational solutions. In Part II, I describe how patents enable firms to extract specialization gains by outsourcing R&D and commercialization functions, which multiplies entry opportunities throughout the supply chain. In Part III, I describe how vertical disintegration promotes secondary markets in intellectual goods. In Part IV, I illustrate these relationships through a case study of the fabless semiconductor market.

I. The Commercialization Problem

Incentive-based discussions of the patent system typically focus on expropriation risk in the goods market, which in turn yields underinnovation in the absence of legal protections against imitation. But empirical evidence casts doubt on this assumption. Outside of the pharmaceutical and chemical industries (important exceptions to be sure), moderate to large-sized firms often have other effective means—reverse-engineering barriers, technology and contract—by which to delay imitative entry.[9] Even if we over-generously accept this body of evidence without qualification[10], expropriation risk still confronts innovators before a consumption good embodying the innovation reaches the market.[11] In an early contribution, Kenneth Arrow drew attention to this sensitive juncture—post-invention but pre-commercialization—by describing a dilemma that has since become known as "Arrow's Paradox" or the "disclosure paradox".[12] Absent a

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[9] The leading evidence is found in survey studies covering large U.S. manufacturing firms, which find that, among legal and extralegal mechanisms for appropriating returns from R&D projects, firm managers (outside of the pharmaceutical and chemicals industries) usually report that patents are among the least effective instruments and are rarely the "but for" condition for proceeding with an R&D project. *See* Wesley M. Cohen et al., *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patents (or Not)* (Nat'l Bureau of Econ. Research Working Paper No. 7552) (2000) (surveying R&D managers randomly drawn from a sample of all R&D labs in the U.S. operating as part of a manufacturing firm); Richard C. Levin et al., *Appropriating the Returns from Industrial Research and Development,* in 3 BROOKINGS PAPERS ON ECONOMIC ACTIVITY: SPECIAL ISSUE ON MICROECONOMICS 783 (Martin Neil Bially & Clifford Winston eds. 1987) (surveying R&D managers in all publicly traded firms in the U.S. with substantial R&D expenses); Edwin Mansfield, *Patents and Innovation: An Empirical Study,* 32 MGMT. SCI. 173 (1986) (surveying R&D managers of 100 randomly chosen U.S. firms from 12 industries). As noted in part in the text above, these studies do not address the value placed by small firms on patent protection; that is an important limitation, as will become apparent in the ensuing discussion. For a recent survey study that addresses the use of patents by small firms in selected industries, see Stuart J.H. Graham, Robert P. Merges, Pamela Samuelson & Ted M. Sichelman, *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey,* BERKELEY TECH. L. J. (2009).

[10] For a more detailed review of this evidence and other related studies, which shows substantial industry-specific and firm-specific variation, see Jonathan M. Barnett, *Do Patents Matter? Empirical Evidence on the Incentive Thesis,* in LAW, INNOVATION AND GROWTH (ed. Robert Litan) (forthcoming 2010).

[11] Unless otherwise specified, I generally use the term, "users", rather than "consumers", given that products or services that embody innovations are often sold to intermediate users rather than end users.

[12] *See supra* note __.

property right to block unauthorized usage, innovators will not disclose an idea to counterparties for the purpose of purchasing the idea or otherwise assisting in its commercial development. The reason is simple: the idea buyer cannot credibly commit against copying the idea if it believes the idea is commercially valuable, in which case the idea seller would lose any ability to profit from it. By anticipation, the innovator declines to invest in generating the idea and underinnovation ensues—*even if* expropriation risk could have been controlled upon release in the goods market. This proposition implies a broad scope of application for patent rights to support the commercialization process. However, it is important to observe that innovators are not helpless: even without patents, expropriation risk in precontractual bargaining can sometimes be limited through some combination of reputation effects, selective disclosure and/or organizational integration. If we take into account these imperfect but often meaningful defenses, we can then define more precisely the set of circumstances where the disclosure paradox—and the resulting impediments to efficient bargaining—will yield underinnovation.

A. Intellectual Property Meets Supply Chain Management

Invention means little without commercialization: an entire millennium lagged between the invention of the water mill and its widespread adoption.[13] Societies that have supported innovation by reward and subsidy systems often have been relatively successful at inducing innovation but relatively unsuccessful at embodying those innovations in consumption goods. The Soviet Union illustrates this observation: invention was forthcoming but dissemination was stalled.[14] Consistent with this view, a handful of legal scholars have recently emphasized the importance of studying the incentives provided by the patent system for the commercialization tasks required to deliver an innovation to market.[15] The allocation of costs among research and

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[13] *See* NATHAN ROSENBERG, INSIDE THE BLACK BOX: TECHNOLOGY AND ECONOMICS 19 (1982).

[14] *See* Maurizio Iacopetta, *Dissemination of Technology in Market and Planned Economies,* THE B.E. JOURNAL OF MACROECONOMICS (2004). For a similar point, see WILLIAM J. BAUMOL, THE FREE-MARKET INNOVATION MACHINE: ANALYZING THE GROWTH MIRACLE OF CAPITALISM (2002).

[15] Prof. F. Scott Kieff in particular has emphasized this point. *See* F. Scott Kieff, *IP Transactions: On the Theory and Practice of Commercializing Innovation,* 42 HOUS. L. REV. 727, 736-37 (2005); F. Scott Kieff, *Property Rights and Property Rules for Commercializing Innovations*, 85 MINN. L. REV. 697, 703-04, 707-712 (2001). *See also* Ted M. Sichelman, *Commercializing Patents,* STANFORD L. REV. (2009)

commercialization activities supports this shift in scholarly attention. Research is typically only a portion, and in all likelihood the smaller portion, of the activities that must be undertaken in order to bring an innovation to market, which can run anywhere from millions of dollars in the case of a minor improvement to several billion dollars in the case of an infrastructural innovation.[16] Invention and commercialization of a new pharmaceutical product typically exceeds $1 billion while invention and commercialization of a new semiconductor chip typically exceeds several billions of dollars.[17] Without some mechanism by which to fund and implement these tasks, innovator firms will decline to invest in the R&D activities that get the process started.

To reflect this commercialization imperative, I consistently situate the innovation process within the supply chain that an innovator (or any entity that controls an innovation) must implement as it moves from generation of the intangible asset to its embodiment in products distributed to intermediate or end users, which in turn generates the revenue stream that supports by anticipation the initial R&D investment. The Figure below presents a generic supply chain comprising a number of functions and inputs—including intangible technological inputs, tangible production inputs, and (not shown in the Figure) capital inputs to fund all cash expenditures—required to deliver an innovation to market. While the disclosure paradox is situated by convention somewhere toward the top of the supply chain, it potentially operates at varying degrees of severity at every step of the supply chain running through market release (and even beyond). As indicated on the left-hand side of the Figure, an innovator may elect to contract with third parties for some, all or no functions and inputs in the supply chain. Where it does not elect to contract for any particular function or input, it must vertically integrate forward and implement that function or generate that input independently. To the extent that

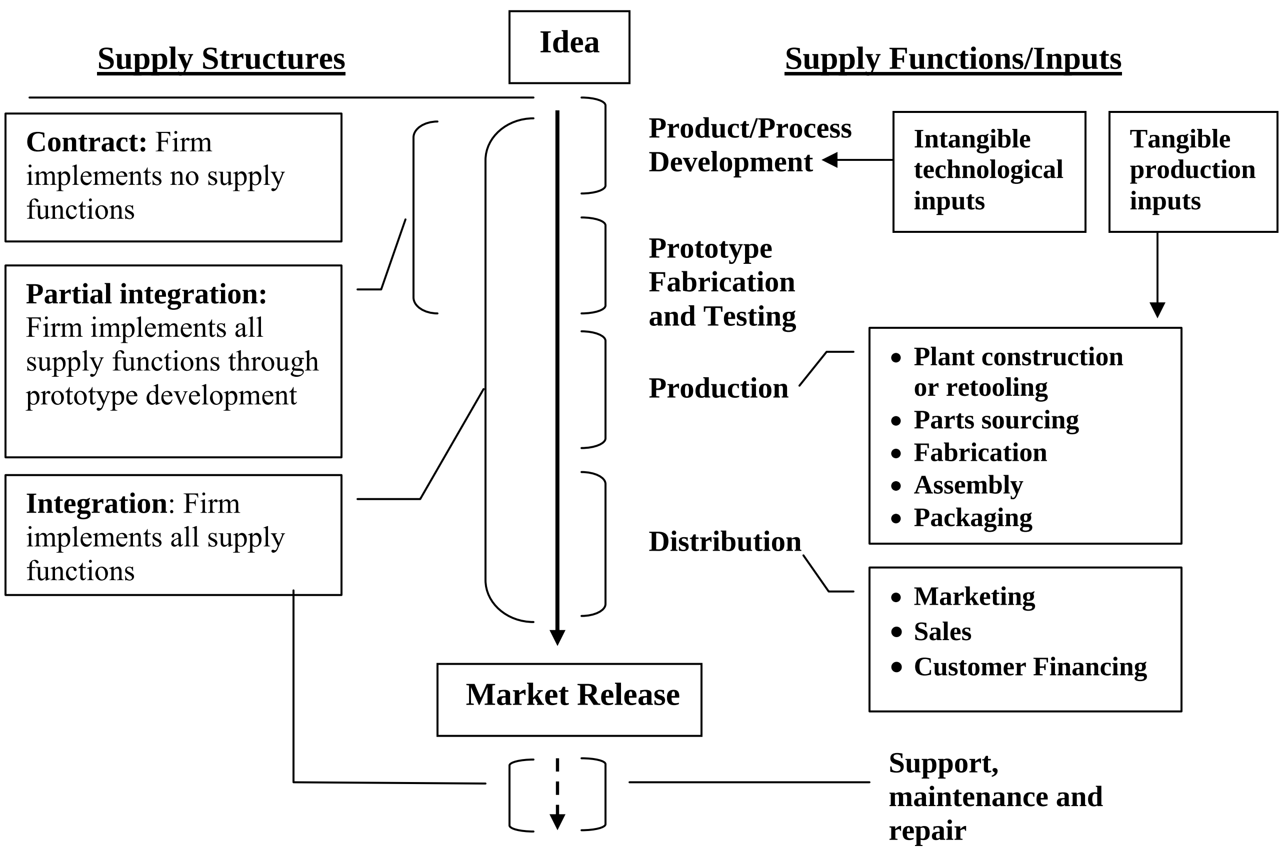
(recognizing the costs of commercialization but arguing that the patent system in its current form can frustrate commercialization efforts).

[16] The point has long been recognized. *See* JOHN JEWKES, DAVID SAWERS & RICHARD STILLERMAN, THE SOURCES OF INVENTION 200 (1958) (noting that "[t]he contrast between the relative cheapness of inventing and the heavy costs of perfecting and developing was frequently remarked upon in the nineteenth century") and 202 (observing that the costs of product development in the twentieth century increased dramatically).

[17] *See* Joseph A. DiMasi et al., *The price of innovation: new estimates of drug development costs,* 22 J. HEALTH ECON. 151, 165, 180 (2003) (excluding marketing and distribution costs, a pharmaceutical firm incurs $800 million in capitalized research, development and testing costs). For figures on chip development, taking into account fabrication plant construction costs, see *infra* note __.

precontractual bargaining (or subsequent interaction in the course of performance) necessitates disclosure of information that can then be used or transferred by the counterparty to the innovator's disadvantage, expropriation risk may block efficient outsourcing transactions, which in turn inflates commercialization costs and by anticipation discourages the initial R&D investment. The remainder of this Part is devoted to identifying the conditions under which that bargaining failure is likely to arise.

Figure I: Generic Supply Chain



B. Contractual Solutions

It is important to understand why contractual solutions cannot reliably overcome the disclosure paradox. Suppose the typical scenario where an inventor has formulated an idea and wishes to sell it to a large integrated firm. Writing a contract contingent on appraisal of the idea (e.g., "Buyer agrees to pay Seller $X for Buyer's idea if it is good") is not feasible because the idea seller (the inventor) and the idea buyer (the firm) cannot agree on valuation without the seller disclosing the idea in the course of negotiations and thereby forfeiting it to the buyer.[18] This dilemma can not be resolved or even appreciably mitigated by "non-disclosure agreements" ("NDAs"). The reason is simple (and widely known to practicing lawyers): barring drafting errors, NDAs typically protect against subsequent disclosure by the idea buyer to third parties but not use by the idea buyer itself. No idea buyer will rationally covenant against use since the idea buyer may already possess the idea, in which case it would be exposed to expropriation by the idea *seller*. Buy-side expropriation risk explains why NDAs often include language precluding the disclosing party from making any state-law misappropriation claims against the recipient party[19], why venture capitalists typically refuse to sign *any* form of NDA, and why, given exposure to state-law misappropriation claims (functionally equivalent to a state-imposed "default" NDA), Hollywood studios generally refuse to receive unsolicited idea submissions.[20]

Rational unwillingness by buyers and sellers to enter into idea transactions are indicative of an underlying drafting constraint: parties cannot write a contract that precludes precontractual expropriation by the idea buyer without simultaneously facilitating postcontractual expropriation by the idea seller. Trade secrecy law provides unreliable protection.[21] While trade secret protections may apply in the context of certain

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[18] Profs. Anton & Yao have proposed a creative solution: the idea seller can protect against expropriation by the idea buyer, firm *A*, by threatening to provide its idea to rival firm *B*, who will then extract rents that would have been enjoyed by firm *A*. *See* James J. Anton & Dennis A. Yao, *Expropriation and Inventions: Appropriable Rents in the Absence of Property Rights,* 84 AMER. ECON. REV. 190 (1994). This argument requires that firms *A* and *B* can engage in tacit collusion to preserve rents on products embodying the disclosed technology; if that were not the case, the innovator would have no credible threat against *A,* who would anticipate that *B* would pay nothing for an innovation that (given *A*'s knowledge) could not deliver a supracompetitive return. This contingency appears to be illustrated by the phenomenon in Hollywood where "shopped-around" scripts are rejected by multiple studios, who then develop related concepts, resulting in the release of multiple films with similar storylines, which in turn depresses revenues as expected. *See* Gans & Stern, *Market for Ideas, supra* note __, at 18-19. In any event, there can be little doubt that expropriation risk remains a typical concern that afflicts real-world negotiation over idea exchanges. *See* Bruno Biais & Enrico Perotti, *Entrepreneurs and new ideas,* 39 RAND J. ECON. 1105, 1106 (2008); Arora & Merges, *supra* note __, at 459.

[19] Personal knowledge based on author's experience in drafting and negotiating NDAs in legal practice.

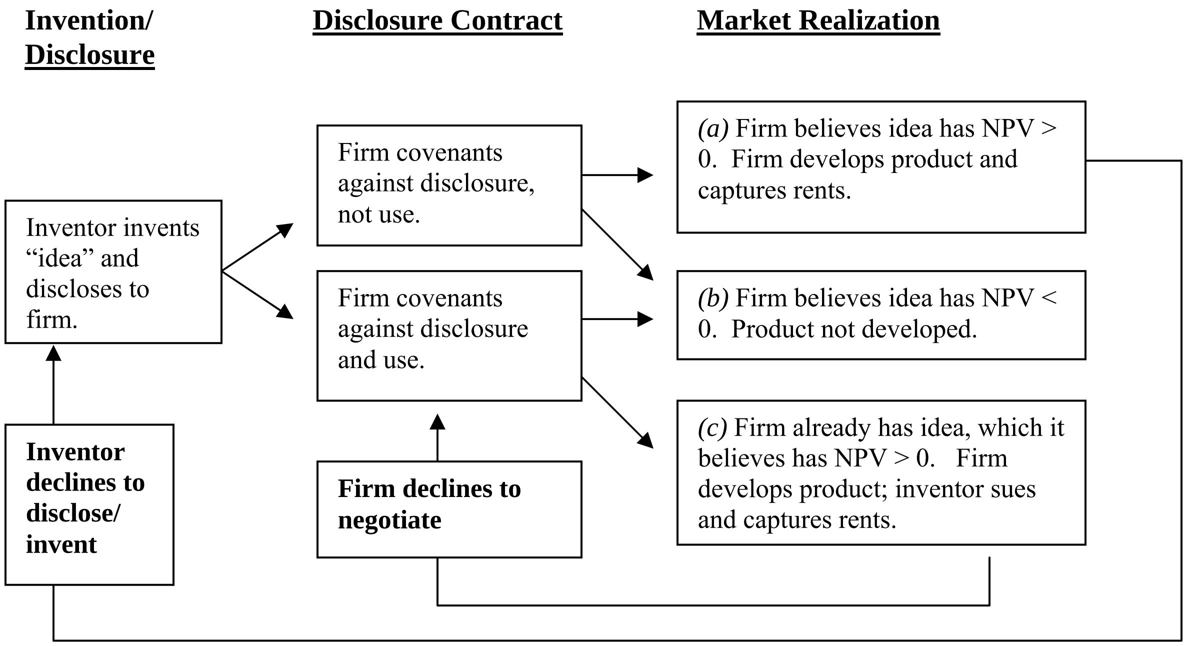
[20] Personal knowledge; confirmed in discussion with entertainment industry executive.

[21] For sake of brevity, I do not address specifically other common-law causes of action against idea appropriation, which are even more unreliable than trade secret claims. *See, e.g.,* Nadel v. Play-by-Play Toys & Novelties, Inc. (2nd Cir. 1999).

confidential communications, those protections can be lost if a court determines that the disclosing party failed to undertake reasonable measures to maintain secrecy (or, in the words of one court, failed "to exercise eternal vigilance" in protecting its trade secret).[22] Both buy-side and sell-side opportunism, coupled with the absence of any reliable contractual or trade-secret protections, frustrate or complicate negotiation of any idea transaction. By anticipation, this may deter the initial investment required to generate the idea. As shown in the Figure below, whether or not this two-sided expropriation threat yields a net social loss depends on the net present value of the suppressed idea. In both case *(a)* (which reflects buyer opportunism) and case *(c)* (which reflects seller opportunism), contracting failure yields a real social cost: new ideas with positive net present value are not realized. Case *(b)*, which anticipates no social loss as a result of inability to contract, is included for completeness.

[22] *See* D.B. Riley, Inc. v. A.B. Engineering Corp., 977 F.Supp. 84, 91 (D. Mass. 1997), *citing* J.T. Healy & Son, Inc. v. James Murphy & Son, Inc., 260 N.E.2d 723, 730-31 (Mass. 1970). For an illustration of the weakness of trade secret protection, consider the following recent case. Silicon Image, a semiconductor chip designer, regularly required its licensees to enter into "NDAs" and operate under various technological constraints to protect against unauthorized distribution and use of the licensed designs. A competitor allegedly misappropriated its designs. The court nonetheless denied a preliminary injunction on the ground that even Silicon Image's diligent precautions were potentially insufficient. *See* Silicon Image, Inc. v. Analogk Semiconductor, Inc., No. 07-cv-00635 JCS, 2008 WL 166950 (N.D. Cal., Jan. 17, 2008). For a fuller discussion of cases that illustrate the uncertainty of trade secrecy protections in precontractual negotiation, see Merges, *Transactional View, supra* note __.

Figure II: The Disclosure Paradox



C. Extra-Contractual Solutions

Absent some meaningful resolution, the disclosure paradox results in two adverse effects on idea markets (defined generally as markets in legally-unprotected technological know-how and other intangible resources). First, on the supply side, it discourages investment by prospective sellers in generating new ideas, given the impossibility of contracting with any buyer. Second, on the demand side, it discourages investment by prospective buyers in identifying new ideas, given the impossibility of contracting with any seller. These bargaining obstacles account for common observations that idea markets are illiquid, suffer from lack of pricing transparency, and are slow to develop.[23] But this unqualified picture is overstated: scholars have documented informal exchanges

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[23] This point has long been recognized. *See* JEWKES ET AL., *supra* note __, at 256 (noting that the "market for new inventive ideas is imperfect" and subject to various deficiencies). A handful of economists have recently shown interest in markets for ideas (including why they are relatively rare and not fully operational). *See, e.g.,* Joshua S. Gans & Scott Stern, *Is There a Market for Ideas?*, J. ECON. LIT. (2009); Joshua S. Gans & Scott Stern, *The Product Market and the "Market for Ideas": Commercialization Strategies for Technology Entrepreneurs*, 32 RES. POL'Y 333 (2003). On the weaknesses of trading markets in patents, see Mark A. Lemley & Nathan Myhrvold, *How to Make a Patent Market*, 102 HOFSTRA L. REV. (2009).

of professional know-how in settings where intellectual property is largely absent.[24] This confirms casual empiricism: practicing lawyers engage in "shop talk" over transactional solutions and litigation strategies, unpatented business proposals are pitched to venture capitalists in Silicon Valley without contractual protections, and unprotected movie ideas are presented to production executives without contractual protections. It would be an exaggeration to contend that these informal idea markets operate with the liquidity, security and sophistication of a formal trading market in tangible goods or financial securities. As I have shown elsewhere, the most robust forms of unprotected idea exchange tend to persist in specialized settings that demand low levels of capital investment, are populated by close-knit professional communities and/or enjoy some limited ability to constrain access through technological or other extra-legal means.[25] But it would be unwarranted to dismiss these practices as insignificant anomalies. So it must be the case that some extralegal mechanism sometimes mitigates expropriation risk, thereby allowing limited but positive levels of idea exchange even without property-rights protections. Two principal devices can account for this phenomenon, as described below.

1. *Informational Opacity*

The disclosure paradox presumes that the seller's idea is transparent upon disclosure, implying that the buyer's expropriation costs are nominal to zero. That is a highly contingent proposition in technologically sophisticated markets. Often the disclosed idea may be informationally opaque: that is, it cannot be fully implemented as an operational matter without further know-how and other forms of "tacit" knowledge. Expropriation risk will decline where the buyer cannot make use of the idea without

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[24] *See, e.g.,* Gerda Gemser & Nachoem Wijnberg, *Effects of Reputational Sanctions on the Competitive Imitation of Design Innovations,* 22 ORG. STUD. 563 (2001) (documenting exchange of technical and style information among designers in luxury European custom furniture industry); Eric von Hippel, *Cooperation between rivals: informal know-how trading,* RES. POLICY (1987) (documenting reciprocal exchange of know-how among engineers in the steel minimill industry). This is an incomplete list. For discussion of other examples, see Jonathan M. Barnett, *The Fable of the Commons* (Working Paper 2010) [henceforth Barnett, *Fable of the Commons*].

[25] *See* Barnett, *Fable of the Commons*, *supra* note __.

substantial assistance from the seller.[26] If that is the case, then the seller can at least partially protect against expropriation by tying a graduated disclosure schedule to a graduated payment schedule. That is: the seller makes incremental disclosures of tacit knowledge (which, in a typical arrangement, may include implementing the idea as an employee of the buyer) in exchange for incremental payments by the buyer. Note, however, that, even if we assume a contracting arrangement that can feasibly implement this objective, this solution is still incomplete: it resolves expropriation by the buyer at the cost of facilitating expropriation by the seller. Assuming the disclosed technology is difficult to implement without supplemental disclosure of know-how, the seller will rationally withhold the final know-how installment in order to expropriate value from the buyer. By anticipation, the proposed transaction must either fail or proceed at some discount to protect against sell-side opportunism. Hence, the disclosure paradox may substantially persist—but without entirely blocking idea exchanges—even in settings where technology is substantially opaque.

2. *Reputation Effects*

The disclosure paradox presumes that the idea buyer is a one-shot player who places no value on accumulating reputational capital that can be deployed to lower the cost of future idea acquisitions. Where that is not the case, reputation effects may enable idea buyers to credibly commit against expropriation so long as idea sellers believe that a repeat-player firm will rationally seek to maintain a reputation for fair dealing in order to attract future idea submissions. Hence, a venture capitalist rationally forfeits single-period gains from expropriation in order to maximize multi-period gains from the future flow of high-value idea submissions. But reputation effects can be overstated as a panacea for opportunistic behavior in the absence of contract. As a practical matter, a

[26] This often seems to be the case. *See* David J. Teece, *Technology Transfer by Multinational Firms: The Resource Cost of Transferring Technological Know-How,* 87 ECON. J. 242, 245-47 (1997) (studying 26 international technology transfer projects and finding that transfer costs vary widely ranging from 2% to 59% of total project costs, and averaging 19%). Under this same rubric, we may include scenarios where the idea recipient can fully understand the idea but has no capacity to develop, or economic interest in developing, the asset independently or transferring the asset to other parties who could do so. This would characterize a potential financial investor, who may retain technical experts to evaluate the innovation but lack the operational expertise, legal capacity or economic interests in commercializing the innovation. Note that this does *not* include a venture capital firm, which does pose an expropriation threat to the extent that the disclosed technology has economic value in any of its portfolio companies.

number of factors limit (but do not extinguish) the disciplining effect of reputational capital. These include: (i) reputation effects are ineffective against one-shot or first-time entrants into an idea market; (ii) "noise" in the reputation market can mute reputational penalties (in particular, sellers' expropriation claims may be perceived as non-credible "sour grapes"); (iii) reputational penalties may be insufficient to restrain counterparties who expropriate an especially valuable idea in order to accrue extraordinary one-time gains; (iv) agency costs may drive a buyer's agent to expropriate an idea submission even if doing so depletes the principal's reputational capital; (v) buyers may have access to a variety of discrete mechanisms by which to siphon value from sellers short of outright expropriation; and (vi) entry barriers in the buyers' market may mute the reputational penalty suffered as a result of occasional misbehavior.[27] In short: reputation effects can mitigate, but can not eliminate, expropriation risk in idea transactions and, perhaps most worrisome from a policy perspective, are especially unreliable in the case of the highest-value idea submissions. Hence, the disclosure paradox may substantially persist—but without entirely blocking idea exchange—even where idea buyers would appear to have long-term incentives to decline short-term expropriation opportunities.

D. Organizational Solutions

The standard incentive thesis anticipates that intellectual property is a universal precondition for intellectual production. But that proposition is overstated to the extent that two assumptions are satisfied: (i) reverse-engineering costs and other imitation barriers limit expropriation risk in the goods market and (ii) reputation effects and informational opacity limit expropriation risk in the commercialization process. Let's suppose a market where the former but not the latter assumption is satisfied: that is, expropriation risk is largely absent in the goods market but persists in the commercialization process that precedes it. This is a "high-risk" contracting environment

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[27] For further discussion of the infirmities of relying on reputation effects to discipline opportunistic behavior, see Jonathan M. Barnett, *Certification Drag: The Opinion Puzzle and Other Transactional Curiosities*, 33 J. CORP. L. 97, 100-06 (2007). For a nuanced view of the limited disciplining force of reputation effects on venture capitalists, see Ronald J. Gilson, *Locating Innovation: The Endogeneity of Technology, Organizational Structure and Financing Contracting* (Working Paper 2009). For a more optimistic view of the ability of reputation effects to facilitate bargaining over ideas, see Burk & McDonnell, *supra* note __, at 602.

where disclosed ideas are transparent and recipients are immune to reputation effects: as a result, expropriation risk blocks arm's-length negotiation, innovators can not achieve commercialization and, by anticipation, decline to innovate. But even in this hostile setting, property rights are a possible but not *unique* remedy to contracting failure and the associated underinnovation result. Strictly speaking, the disclosure paradox simply implies that one particular route by which an innovation can reach market—commercialization through contracting with third parties—will be frustrated in the absence of patent protection. However, that does not preclude the innovator from independently implementing the commercialization process and thereby avoiding disclosure to third parties.[28] If we take into account this organizational remedy, then we can appreciate more precisely the importance of the disclosure paradox to intellectual property analysis. Properly understood, the disclosure paradox does not describe how expropriation risk distorts innovation behavior; rather, it describes how expropriation risk distorts *organizational* behavior, which in turn may or may not have effects over innovation behavior. This fundamental change of perspective modifies the set of circumstances over which the incentive thesis applies, eroding it further in some cases but strengthening it in other cases.

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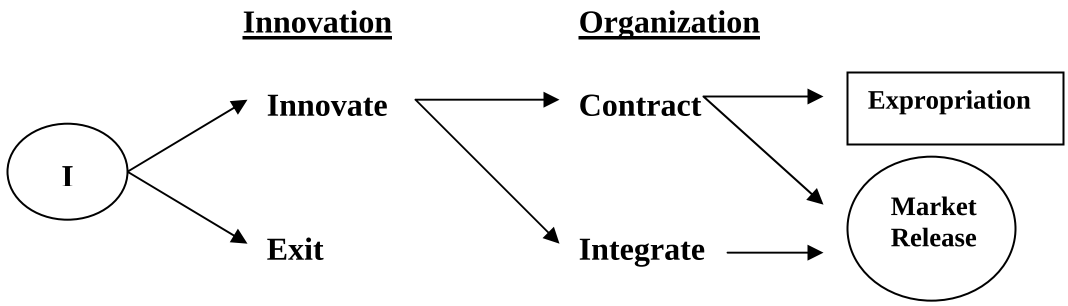
[28] Arrow noted this possibility, stating that property rights in information may be held through patents *or* "in the intangible assets of the firm if the information is retained by the firm and used only to increase its profits". *See* Arrow, *supra* note __, at 617. Later commentators have made similar observations. *See* Bar-Gill & Parchomovsky, *supra* note __, at 1664 (noting that a "research group" can protect against expropriation by a "customer" through vertical integration); Zeckhauser, *supra* note __, at 12744 note (e) (noting integration as alternative means by which to protect against knowledge leakage). It might be objected that integration is an imperfect defense against expropriation risk insofar as entrepreneurs are still exposed to "idea theft" by employees who can depart for rivals or set up competing operations. For an extended statement of this view, see Burk & McDonnell, *supra* note __. That is certainly an important contingency, although a firm can use a variety of means, including non-competition and confidentiality agreements, reputation effects in the labor market, internal organizational practices, deferred compensation and equity-based incentive schemes, and the threat of dismissal, by which to constrain employees from expropriating information. These instruments are not perfect but would almost certainly seem to offer a more potent set of tools by which to control expropriation risk relative to arm's-length interactions with unrelated third parties. For a similar view, see OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS 10 (1975); Michael H. Riordan & Oliver E. Williamson, *Asset Specificity and Economic Organization,* 3 INT'L J. IND. ORG. 365 (1985); *see also* Arora & Merges, *supra* note __, at 452 (noting that "greater control over disclosure of internal information is a well-recognized feature of the employment relationship, as compared with independent contractor status"). Moreover, employees may have reduced incentives to expropriate an employer's intangible assets if they anticipate facing the same "external" expropriation risk in seeking to commercialize those assets independently. At a minimum, so long as firms can control internal expropriation risk at some lower cost relative to controlling external expropriation risk, then, relative to contract-based outsourcing, integration offers a preferred mechanism by which to accrue innovation returns in the absence of patent protection.

1. Organizational Selection

Conventionally legal and economic analysis focuses on the connection between patent protection and an innovator's decision whether or not to invest in R&D. Realism, however, demands that the innovator's decision process take into account the full sequence of R&D *and* commercialization activities that will be required to reach market and realize any positive payoff. To capture both stages, we can construe the innovator's decision process as a two-step sequence "in reverse": it selects the organizational form by which to deliver an innovation to market, which implies a certain commercialization cost, which in turn determines whether it elects to make the innovation investment. The Figure below depicts this sequence, where the innovator (denoted by "I") can elect among two organizational options, *Contract* or *Integrate,* which, by anticipation, determines its choice among two investment options, *Innovate* or *Exit.* By *Integrate*, I mean that an innovator implements a given set of supply chain functions independently; by *Contract,* I mean that an innovator initiates arm's-length bargaining with a third party to implement those supply chain functions, which necessitates disclosure of the idea. *Integrate* imposes zero expropriation risk and yields positive revenues at market release. *Contract* imposes expropriation risk: if negotiations do not yield a binding contract, the counterparty can commercialize the disclosed information and, by assumption, the innovator accrues zero revenues at market release.[29] In totality, the innovator therefore faces a choice set consisting of three action pairs: [*Innovate/Contract; Innovate/Integrate;* or *Exit*].

[29] In greater detail, if an innovator elects *Contract,* two outcomes are possible: (i) the innovator enters into a binding contract with the third party, in which case I assume the product will be commercialized and the innovator will receive positive revenues at market release; or (ii) the innovator fails to enter into a binding contract with the third party, in which case I assume that full disclosure has been made, the counterparty commercializes the idea and the innovator accrues none of the revenues earned at market release, leaving it with a net loss equal to its R&D costs. The latter outcome implicitly assumes that the innovator can not independently commercialize the idea.

Figure III: The Innovator's Election Sequence



If we assume that the innovator seeks to maximize revenues accrued upon market release less commercialization costs and less R&D costs[30], then, absent expropriation risk, it will always elect the lowest-cost organizational form by which to deliver the innovation to market. Assuming a competitive market of external suppliers of supply chain functions and inputs, an innovator's outsourcing costs (equivalent to the payment it must make to a third party provider) must approximately equal the costs that would be incurred by the provider to supply the given supply chain function or input. That is: any provider is a "price taker" and therefore can not demand more than the cost of its commercialization services plus a competitive return.[31] Hence, in making its organizational election, an innovator compares its "own-commercialization" costs in implementing a given set of supply chain functions against the commercialization costs

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30 Formally: the innovator seeks to maximize $R_{(1-w)} - K_c - K_r$, where: R denotes revenues earned on market release; w (where $0 \leq w \leq 1$) denotes expropriation risk; K_c denotes commercialization costs; and K_r denotes R&D costs. Note that $w = 0$ under two scenarios: (i) *Contract* under patent protection (which I assume for simplicity can be enforced at zero cost), and (ii) *Integrate* irrespective of patent protection. As the strength of patent protection declines, w increases in value, approaching unity (in which case expropriation is certain); as the strength of patent protection increases, w declines in value, approaching zero (in which case expropriation risk disappears).

31 Assuming a competitive market for third-party supply services (one innovator with a unique technological input, multiple suppliers with homogenous production or capital inputs) distinguishes this construction from other contributions that construe the "integrate/contract" choice faced by an innovator firm following the "property rights" approach to firm boundaries, which assumes a two-party negotiation between the firm (often called the "research unit"), which has generated an idea, and the counterparty (often called the "customer"), which wishes potentially to acquire the idea and commercialize it. In that construction the parties must agree on some division of the joint surplus generated through each party's nonsalvageable investments in the relationship. *See, e.g.,* Arora & Merges, *supra* note __; and Bar-Gill & Parchomovsky, *supra* note __, who extend a model developed by Philippe Aghion & Jean Tirole, *The Management of Innovation,* 109 Q. J. ECON. 1185 (1994).

of the least-cost external provider. Any observed supply chain configuration (which is constituted by the innovator's *Contract/Integrate* elections at each point of the supply chain) therefore reflects the comparative cost advantages of external and internal providers of the supply chain functions and inputs required to deliver an innovation to market. If own-commercialization costs exceed the commercialization costs of the least-cost external provider, then the innovator will elect *Contract;* if the values are reversed, it will elect *Integrate.* Both actions are contingent on the assumption that at least *Innovate/Contract* or *Innovate/Integrate* yields anticipated net positive returns (meaning: R&D costs *plus* commercialization costs together exceed expected revenues upon market release). Where that assumption is not satisfied, there is no feasible commercialization option and the innovator by anticipation elects the remaining option of *Exit*: that is, it declines to innovate.

2. Organizational Distortion

The innovator's ability to select organizational forms so as to minimize commercialization costs rests on a critical predicate: namely, there is no expropriation risk in transferring information to third-party providers of supply chain functions or inputs. That predicate is not satisfied precisely in the contracting environment where the disclosure paradox is most severe: third-party suppliers pose a competitive threat through the use or resale of disclosed information and no combination of reputation effects and/or informational opacity sufficiently protects against that threat. In that environment, the absence of intellectual property has a dramatic effect on an innovator's organizational choice set: the *Contract* option is precluded and the innovator's remaining options reduce to [*Innovate/Integrate; Exit*]. This distortion is critical: there is no longer any assurance that observed supply chain configurations reflect the comparative cost advantages of external and internal providers of the supply chain functions and inputs required to deliver an innovation to market. Contrary to the standard formulation of the incentive thesis, however, this does not necessarily mean that innovative output ceases or even declines in the absence of patent protection. That is because innovators may protect against expropriation risk by adopting integrated structures that avoid interaction with third parties. Empirical evidence shows that this is precisely what happens: in industries or jurisdictions where intellectual property rights are weak, firms reduce technology transfer and/or adopt joint ventures and other firm-like arrangements (effectively, a modified form of *Integrate*) in order to implement technology transfers.[32]

These organizational substitution effects might be viewed as grounds for rejecting the incentive thesis: firms "make up" for shortfalls in patent coverage by migrating to non-patent alternatives. But that would be a hasty conclusion. Even if innovators can "make up" for shortfalls in patent coverage through non-patent substitutes, they will still be worse off whenever they must incur incremental costs in electing *Integrate* over *Contract*. Those incremental costs will depend on whether the innovator or the "market" is the least-cost provider with respect to any given supply chain function or input. Reductions in patent coverage will therefore yield a continuous range of disincentive effects—from complete to partial to zero—that differ across innovators *and* markets as a function of any innovator's own-commercialization costs relative to the commercialization costs of the market's least-cost combination of external providers.

To illustrate the variable effects of changes in patent protection, I envision three innovator types that operate under various levels of patent protection and experience different organizational and innovation effects given the existing level of expropriation risk, which is the *same* across innovators, and "integration" (that is, own-commercialization) costs, which *differ* across innovators. The set of innovator types and the proposed level of integration costs corresponding to each type are shown below. Integration costs are assumed to be a function of the innovator's existing level of supply chain integration: i.e., where an innovator already has an established integrated supply chain, its integration costs are low; where it does not, those costs are high. The Table and subsequent discussion set forth a simple relationship: as incremental integration costs increase, reductions in patent coverage exert stronger disincentive effects; as those costs fall, reductions in patent coverage exert weaker or even no disincentive effects.

32 *See* Bharat Anand & Tarun Khanna, *The Structure of Licensing Contracts,* 48 J. IND. ECON. 103 (2000) (based on sample set of 1612 technology licensing agreements, finding that, in industries with weak intellectual property rights, there was a lower incidence of licensing activity but firms continued to execute technology transfer in the form of joint ventures, cross-licensing or licensing to known parties); Joanne Oxley, *Institutional Environment and the Mechanisms of Governance: The Impact of Intellectual Property Protection on the Structure of Inter-Firm Alliances,* 38 J. ECON. BEHAV. & ORG. 283 (1999) (finding that firms tend to use joint ventures or similar arrangements in jurisdictions with weak intellectual property rights and arm's-length contractual relationships in jurisdictions with strong intellectual property rights).

Table I: Disincentive Effects as a Function of Integration Costs

Type	Existing Supply-Chain Integration	Integration Costs	Disincentive Effect
Large Firm A	Complete	Low	Zero
Large Firm B	Limited	Moderate	Partial
Small Firm	None	High	Complete

Large Firm A (Zero Disincentive Effect). Suppose a large integrated firm that has lower commercialization costs than any combination of external providers. For example, it may have in place a worldwide production, marketing and distribution infrastructure. The firm will therefore always elect *Integrate* as its first-best organizational form irrespective of the available level of patent coverage and resulting level of expropriation risk. Patents make no difference: the firm's organizational choices and innovation incentives are constant.

*Large Firm B (Partial Disincentive Effect). S*uppose another large firm that has higher commercialization costs than any combination of external providers with respect to some portion of the supply chain. For example, it may have strong R&D capacities but a limited production and distribution infrastructure that could be upgraded at some significant cost to produce and market the relevant innovation. It will therefore usually elect *Contract* as its first-best organizational option. However, as patent protection declines and expropriation risk rises, the *Contract* option ceases to be feasible and the firm must elect *Integrate* as its second-best organizational option. Relaxing patent protection yields a *partial* disincentive effect: *Integrate* is a cost-feasible but not cost-minimizing organizational option relative to *Contract,* which in turn inflates the firm's commercialization costs and reduces, but does not extinguish, its innovation incentives.

Small Firm (Complete Disincentive Effect). Suppose a start-up that has exceptionally higher commercialization costs relative to any combination of external providers. For example, it may have no production or distribution infrastructure and would incur exorbitant costs to implement commercialization independently. Or its innovation may constitute an improved component or addition to a larger and more complex good which it has no capacity to produce, distribute or support. That means its organizational choices are always restricted to *Contract.* As patent protection declines and expropriation risk rises, there is no longer any feasible organizational option and, by anticipation, the innovator must elect *Exit* over *Innovate.*

To summarize: reductions in patent protection yield a range of entity-specific organizational effects, which in turn translate into a corresponding range of entity-specific innovation effects. Maintaining the standing assumption that expropriation risk is sufficiently controlled in the goods market, these organizational and innovation effects can be reduced to a function of the difference between integration costs and outsourcing costs over the required set of supply chain functions and inputs. Innovation effects follow from organizational effects. When patent protection "makes a difference" in a firm's organizational behavior, it necessarily "makes a difference" in a firm's innovation behavior. Otherwise patent protection "makes no difference": highly-integrated entities' innovation incentives are unchanged under stronger, weaker or even zero levels of patent coverage. For highly-integrated entities (and any other entity that has equal or lower commercialization costs relative to the market), the disclosure paradox and the resulting obstacles to interfirm contracting are immaterial: even in the highest-risk contracting environment, it will elect *Integrate* as its first-best commercialization option. For more weakly-integrated entities (and any other entity that has higher commercialization costs relative to the market), the disclosure paradox and the resulting obstacles to interfirm contracting can matter to a substantial extent and sometimes, to a catastrophic extent: in the highest-risk contracting environments, an innovator must elect *Integrate* as a second-best option or, in the case of the most weakly-integrated entities with exorbitant commercialization costs, must elect *Exit.*

III. How Patents Organize Firms and Markets

The discussion so far can be reduced to a single proposition. *Without intellectual property, the expropriation risk inherent to contracting over ideas (which varies as a* *function of reputation effects and informational opacity) can distort innovators' organizational choices (which vary as a function of relative commercialization costs), which in turn exerts disincentive effects of varying magnitudes on innovation activity.* Even if we exclude expropriation risk in the goods market, the incentive case for patents clearly persists in the case of weakly-integrated entities that have high commercialization costs and operate in high-risk contracting environments. Based on this proposition, it might be concluded that the patent system is best justified as a specialized scheme for financing innovation by individual inventors and small R&D firms. In this Part, I argue that the organizational diversity facilitated by the patent system—of which the small R&D firm is the most obvious but not exclusive manifestation—can yield two categories of social gains that diffuse across a substantially broader population. First, the contracting environment secured by patents enables innovators—both large and small—to adjust firm scope without reference to expropriation risk. That allows innovators to extract specialization gains by transacting with lower-cost suppliers of any required function or input. Second, firms' ability to narrow firm scope to any portion of the supply chain lowers entry costs by reducing—perhaps dramatically—the minimum size of the market into which any firm must attempt entry. These firm-level and market-level organizational effects translate into innovation effects through the same mechanism: interfirm bargaining yields efficient adjustments to firm and market supply chains, which minimizes innovation and commercialization costs, which promotes innovation and entry consistent with the standard rationale.

A. **Organizational Distortions and Specialization Losses**

So far I have proposed a loosely inverse correlation between patent strength and firm scope: everything else being equal, weaker patents tend to induce higher levels of integration in order to protect against expropriation risk and stronger patents enable innovators to select lower levels of integration in order to extract specialization gains through contracting with third-party providers. Bu the organizational effects of weak or zero patents are a matter of indifference from a social point of view unless these translate into adverse effects over firms' innovation behavior. This will necessarily occur in every case where the innovator is compelled to incur commercialization costs that it would not otherwise bear under lower levels of expropriation risk. To appreciate the social cost of this organizational distortion requires application of the basic principle of division of labor. Following this principle (as famously set forth by Adam Smith[33]), division of labor within a single enterprise promotes efficiency gains through individual-level specialization of tasks, largely as a result of the concentration of effort by workers on perfecting performance of an assigned task. This can be re-construed as an application of innovation incentives: specialization induces productivity gains by providing workers with incentives to invest in task-specific process innovation.[34] As modern commentators subsequently observed (extending suggestions made by Smith[35]), this same logic anticipates efficiency gains through specialization of tasks *across* firms within a single industry or across firms within multiple industries.[36] Firm-level division of labor yields specialization gains by shifting any given set of supply chain functions to the lowest-cost supplier of those functions, which in turn can facilitate disaggregation of the supply chain among the least-cost combination of internal and external suppliers.

But there is a crucial difference between individual-level specialization and firm-level specialization. To the extent that firm-level specialization necessitates precontractual negotiation (and/or interaction with third parties in the course of performance[37]) that necessitates disclosure of knowledge that could then be used to the innovator's disadvantage, it is inherently constrained in any setting where some combination of contract, technology and/or reputation cannot resolve the expropriation

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33 *See* ADAM SMITH, THE WEALTH OF NATIONS (Book 1, Ch. 1), esp. p.8 (1776).

34 Smith was aware of the connection between specialization and invention incentives. *See id.*, at 13 (noting that concentration of effort on a single task encourages workers "to discover easier and readier methods" of completing the task).

35 *See id.*, at 9-10 (noting specialization advantages across trades, regions and countries).

36 *See* George Stigler, *The division of labor is limited by the extent of the market,* 59 J. POL. ECON. 185 (1951). Stigler's thesis builds upon ideas set forth in an earlier contribution, see Allyn Young, *Increasing returns and economic progress,* 38 ECON. J. 527 (1928). For related discussion of the manner in which division of labor facilitates specialization of tasks across technology industries, see ARORA ET AL., at §1.2.3; Ashish Arora & Alfonso Gambardella, *The Changing Technology of Technological Change: General and Abstract Knowledge and the Division of Innovative Labor,* 23 RES. POL'Y 523 (1994).

37 Meaning: even if the innovator enters into a contract to outsource a downstream commercialization function, it is still exposed to knowledge leakage during the course of performance of the contract, assuming an incompletely-specified contract that does not address all possible expropriation opportunities. On the role played by patents in augmenting contractual protections against misappropriation, see Merges, *Transactional View, supra* note __.

threat identified by the disclosure paradox. It is important to appreciate that supply chains are surprisingly pliable: suppliers of downstream production functions can backward integrate into upstream innovation functions, while suppliers of upstream technological inputs can forward integrate into production functions. As an illustration, consider that Microsoft, which would normally be considered an end-consumer of semiconductor chips, temporarily became a leading developer of "systems on a chip" semiconductors during the development of the xBox game console (i.e., it jumped from the bottom to the top of the chip supply chain).[38] Apple has just undertaken the same backward integration strategy with respect to the iPad "tablet" device, for which it independently developed a customized semiconductor chip.[39] Given the lurking danger of backward and forward integration, the process of division of labor across firms, and ensuing specialization gains, are dependent (in high-risk contracting environments) on some form of intellectual property to constrain expropriation risk as innovators disclose valuable technological information to actual or potential rivals.

If specialization gains drive efficient configuration of the supply chain through interfirm contracting, then overintegration as a response to expropriation risk is not "merely" an organizational effect but yields adverse effects over firms' innovation incentives. Where (i) weak patent protection compels a firm to select *Integrate* with respect to any given supply chain function or input and (ii) at some lower level of expropriation risk, *Integrate* would not otherwise constitute the firm's least-cost organizational option with respect to that function or input, then any specialization gains that *could* have been secured through contract-based relationships with lower-cost suppliers are forfeited. Characterizing overintegration costs as specialization losses substantially expands the set of circumstances where weak or zero patent coverage is likely to result in adverse effects over firms' innovative output—in fact, it may reduce the theoretical case of the large firm that always prefers *Integrate* to a practically atypical case. In any market where there are economies of scale in the delivery of any given supply chain function or technological input, it is *extremely likely* that recourse to

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38 For a full account, see DAVID SHIPPY, THE RACE FOR A NEW GAME MACHINE: CREATING THE CHIPS INSIDE THE XBOX 360 AND THE PLAYSTATION 3 (2010).

39 *See* Ashlee Vance & Brad Stone, *A Little Chip Designed by Apple Itself,* N.Y. Times, Feb. 2, 2010.

integration in order to address expropriation risk is a second-best option that entails forfeiture of specialization gains that could have been obtained by contract. The rationale is straightforward. Any specialized provider of a supply chain function or input can spread its fixed costs over a broad pool of manufacturers in the downstream market, whereas any individual firm can only spread those costs over its own manufacturing operations.[40] Moreover, as is well known in the economics of industrial organization, specialization is promoted in turn by a positive feedback effect: as specialization lowers input costs, prices for finished goods in the user market fall, which in turn pushes up demand, which in turn induces further entry to serve the expanding market for intermediate or end-user consumption.[41]

Critically, this competitively-driven process of cost minimization, output expansion and increased entry can not get started without a property-rights infrastructure to induce rational investment by innovators at the top of the supply chain and suppliers at all downstream points on the supply chain. Without patents, we therefore can not observe the counterfactual world that would potentially elicit entry by independent firms at any number of points on the supply chain to deliver discrete R&D inputs or supply chain functions at some cost lower than that which is currently being incurred by integrated firms. This proposition has a subtle but crucial implication for innovation policy. Weak or no patents can have adverse effects on innovation incentives even if it appears that the relevant market "adequately" supports innovation by recourse to vertical integration. Partial disincentive effects may constitute a "hidden cost" of weak patent coverage: concentrated markets consisting of large firms that perform substantial amounts of R&D but operate at systematically excessive levels of integration in order to eliminate expropriation risk. While integration may enable firms to accrue returns

[40] An interesting objection to this line of argument is that specialization gains could be accrued by retaining a single-firm organization and allowing the firm to sell its excess output to third parties, which would similarly internalize the economies of scale by providing inputs to multiple firms. This objection is less than fully compelling, however, because the single firm would face a credible commitment problem with respect to any outside buyers that operate in the same market, who would fear that the firm-supplier would cut off production in order to serve the firm's larger competitive objectives. For similar reasoning, see WILLIAMSON, *supra* note __, at 18-19.

[41] That is not all: the same feedback effect that expands the market can result in greater product variety as the costs of specialized inputs can be spread over a greater number of units. That is: a specialized upstream firm may produce "niche" components in higher volumes in order to service the entire market, whereas no individual producer would find it profitable to do so for its own purposes. *See* Paul Romer, *Growth based on increasing returns due to specialization*, 77 AMER. ECON. REV. 56 (1987).

sufficient to cover some R&D costs, those firms may still be forfeiting specialization gains that could be accrued under contract-based forms of organization that would be feasible under lower levels of expropriation risk. And the most weakly-integrated firms that would have existed under stronger forms of patent protection can not be observed at all. This is a generalized form of survivorship bias: without patents, we observe only the organizational structures that can support an integrated innovation and commercialization process and only the firms that can fund those structures. Even in markets where integrated firms appear to support substantial innovation, we still can not exclude the possibility that output would have been higher under the precluded portion of the organizational choice set. In short: underprotection (sometimes) yields overintegration, which (sometimes) yields underinnovation.

B. Intellectual Property through the Lens of Market Structure

Patents yield organizational effects at the "micro" level of firm scope by lowering the costs of contracting over intellectual resources, which in turn yields innovation effects by allocating supply chain functions to the cost-minimizing combination of internal and external providers. These firm-level organizational and innovation effects in turn provide the basis for drawing a link at a "macro" level of generality between patent strength and market structure, which in turn anticipates innovation effects from the market-level organizational effects of stronger and weaker forms of patent protection. This proposition can be simply stated. *Absent reputational or contractual technologies by which to discipline precontractual expropriation, patent protection decreases the cost of entering markets for firms that have relatively higher commercialization costs over a given set of supply chain functions and inputs*; *the absence of patent protection increases the cost of entering markets for that same class of firms.* This claim (which I will qualify below in two important respects) follows from the firm-level organizational effects of patent coverage. By opening up the organizational choice set, patent protection enables a firm to enter any given market without incurring the cost of assembling an integrated infrastructure in order to preclude expropriation risk. Under the security umbrella provided by patent protection, a firm can use contractual instruments to enter the market at *any* number of points on the supply chain, thereby substantially lowering the costs of entering the market. Without patent protection, the *Contract* option is foreclosed and a firm must enter the market at *every* point on the supply chain, thereby substantially elevating entry costs. Counterintuitively, a market with stronger patents will sometimes induce greater entry (and therefore pose a greater threat to dominant firms) than a market with weaker or no patents by expanding feasible entry points into the market. Conversely, a market with weak or no patents will sometimes discourage entry (and therefore shelter dominant firms) by inflating the size of the relevant market into which entry can be feasibly attempted[42], which operates to the advantage of integrated firms that can more easily bear the costs of doing so.

Below I illustrate in further detail this link between firm-level and market-level disaggregation by constructing a two-part sequence where patent rights facilitate organizational forms that break up consolidated *firm* supply chain structures, which in turn facilitates entry by specialized suppliers of research, production and other functions located at discrete points of what is now the *market* supply chain. This sequence relies on two largely uncontroversial assumptions concerning the "scale characteristics" of different portions of the supply chain. First, I assume (as is usually reasonable) that the downstream production and distribution functions of the supply chain are the most capital-intensive activities, require a physical and administrative infrastructure that demands considerable time and resources to establish and maintain, and are characterized

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[42] It is worthwhile to address an obvious objection. It may be argued that raising the minimum cost of entry makes no difference in regulating entry barriers given that an outside financier will rationally provide capital to any net-positive-value project. That is: commercialization costs are not a barrier to entry assuming perfectly efficient capital markets. Robert H. Bork, *Vertical Integration and Competitive Processes,* in PUBLIC POLICY TOWARD MERGERS 139-49 (eds. J. Fred Weston & Sam Peltzman 1969). That is no longer the case, however, once we reasonably drop the assumption of perfectly efficient capital markets. There are (at least) three uncontroversial reasons to believe external capital markets for R&D are substantially imperfect. First, discussions with potential investors and lenders that necessitate disclosure of technological information restore expropriation risk to some extent. This may be mitigated to the extent that a financing entity lacks operational expertise or legal capacity to commercialize the underlying innovation or is subject to reputational pressures that discourage expropriation. Second, in the absence of a secure property right, all lending is unsecured, which substantially inflates the cost of capital. Third, this argument requires perfect information on the part of lenders and complete contracts on the part of lenders and borrowers. Otherwise adverse selection will require that lenders or investors discount all claims by entrepreneurs as to technological quality so as to reflect uncertainty over the entrepreneur's claims. As it turns out, start-ups appear to use *patents* to alleviate this problem by signaling underlying value to venture-capitalist investors. For further discussion, see JACK HIRSHLEIFER, INVESTMENT, INTEREST AND CAPITAL 200-01 (1970); Oliver E. Williamson, *The Vertical Integration of Production: Market Failure Considerations,* 6 AMER. ECON. REV. 112 (1971), *reprinted in* FIRMS, MARKETS AND HIERARCHIES: A TRANSACTION COST ECONOMICS PERSPECTIVE Ch. 2 (1999) (eds. David Teece & Oliver E. Williamson).

by economies of scale and low levels of firm differentiation. Second, I assume (as is reasonable in some settings) that the upstream R&D/design functions require somewhat lower resource allocations than the production and distribution functions, rely on highly-differentiated human and intellectual resources, and are characterized by *dis*economies of scale. The latter assumption is a fairly broad simplification that must be evaluated on a market-specific basis.[43] However, the limited view that smaller firms have some cost-advantage in certain R&D markets is grounded in both (i) empirical evidence that small firms are often the originators of the most novel technologies and, relative to larger firms, obtain more patents and exhibit higher measures of innovative output relative to R&D dollars[44] and (ii) widespread belief in the business world and among innovation scholars that the most "drastic" forms of innovation tend to function best in smaller settings free from the bureaucratic slack of large-firm organization.[45]

Two additional assumptions are required to build the link between patent rights and increased entry opportunities. First, we must assume that there does not exist any technological constraint that would otherwise bar segregation of design and production

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[43] The relationship between firm size and innovation activity has been the subject of several decades' worth of research by industrial organizational economists; the results are complex and not prone to simple generalization across markets. For leading reviews, see P.A. GEROSKI, MARKET DYNAMICS AND ENTRY (1991); MORTON I. KAMIEN & NANCY L. SCHWARTZ, MARKET STRUCTURE AND INNOVATION (1982).

[44] *See* FREDERIC M. SCHERER & D. ROSS, INDUSTRIAL MARKET STRUCTURE AND PERFORMANCE 654-56 (1990); Zoltan J. Acs and David B. Audretsch, *Innovation as a Means of Entry*, in INNOVATION AND TECHNICAL CHANGE: AN INTERNATIONAL COMPARISON (eds. Zoltan J. Acs and David B. Audretsch, 1991); Zoltan J. Acs and David B. Audretsch, *Innovation in Large and Small Firms: An Empirical Analysis,* 78 AMER. ECON. REV. 678 (1988); Zeckhauser, *supra* note __, at 12746. Note that an older line of inquiry in the industrial organization literature holds that there are economies of scale in R&D, which explains positive correlations between firm size and the amount of R&D: i.e., firms spend more on R&D proportionate to size. This can be explained by the fact that large firm size allows a firm to spread the cost of R&D over a larger amount of output. However, this is contingent on firms' inability to sell disembodied information due to expropriation concerns; where that is no longer the case, then large firm size gives no inherent advantage in R&D. *See* Wesley M. Cohen and Steven Klepper, *A reprise of size and R&D,* ECON J. (1996). To the contrary: if there is no advantage to size for large firms (since upstream research-only firms can now enter and spread the cost of R&D over the entire industry output), then we can anticipate that large firms will be forced to exit the research function.

[45] Theoretical analyses of large-firm underperformance in R&D (or more precisely, "drastic" R&D) focus on informational asymmetries and agency costs as standard culprits, which lead large-firm managers to favor safe projects over risky projects even if the former has a lower discounted present value. For arguments to this effect, see Bengt Holmstrom, *Agency Costs and Innovation*, in THE MARKETS FOR INNOVATION, OWNERSHIP AND CONTROL 131, 131-53 (Richard H. Day et al. eds., 1993). Broader arguments fault the hierarchical structure of large-firm organizations. *See, e.g.*, David J. Teece, *Firm Organization, Industrial Structure and Technological Innovation*, 31 J. ECON. BEHAV. & ORG. 193, 201, 212-13 (1996).

functions as a practical matter. This assumption will be most clearly satisfied in markets that have developed standardized "plug and play" interfaces that enable firms to work independently on modular components of a single product architecture.[46] Second, we must assume that no incumbent has a patent portfolio that covers all technological entry points into a given market and refuses to license it to entrants. This assumption will be most clearly satisfied in technologically immature markets that have not yet settled on a dominant design or technologically rich markets that offer abundant research and product development opportunities.[47] Where this assumption is not satisfied, then patent protection will exert the entry-deterrent effect commonly ascribed to it (and for which innovation history provides documented examples).[48]

Together these four assumptions ensure that (i) there exist upstream and downstream specialization gains that firms can extract through vertical disaggregation, (ii) there does not exist any technological constraint that would otherwise bar extraction of those specialization gains, and (iii) no incumbent has a patent portfolio by which it can block every technological entry point into the market. The Figure below summarizes the following arguments in graphic form and I will refer to it periodically in the discussion below.

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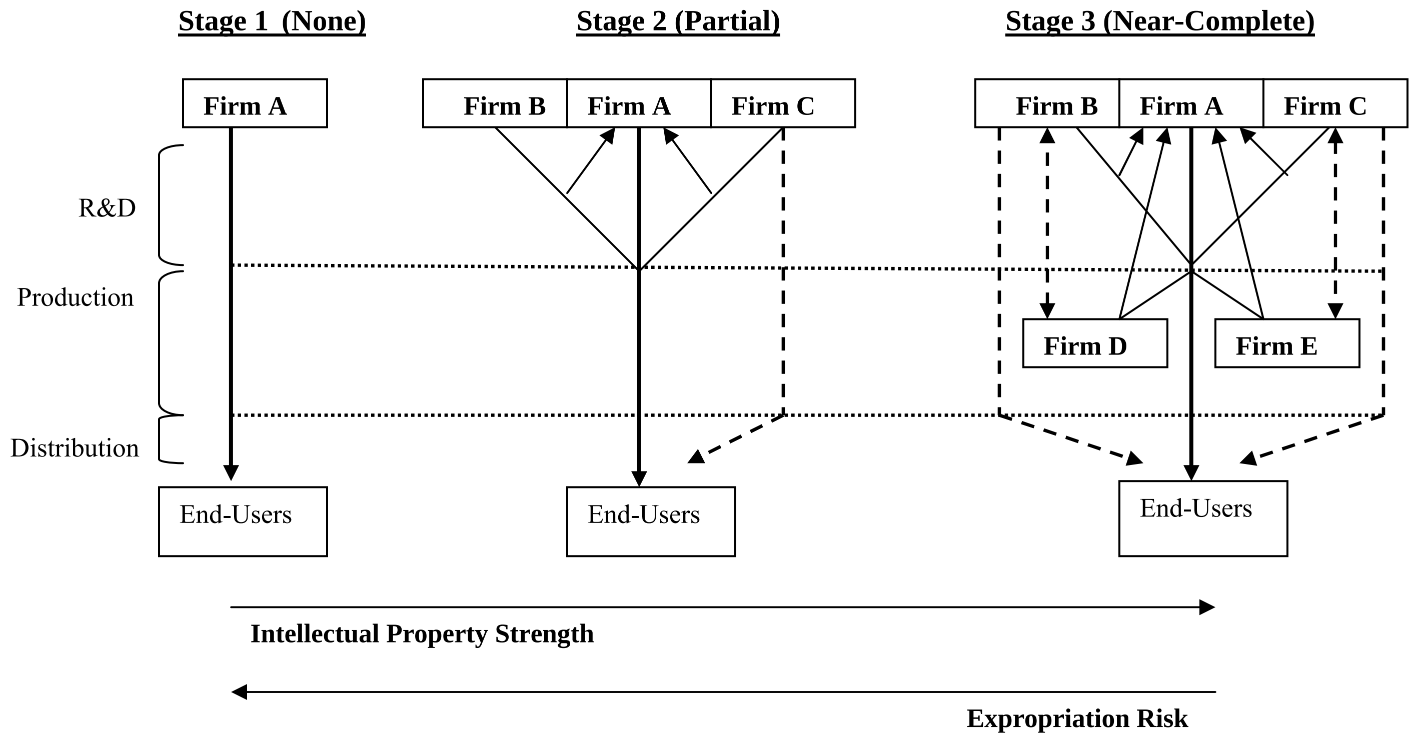
[46] For further discussion with respect to the semiconductor market, see *infra* note [ ] and accompanying text.

[47] David Adelman emphasizes this point with respect to the biotechnology markets, on the basis of which he concludes that patents are unlikely to impede innovation in the industry. *See* David E. Adelman, *A Fallacy of the Commons in Biotech Patent Policy,* 20 BERK. TECH. L. J. 985 (2005).

[48] For the leading account, see Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839 (1980). Identifying the circumstances under which the entry-deterring or entry-enabling effects of patent protection are likely to predominate is an open question for future inquiry. As noted above, it appears that the "net entry" effects of patent protection may be sensitive to the industry's location on the innovation lifecycle and the technological richness of the innovation environment. Fortuitously, this would seem to imply that patents' entry-enabling effects will be strongest when markets are "young" and "fertile", which would seem to be precisely the case where there would be the strongest social interest in inducing entry, and weakest when markets are "old" and "exhausted", which would seem to be the case where there would be the least social interest in inducing entry.

Figure IV: Progressive Disaggregation of Supply Chains



1. *Partial Disaggregation*

For simplicity, I assume a supply chain consisting of three generic functions: (i) R&D, (ii) production, and (iii) distribution. As shown in *Stage 1*, where patents are weak or absent, incumbent *Firm A* must select *Integrate* with respect to every supply chain function in order to bring its innovation to market without bearing the expropriation risk inherent to bargaining with third parties. Conversely, patents restore the possibility of *Contract* and allow *Firm A* to interact with lower-cost providers of upstream supply chain functions (*Firms B* and *C*) (or equivalently, allow *Firms B* and *C* to interact with providers of downstream supply chain functions). As shown in *Stage 2*, contractual negotiation within the security of patent rights enables *Firm A* to adopt a disaggregated structure that allocates the upstream portion of the supply chain to lower-cost providers. This possibility of contracting between the incumbent (*Firm A*) and external providers induces entry by firms that have a cost advantage in design and research services but a cost disadvantage along the remainder of the supply chain. The result (as shown in *Stage*

2 in *Figure IV*): partial disaggregation of the supply chain into an upstream cluster of stand-alone R&D enterprises, *Firms B* and *C*, who provide technological inputs to *Firm A*, which continues to perform independently all other downstream product-delivery functions (and, by assumption, retains some R&D functions so that it can "backward integrate" (or credibly threaten to do so) in some cases).[49] Relative to *Stage 1*, a competitive supply of upstream design functions lowers total innovation and commercialization costs, thereby increasing expected profits and encouraging innovation.

2. *Nearly Complete Disaggregation*

Disaggregation of the R&D-intensive upstream portion of the supply chain in turn precipitates disaggregation of the capital-intensive downstream portion of the supply chain. Consider that stand-alone upstream firms (*Firms B* and *C*) may be viewed not only as suppliers of R&D services to downstream firms but as *purchasers* of production and distribution services required to bring an innovation to market (for which upstream firms pay by forfeiting a portion of the revenues earned on sales to end-users). Any upstream firm seeks to maximize profits by minimizing the cost of obtaining production and distribution services from external providers. To do so, it seeks alternatives to selling solely to *Firm A* (as is the case in *Stage 2*), which, as a monopsonist purchaser of R&D inputs, will exercise disproportionate bargaining power, take the lion's share of user revenues and have limited competitive pressures to minimize product-delivery costs. It therefore follows that the competitive supply of R&D services by firms at the upstream portion of the supply chain (*Firms B* and *C*) in turn elicits entry at the *downstream* portion of the supply chain by firms that have a cost advantage in production and distribution functions (*Firms D* and *E*). Downstream suppliers of "stand alone" production functions enable upstream suppliers of technological inputs to reach market without incurring the exorbitant fixed costs of forward integration *and* without relying solely on the production capacities of the existing incumbent. As shown by the dashed lines, *Firms B* and *C* generate technological inputs that can then be embodied in

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[49] As indicated by the dashed line running from *Firm C* to end-users, I suppose that some stand-alone R&D firms that enter at the upstream segment of the supply chain may develop limited forward integration capacities (in part, to preserve bargaining power in negotiations with *Firm A* over the division of joint surplus from end-user revenues).

consumption-ready products through contractual relationships with *Firms D* and *E*, which then return the finished goods to *Firms B* and *C* for distribution to end-users, thereby bypassing *Firm A* entirely if so desired.[50] Assuming a substantially homogenous goods market, vertical disintegration by upstream technology suppliers in turn compels the integrated incumbent, *Firm A*, to pursue the same outsourcing partnership with *Firms D* and *E* in order to replicate its competitors' cost structure. To the extent that an outside provider can achieve economies of scale in any given supply chain function superior to those achieved by any single firm, competitive pressures in homogenous-goods markets will compel *every* firm to outsource *every* supply chain function in order to replicate the same cost structure. The end-result: legal propertization of the "common" pool of intellectual resources ultimately results in "quasi-collectivization" of the upstream research and downstream production functions of the market supply chain (as shown in *Stage 3*).

C. **Illustrations: Patents, R&D Firms and Adaptive Supply Chains**

This stylized sequence should not be interpreted overly deterministically: it is not intended to suggest that strong property rights are always or even usually a precondition for maximizing innovation investment. *A priori,* concentrated markets dominated by a small number of highly-integrated firms may support innovation to the same or even greater extent than unconcentrated markets characterized by a large number of weakly-integrated firms.[51] Precisely understood, my claim is simply as follows: *strong property rights enable firms to disaggregate supply chains to the extent necessary to extract specialization gains with respect to each input and function on the supply chain*. Without strong property rights, any specialization gains remain trapped within the consolidated supply chains that firms must adopt in order to protect against knowledge leakage in the commercialization process. Patents enable firms to use precontractual negotiation so as

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50 The Figure contemplates that *Firms B* and *C* continue to sell some technological inputs to *Firm A*.

51 A prominent stream of economic thought once promoted the view that innovation proceeds best under oligopolistic or even monopoly conditions. *See* JEWKES ET AL., *supra* note __, at 248 (noting, as of 1958, the "modern, and by now widely held, opinion that monopoly encourages, and may even be a condition precedent to, innovation"). For the original source for this "Schumpeterian Hypothesis", see JOSEPH A. SCHUMPETER, CAPITALISM, SOCIALISM, AND DEMOCRACY 131-34 (5th ed. 1975).

to pursue the theoretically-contemplated sequence of organizational disaggregation to the extent required to maximize specialization gains. Where specialization gains are available through interfirm contracting, these organizational effects translate into innovation effects that apply across virtually the whole length of the supply chain.[52] Reduced expropriation risk enables outside firms to enter the market at discrete portions of the supply chain (see *Firms B, C, D* and *E*), which in turn enables existing firms (*Firm A*) to purchase supply chain functions at a lower cost, thereby lowering innovation and commercialization costs, raising firm profits and promoting innovation consistent with the standard thesis. Below I briefly consider two well-studied technology markets that exemplify these disintegration processes to varying extents.

1. *Petrochemical Processing*

Starting in the 1920s, specialized engineering firms (equivalent to upstream providers of technological inputs) in the oil and gas industry have licensed process technologies to a large number of downstream manufacturers (principally, petrochemical refiners). Most notably, the Universal Oil Products Company (or "UOP"), which developed some of the key process technologies for the petroleum refining industry, licensed its technology to refiners together with the provision of technical services required for effective implementation.[53] The downstream client base serviced by UOP and similar entities included a large number of smaller refiners, which implies that upstream disaggregation of the research function facilitated entry into the downstream production and distribution portions of the supply chain. New firms that could cost-effectively construct an integrated manufacturing and distribution infrastructure but lacked readily-available design competencies saved the cost of integrating backwards into the upstream portion of the supply chain by contracting with lower-cost providers of

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52 I say "virtually" because one party may suffer: incumbents that would have been protected from entry under a weaker patent regime and would have enjoyed greater profits relative to the profit stream available under a stronger patent regime. That is: the incumbent's share of a smaller market is greater than its share of a larger market. This private loss obviously does not "count" from a social point of view and can be ignored.

53 *See* CHARLES REMSBERG & HAL HIGDON, IDEAS FOR RENT: THE UOP STORY (1994).

technological inputs.[54] Tellingly, the prospect of the merger of UOP with a large integrated corporation in the oil industry in 1955 caused panic among the independent refining industry, which stated that it could not survive without an independent source of technology and technical services by which to compete with larger integrated enterprises.[55] Continuing through the present day, vertical specialization has almost entirely segregated the design function from the production and other capital-intensive functions in the supply chain: for the period 1980-90, specialized engineering firms engineered three-fourths of all chemical processing plants in the world.[56] This result follows basic division of labor principles: the engineering firms operate as upstream tool providers to a large pool of downstream manufacturing and distribution companies and, as such, enjoy economies of scale (and scope) that can not be matched by even the largest incumbents in the market.

2. *Biopharmaceuticals*

Patents for biotechnological inventions have been well-established since the Supreme Court's 1980 decision in *Diamond v. Chakrabarty,* which upheld a patent for a genetically-engineered microorganism.[57] Roughly since that time, thousands of small research-intensive firms have emerged that supply biopharmaceutical innovations to large pharmaceutical companies that fund and implement capital-intensive testing, production and distribution functions. This is perhaps the most widely-discussed illustration for the critical role played by patents in supporting the viability of specialized R&D firms. Operating within the secure contracting environment provided by patent rights, the biotechnology industry has developed a virtually-unequaled diversity of sponsorship,

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[54] *See* ARORA ET AL., *supra* note __, at 46-47, 151-52; Ashish Arora & Alfonso Gambardella, *Evolution of industry structure in the chemical industry,* in CHEMICALS AND LONG-TERM GROWTH (eds. Ashish Arora et al. 1998); Nathan Rosenberg, *Chemical Engineering as a General Purpose Technology*, in GENERAL PURPOSE TECHNOLOGIES AND ECONOMIC GROWTH 188-89 (ed. Elhanan Helpman 1998).

[55] *See* REMSBERG & HIGDON, *supra* note __, at 291-92. UOP has subsequently operated as a subsidiary of several larger operating companies (its current parent is Honeywell), but has retained its role as predominantly a R&D and licensing operation. For current information on the company, see http://www.uop.com/overview/8000.html (last visited July 23, 2009).

[56] *See* ARORA ET AL., *supra* note __, at 48-49. For similar findings for the period 1960-66, see CHRISTOPHER FREEMAN, THE ECONOMICS OF INDUSTRIAL INNOVATION 30 (2d ed. 1982).

[57] 447 U.S. 303 (1980).

cooperation, alliance, joint-venture and partial-ownership arrangements among large pharmaceutical companies, smaller research-intensive biotechnology firms, and university technology-transfer offices.[58] Consistent with the specialization logic that anticipates firm entry under secure property rights, even the research portion of the supply chain has experienced disaggregation effects: research tool companies provide biotechnology and pharmaceutical firms with diagnostic and design tools for developing medical therapies for the user market.[59] Given that, generally speaking, the buyers of research inputs from upstream biotechnology firms have *not* elected to vertically integrate backward into the R&D stage, while small-firm suppliers of research inputs have usually *not* elected to integrate forward into the manufacturing and distribution stage (with some exceptions in both cases[60]), we can conclude with reasonable certainty that electing *Integrate* over *Contract* would most likely represent the more costly form of organizing innovation in this market. If that is true, then patent protection and the expanded set of organizational options have most likely yielded specialization gains, thereby reducing commercialization costs and promoting innovation—again, consistent with the conventional incentive thesis as applied in this targeted fashion.

D. Summary: Learning Through Bargaining

The loosely inverse relationship between patent strength and supply chain integration is not intended to support either the positive claim that markets will always disintegrate under strong patents or the normative claim that markets will always maximize innovation investment at substantial levels of disintegration. The socially-efficient level of firm and market integration is unknown in any particular case. But it is

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58 *See* ARORA et al., *supra* note __, at §3.4.2-.3; Gary Pisano, Weijan Shan & David Teece, *Joint Ventures and Collaboration in the Biotechnology Industry,* INTERNATIONAL COLLABORATIVE VENTURES IN U.S. MANUFACTURING (ed. David Mowery 1988).

59 *See* ARORA ET AL., *supra* note __, at 7 and §§ 3.4.2-.3; Best, *supra* note __, at 215-16.

60 Large pharmaceutical companies maintain independent research capacities in biotechnology while the largest biotechnology companies have integrated vertically with respect to certain products. This can be explained either as a profit-maximizing strategy to capture all profits relating to certain products and/or to a strategic desire to maintain bargaining leverage with respect to potential partners by maintaining a credible threat of being able "to go it alone". The latter can reduce to the former insofar as maintaining a credible threat to integrate backwards maximizes the portion of the joint surplus that can be secured through bargaining with an external provider of any given supply chain function.

precisely the impossibility that any outside observer could determine optimal firm or market structure that supplies the strongest case for secure patent coverage (at least as a matter of "gross" social cost-benefit analysis[61]). Without secure intellectual property rights to guard against expropriation risk, the market has no opportunity to learn through bargaining the level of disaggregation that minimizes total innovation and commercialization costs. The process of learning through bargaining, and resulting optimization of the supply chain to reflect firms' comparative cost advantages, provides the fundamental link between organizational effects and innovation effects. Weak or zero patent coverage predetermines a market structure that precludes anything other than highly-integrated organizational forms, which may sometimes inflate commercialization costs and depress innovation relative to some less-integrated form of organization that innovators would select absent expropriation risk. That is not only a private loss but a social loss under all three accepted definitions of economic efficiency: (i) it is innovatively inefficient to the extent it reduces R&D investment, (ii) it is productively inefficient to the extent it increases the social resources allocated to produce a given stream of innovative output, and (iii) it is allocatively inefficient insofar as increased commercialization costs are passed on to users, some of whom "drop out" of the

[61] Note in particular that this Article's framework does not address two social costs of patent protection that would be reflected in a "net" analysis: (i) transaction costs that impede subsequent innovation (provided that any subsequent innovation would have taken place under weaker levels of intellectual property), and (ii) deadweight losses incurred by consumers as a result of supracompetitive pricing. On transaction costs, it must be noted that (*a)* decreases in intellectual property generate *another* set of transaction costs captured by the disclosure paradox, which generate negative effects on first-mover innovation incentives, and (*b)* in many technology settings, first-mover firms tend to be smaller and otherwise systematically disadvantaged relative to second-mover firms, in which case there may be an argument for weighting "first-mover transaction costs" greater than "second-mover transaction costs". For further discussion of this point, see *infra* Part IV.D. Deadweight losses lie outside the scope of an incentive-based analysis and, in any case, are unlikely to change any normative inference in favor of the property-rights solution, for two reasons. First, where reduced patent protection forces firms to select more costly integrated structures, then prices rise, constraining output relative to an environment where firms could select less costly contract-based structures. Second, even assuming the standard positive correlation between patent strength and deadweight losses, consumers may *still* be better off: if it is true, as economic commentators widely agree, that dynamic efficiency gains in technological advance are likely to far outweigh any static efficiency losses in the form of constrained output, then (setting aside distributive concerns) consumers should collectively prefer incurring supracompetitive pricing over the short term in order to enjoy an accelerated rate of technological advance over the long term. *See, e.g.,* Phillip Areeda, *Antitrust Law as Industrial Policy: Should Judges and Juries Make It?,* in ANTITRUST, INNOVATION AND COMPETITIVENESS 31 (ed. Thomas M. Jorde & David J. Teece 1992) (noting widespread view among economists that "innovation has been thought to contribute far more to our well-being than keeping prices closer to costs through competition").

market.[62] In any case where it is not already the first-best commercialization option, organizational substitutes for patent protection impose a "commercialization tax" that distorts R&D investment in the upstream market, commercialization expenditures in the "midstream" market, and product output in the goods market.

III. Beyond Incentives: How Patents Make Markets

So far I have proposed a targeted reformulation of the incentive thesis: strong patents enable firms to calibrate organizational structures in order to maximize the extraction of specialization gains in the innovation and commercialization process, which in turn yields positive effects on innovative entry consistent with the standard thesis as applied in mediated form. In this Part, I identify a set of social gains that derive from these organizational effects but cannot be captured by the conventional relationship between "more IP" and "more innovation". In particular, I argue that the efficient segregation of research, production and other functions along the supply chain supports the emergence of secondary markets for trading, licensing and valuing disembodied intellectual resources. That is: intellectual property not only reorganizes primary markets that embody innovations in consumption-ready products but ultimately supports secondary markets in the technological inputs and tools that feed the R&D portion of the innovation pipeline. These derivative markets are familiar characteristics of virtually any developed primary market for tangible goods and, in the intangible goods context, can be expected to yield analogous pricing and liquidity efficiencies. Secondary trading and valuation markets further lower firms' innovation and commercialization costs and, by a positive feedback effect, expand the market into which these firms can expect to sell their innovations, which in turn induces further innovative entry. It is now possible to describe the full sequence of organizational effects that can flow from secure property rights to mitigate expropriation risk in the commercialization process. Where (i) intellectual property enables innovators to select forms of organization that would not be feasible under higher levels of expropriation risk, then (ii) it enables the extraction of specialization gains through efficient reconfigurations of the supply chain, which (iii)

[62] For further discussion of these three types of economic efficiency, see F.M. Scherer, *Antitrust, Efficiency and Progress,* 62 N.Y.U. L. REV. 998, 1012 (1987); Joseph F. Brodley, *Consumer Welfare and Technological Progress,* 62 N.Y.U. L. REV. 1020, 1025-27 (1987).

expands entry opportunities, and, as will now be discussed, (iv) promotes the formation of secondary markets that trade in the resulting pool of supply chain functions and inputs.

A. *The Disintegration Problem*

In its most fully realized form, the classical integrated enterprise can be construed as a massive middleman who matches the suppliers of raw inputs, unfinished goods or finished goods with the buyers of those goods, earning a return on the spread between the price of inputs purchased and the price of goods sold, less all intervening production, distribution and transaction costs.[63] It may therefore appear initially (as is often described or predicted in popular and some scholarly commentary) that vertical disintegration of the supply chain implies disintermediation, thereby allowing suppliers to interact directly with buyers and avoiding the premium assessed by the now-redundant middleman. Hence, in *Stage 3* in *Figure IV*, I indicated the possibility that *Firms B* and *C* may bypass *Firm A* (equivalent to the classic middleman) to reach the target user market. However, a fuller analysis shows that roughly the contrary is the case: the monolithic super-middleman that occupies a single node of the supply chain is replaced by multiple smaller-scale middlemen that operate at multiple nodes of the supply chain. Disaggregated supply chains must be *re*-intermediated in order to address the transactional complexity induced by moving the procurement of supply chain functions and inputs from an internal market governed by managerial fiat (equivalent to *Integrate*) to an external market governed by a contractual network of third parties (equivalent to *Contract*). Assuming some substantial level of supply chain disaggregation, diffuse populations of end-users, intermediate users and suppliers would otherwise face a formidable matching and search problem, resulting in exorbitant identification, valuation, and negotiation costs in order to assemble the inputs required at each step of the supply chain. Re-intermediation is therefore the final and necessary step in the disaggregation of the supply chain that is enabled by secure patent protection: without it, the transaction

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[63] *See* DANIEL F. SPULBER, MARKET MICROSTRUCTURE: INTERMEDIARIES AND THE THEORY OF THE FIRM ___ (1999). For the classic work on the integrated enterprise in U.S. business history, see ALFRED D. CHANDLER, JR., SCALE AND SCOPE: THE DYNAMICS OF INDUSTRIAL CAPITALISM (1992).

costs of decentralized exchange would deplete or even extinguish the specialization gains from disaggregated design, production and distribution functions.

B. *The Re-Intermediation Solution*

Whereas fully-integrated markets operate across a single point of interaction between the firm and the end-user population, substantially disaggregated markets operate across multiple points of interaction between the firm and a large population of external providers of supply chain functions. This can be illustrated by comparing the fully integrated supply chain set forth in *Stage 1* of *Figure IV* with the substantially disintegrated supply chain set forth in *Stage 3*. In the former case, third-party transactions are limited to distribution of the final product by *Firm A* to end-users, which rely on *Firm A* to locate, evaluate and assemble all product components. In the latter case, the set of third-party transactions includes both (i) existing interactions between *Firm A* and the end-user population, (ii) additional interactions between *Firms B* and *C* and the end-user population, and (iii) multiple intermediate transactions between one or more purchaser-firms (*Firms A, B* or *C*) and one or more supplier-firms (*Firms B, C, D* or *E*).

The increased complexity of identifying and evaluating intellectual resources within a disaggregated commercialization pathway necessitates transactional structures and intermediary entities that facilitate exchanges among buyers and sellers of supply chain functions and inputs. *Disaggregation therefore implies re-intermediation*. Just as competitive pressures drive firms to locate the least-cost external provider of any supply chain function, which in turn induces entry by specialized suppliers of discrete supply chain functions, competitive pressures drive firms to adopt the most effective transactional technologies to lower the cost of locating and evaluating least-cost providers, which in turn induces entry by specialized suppliers of transactional solutions. Consistent with the logic of specialization that induces "first-order" entry of specialized suppliers of design, production and other functions to lower innovation and commercialization costs, transactional complexity induces "second-order" entry by specialized suppliers of transactional solutions to lower the costs of informational complexity. In short: intellectual property breaks up the primary market for supply chain functions and inputs that support the invention and commercialization process, which in turn generates secondary markets for intermediation services to match the buyers and sellers of those functions and inputs.

The re-intermediation process is illustrated graphically in the Figure below, which expands upon *Stage 3* of *Figure IV* to reflect the new "market in ideas" that results from re-intermediation of a disaggregated supply chain (which can in turn ultimately be traced back to the low-risk contracting environment secured by robust property rights). In particular, two new market segments have emerged: an "idea procurement" market at the top of the supply chain and a "systems integration" market at the bottom of the supply chain. Who populates these new markets in ideas, components and so forth? There are a few important categories, almost none of which exist in the fully-integrated organizational structures that prevail in high-risk contracting environments. Moving from the bottom to the top of the supply chain, these include:

- *System Integrators.* This refers to *Firm G*, who, taking advantage of the increased number of design configurations, assembles components from Firms *A, B* and *C* into product bundles for user consumption, thereby relieving search and evaluation costs for producers, intermediate users, and end-users.[64]

- *IP Dealers.* This category refers to firms that purchase and warehouse intellectual assets for resale to other entities, thereby relieving search costs for producers and intermediate users.

- *IP Brokers and Appraisers*. This category refers to firms and consultants that facilitate exchanges of intellectual resources between producers and intermediate users, thereby relieving search, evaluation and negotiation costs.

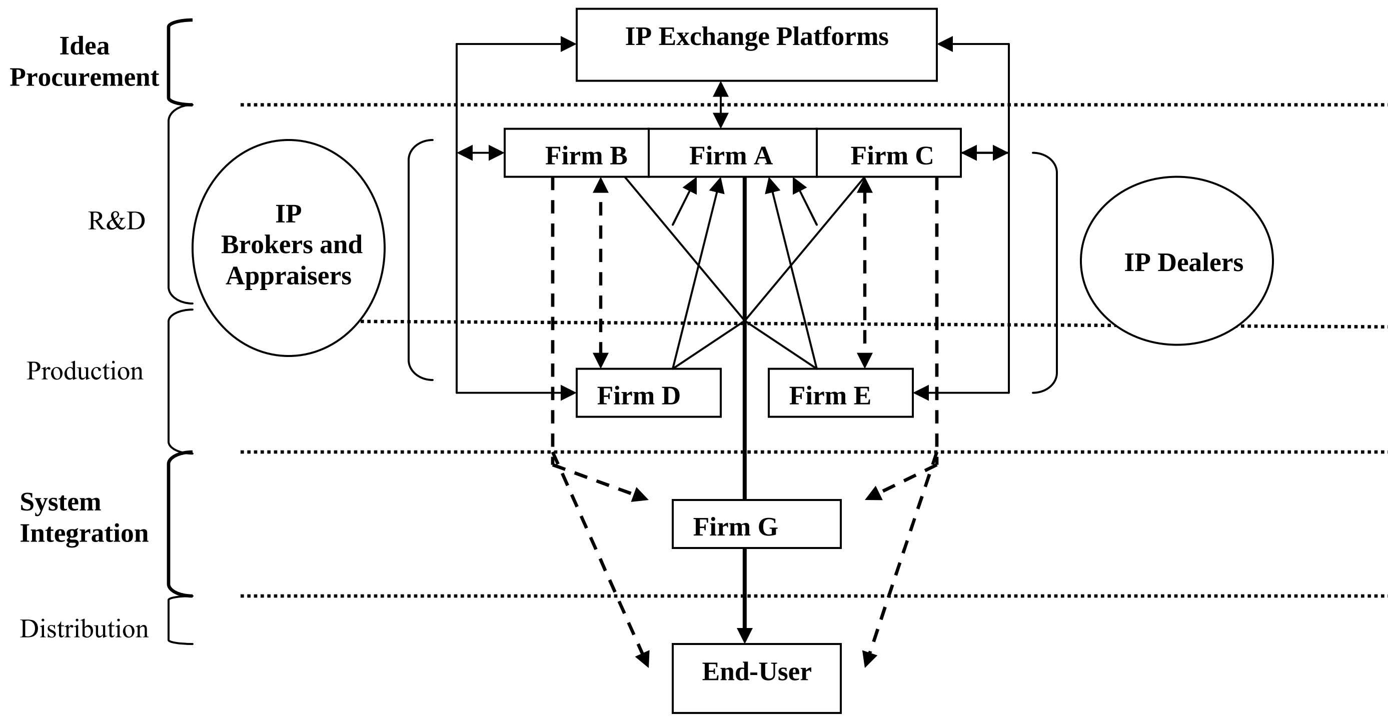
- *IP Exchange Platforms.* This category refers to intermediaries such as auction houses, clearinghouses, or trading platforms, which offer venues for exchanging

[64] Note that the Figure contemplates that Firms *A*, *B* and *C* may also distribute component bundles to users directly through in-house assembly services.

intellectual assets, thereby relieving search and evaluation costs for producers and intermediate users.

Aside from systems integration, some of these entity types may appear to be somewhat unusual (and certainly, nascent) fixtures in intangible-goods markets but should sound familiar in any developed market for tangible-goods markets (or secondary markets in financial instruments). Those markets are replete with intermediaries that match users and producers, including trading platforms that facilitate exchange among diffuse buyer/seller populations and a wide variety of middlemen that perform matching, valuation and warehousing functions that enhance market liquidity. The proliferation of exchange intermediaries as a response to supply chain disintegration suggests an important policy implication for evaluating the transaction costs that are typically associated with patent-intensive markets for intangible goods. These costs are immaterial if they are simply the price that must be paid for generating social value through expanded opportunities for reducing commercialization costs by breaking up supply chain functions and inputs. Certainly, as is widely observed, the indefinite boundaries of some patents means that these markets support the strategic acquisition of patents for purposes of frivolous litigation against cash-rich firms and other targets, which may "on net" counsel against strong patent rights in certain markets. Nonetheless any complete analysis must recognize that relaxing patent protection necessarily frustrates the re-intermediation process whereby trading and brokering markets emerge in order to match disembodied supply chain functions and inputs. At the very least, that is a nontrivial consideration that must be integrated into any cost-benefit evaluation of the patent system or proposed reforms to it.

Figure V: The Re-Intermediated Supply Chain
(Blueprint for an Ideas Market)



C. **Markets in Ideas**

The proposed relationships between patent strength, transactional complexity and the expansion of secondary markets in patented assets find confirmation in innovation history. As economic historians have documented in great detail[65], periods during which patents have been strongly enforced are characterized by real-world approximations of "markets in ideas": intensive trading of patent rights is promoted by transactional intermediaries that acquire patent rights for sale and assignment, which in turn delivers revenue streams that promote the emergence of small firms, individual inventors and other disembodied entities dedicated to R&D activities. Not coincidentally, these idea-trading markets have been most robust during the mid- to late 19th-century and late 20th-century through the present, two periods during which patents have been adopted and enforced at historically strong levels.

65 *See infra* Part III.C.1.

1. *Historical Markets*

During the middle to late 19th-century, strong enforcement of patents supported the development of a network of "patent dealers" and other intermediaries that sought to broker or otherwise facilitate the trading of patented inventions. This secondary market operated to the mutual benefit of individual inventors who could not otherwise support independent commercialization and large firms who did not have strong R&D competencies: a textbook case where patent protection enables bargaining processes that exploit firm-specific competencies at different points on the supply chain.[66] In turn, consistent with the proposed link between organizational and innovation effects, the ability to trade patent-protected assets without fear of expropriation appears to have induced the emergence of a class of professional inventors that could specialize in innovative activity on a long-term basis.[67] Tellingly, as the individual inventor was eclipsed by the corporate R&D department in the early 20th century, patenting rates per capita initiated a long historical decline that persisted until the late 20th-century.[68] This result is at least facially consistent with this Article's theoretical expectations: as patent use declined, firms substituted toward higher levels of organizational integration as an alternative device by which to secure innovation returns.

2. *Contemporary Markets*

A little more than a century later, virtually the same pattern observed in the mid-to-late 19th century has re-appeared in the wake of the strengthening of patents under the

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[66] *See* Naomi Lamoreaux & Kenneth L. Sokoloff, *Inventors, Firms, and the Market for Technology in the Late Nineteenth and Early Twentieth Centuries,* in LEARNING BY DOING IN MARKETS, FIRMS AND COUNTRIES (eds. Naomi Lamoreaux et al.) 19-57 (1999) [hereinafter Lamoreaux & Sokoloff, *Inventors*]; Naomi Lamoreaux & Kenneth L. Sokoloff, *The Market for Technology and the Organization of Invention in U.S. History,* in ENTREPRENEURSHIP, INNOVATION AND THE GROWTH MECHANISM OF THE FREE-ENTERPRISE ECONOMIES (eds. Eytan Sheshinski et al. 2007) [henceforth Lamoreaux & Sokoloff, *The Market for Technology*]. See also KHAN, *supra* note __, at 60-61 (stating that in the late nineteenth-century, U.S. inventors regularly traded patent rights, which facilitated raising outside capital, which was in turn reinvested in inventive effort), 95-96 (citing data showing an extensive antebellum market in trading of patent rights) and 204-06 (noting that the assignment or sale of patent rights to antebellum investors often resulted in great profits).

[67] *See* Lamoreaux & Sokoloff, *Inventors, supra* note __, at 29-30, citing data in Kenneth L. Sokoloff & B. Zorina Khan, *The Democratization of Invention During Early Industrialization: Evidence from the United States, 1790-1846,* 50 J. ECON. HIST. 363 (1990).

[68] *See* Lamoreaux & Sokoloff, *The Market for Technology, supra* note __, at 236.

direction of the Court of Appeals for the Federal Circuit, established in 1982. The increased enforcement of patent protections appears to have induced strongly increased rates of participation of small firms in R&D: in 2003, small firms performed 25% of industrial R&D as compared to 5% of industrial R&D in 1981 (immediately prior to the establishment of the Federal Circuit).[69] As would be expected, increased small-firm innovation has been accompanied by the expansion of markets for the licensing and transfer of patented technology.[70] This includes: (i) the growth of patent holding companies and other "disembodied" entities that specialize in the acquisition and licensing (and sometimes, as noted, opportunistic litigation) of patent rights, (ii) the emergence of technology transfer offices for purposes of licensing at academic research institutions, and (iii) nascent attempts to develop platforms for the auctioning, sale and trading of patents.[71] This outcome is expected: patents limit expropriation risk and thereby enable interfirm bargaining over technology transfer, which in turn induces entry by intermediaries that seek to earn profits on enabling those transactions.

Strong patent protection, along with the resulting reduction in contracting risk and expansion of secondary markets in patent-protected assets, has yielded a further organizational effect. It allows highly-integrated large firms to migrate *up* the supply chain by scaling back involvement in capital-intensive production processes and concentrating on R&D-intensive activities. Consider three leading examples. Starting in the early 1990s, IBM (the leading U.S. patentee) has converted much of its business into an "outsourcing" operation that licenses internally-developed (and often patented) technologies to third parties for manufacturing, distribution and/or service functions. In 1999, Qualcomm, the world's leading provider of "CDMA"-based wireless

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69 *See* Rosemarie H. Ziedonis, *On the Apparent Failure of Patents: A Response to Bessen and Meurer,* ACAD. OF MGMT. PERSPECTIVES (2008).

70 *See* Merges, *Input Markets, supra* note __; Feng Gu & Baruch Lev, *Markets in Intangibles: Patent Licensing* (Working Paper 2001). Estimates of the value of the market for patent licensing, sale and trading of patent technology vary substantially. *See, e.g,* ARORA ET AL., *supra* note __, at 40 (estimated value of $35-50 billion per year); Ashby H. B. Monk, *The emerging market for intellectual property: drivers, restrainers and implications*, 9 J. ECON. GEOGRAPHY 469 (2009) (citing estimates of $500 million in 2006 in the U.S. but noting that precise estimates are not available); Gu & Lev, *supra* note __ (noting data showing that revenues from patent licensing rose from $15 billion in 1990 to more than $110 billion in 1999).

71 For the most complete listing of these trading platforms and other patent intermediary entities, see Monk, *supra* note __.

communications technologies sold off its manufacturing operations and converted its business into what is largely a licensing and technical support operation based on a portfolio of more than 10,000 patents.[72] Cisco, one of the world's leading providers of network equipment and technology, has never developed any internal production capacities and relies heavily on acquisitions in order to accumulate a stock of knowledge capital.[73] That is, it uses patent rights to enter into contractual arrangements that attract knowledge flows *into* the company from specialized research firms and then uses patent rights to enter into contractual arrangements that regulate knowledge flows *out* of the company to specialized producers.

It may fairly be argued that these disintegration processes reflect extra-legal considerations such as reduced transportation costs, tariff barriers, and communication costs. That is undoubtedly part of the story. However, absent secure patent rights, these disintegration processes would be far riskier and perhaps unfeasible propositions. Without a sufficiently potent combination of contract, reputation effects and informational opacity, firms that outsourced a substantial portion of the supply chain would be exposed to expropriation by suppliers and other business partners. In high expropriation-risk environments, firms are compelled to adopt closed structures to protect against counterparty opportunism, thereby forfeiting the opportunity to uncover specialization gains, which in turn potentially increases innovation and commercialization costs. This does not mean that firms will always or even usually choose disaggregated structures in strong patent environments. Expropriation risk obviously can not be the sole determinant of firm boundaries and, where contracting can be implemented under low-risk conditions, expropriation risk will be substantially reduced and so too will the organizational (and hence, incentive) effects of patent protection. However, subject to technological constraints, it can safely be asserted that

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72 *See* DAVE MOCK, THE QUALCOMM EQUATION 145 (2005) (describing sale as part of settlement with Ericsson concerning patent infringement dispute). The same is true of other established electronics firms, is universally the case among smaller electronics firms, and is true of large electronics firms such as Sun Microsystems that have never developed internal production capacities. *See* Timothy J. Sturgeon, *Turnkey Production Networks: The Organizational Delinking of Production from Innovation,* in NEW PRODUCT DEVELOPMENT AND PRODUCTION NETWORKS: GLOBAL INDUSTRIAL EXPERIENCE 76 (ed. Ulrich Jurgens 2000).

73 *See* Henry Chesbrough, *Open Innovation: A New Paradigm for Understanding Industrial Innovation,* in OPEN INNOVATION: RESEARCH A NEW PARADIGM 12 (ed. Henry Chesbrough 2006).

firms operating under strong property rights will always have the *opportunity* to select the organizational structure that maximizes specialization gains. That in turn minimizes commercialization costs and maximizes firm profits from innovation activity—consistent, once again, with the standard incentive thesis as implemented through the medium of organizational form.

IV. Case Study: The "Fabless" Semiconductor Market

The discussion to this point can now be reduced to a simple proposition: in high-risk contracting environments, patents enable markets to converge on a division of labor that minimizes innovation and commercialization costs. Those organizational effects yield both innovation effects consistent with the standard incentive thesis as well as structural effects on the growth of secondary markets that go beyond it. To illustrate these relationships in greater detail, I will now examine the organizational effects of patent protection over roughly the past two decades in a selected segment of the semiconductor market. Consistent with theoretical expectations, and building on recent scholarship in the business management literature[74], I describe how patent rights, together with favorable technological developments, appear to have enabled a fundamental transformation of firm and market structures that challenge the industry's historical model of integrated research, production and distribution. In particular, upstream entry by patent-intensive R&D firms has been accompanied by the disintegration and multiplication of markets: (i) downstream disaggregation of capital-intensive production functions to stand-alone manufacturing firms, (ii) markets in the provision of design tools and other services to facilitate upstream R&D, and, at an emergent level, (iii) markets in the trading of supply chain functions and inputs. This is a remarkably close (if still imperfectly developed) realization of the market for ideas in an industry that stands at the heart of our information-based economy.

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[74] In particular, see CLAIR BROWN & GREG LINDEN, CHIPS AND CHANGE: HOW CRISIS SHAPES THE SEMICONDUCTOR INDUSTRY (2009), Ch. 3; Greg Linden & Deepak Somaya, *System-on-a-chip integration in the semiconductor industry: industry structure and firm strategies,* 12 IND. & CORP. CHANGE 545 (2003). *See also* Ludovic Dibiaggio, *Design complexity, vertical disintegration and knowledge organization in the semiconductor industry,* IND. & CORP. CHANGE (2007).

A. Industry Background

The semiconductor industry is of paramount economic importance. Worldwide revenues totaled $258 billion in 2008 and its applications are used in all manner of communications, computing and electronics products in the consumer, enterprise, industrial and military markets. Described very simply, a semiconductor chip consists of an integrated circuit[75] engraved on a silicon wafer using photolithographic technology. Integrated circuits in turn are categorized by function: memory chips, logic chips, and microprocessor chips (the latter being characterized by the fact that chips can be programmed to perform a set of instructions).[76] Recent advances in miniaturization technology (in particular, the continuing expansion of the number of transistors that can be placed on an integrated circuit) have allowed the memory, logic and processing functions to be embedded on a single chip in order to implement a customized application. Miniaturization advances have resulted in "system on a chip" (or "SoC") devices that deliver improvements in speed, space and power consumption.[77] This market segment had 2008 worldwide revenues of approximately $51 billion[78] and will be the focus of the discussion below.

1. *The Integration Model*

For several decades, the semiconductor industry largely operated on a vertical integration model where each firm independently carried out research, product development, production, distribution and support functions.[79] During this postwar period, patent rights were generally weakly enforced by the courts and semiconductor firms tended to follow an industry norm against aggressive enforcement of patent

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[75] For simplicity, an integrated circuit might usefully be understood as a "computer on a chip" consisting of hardware (input/output and memory units) and software containing operating instructions that cause the hardware to implement the desired tasks.

[76] *See* GALE GROUP, SEMICONDUCTORS AND RELATED DEVICES (viewed May 20, 2008).

[77] *See* Linden & Somaya, *supra* note __, at __.

[78] *See infra* note __ and Figure VII and accompanying text.

[79] Distribution was sometimes outsourced with the manufacturer retaining some "captive" distribution capacities. Some distributors also provided basic support services. *See* PORTER, *supra* note __, at 4-7, 13. For an extensive history of the industry, see BO LOJEK, HISTORY OF SEMICONDUCTOR ENGINEERING.

rights.[80] In the early 1980s, this environment changed as a result of several events: the emergence of low-cost Japanese competitors in the memory chip ("DRAM") market[81], stronger enforcement of patent rights by the Federal Circuit, passage of *sui generis* legislation to protect chip designs[82], substantially increased rates of patenting by all firms[83] and aggressive patent litigation by some firms.[84] The chart below shows the dramatically increased rates of U.S. patenting by semiconductor firms during this period, a growth rate that exceeds the overall increase in U.S. patenting during the same period.[85] Following standard views, it might be tempting to depict this phenomenon as a classic case where an industry that once thrived without strong property rights has been saddled with an unnecessarily aggressive patent regime. As we shall see, several developments complicate this view.

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80 *See* DAVID P. ANGEL, RESTRUCTURING FOR INNOVATION: THE REMAKING OF THE U.S. SEMICONDUCTOR INDUSTRY 38-43 (1994); CHRISTOPHE LECUYER, MAKING SILICON VALLEY: INNOVATION AND THE GROWTH OF HIGH TECH, 1930-1970, at Ch. 7.

81 Japanese (and later, Korean and Taiwanese) firms pushed U.S. firms' share of the worldwide semiconductor market from approximately 56.7% in 1982 to 42.6% in 1992 and 48.3% in 2005. *See* SEMICONDUCTOR INDUSTRY ASSOCIATION, STATS: WORLD MARKET SALES & SHARES—1982-2005 (2006), http://www.sia-online.org/galleries/press_release_files/shares.pdf.

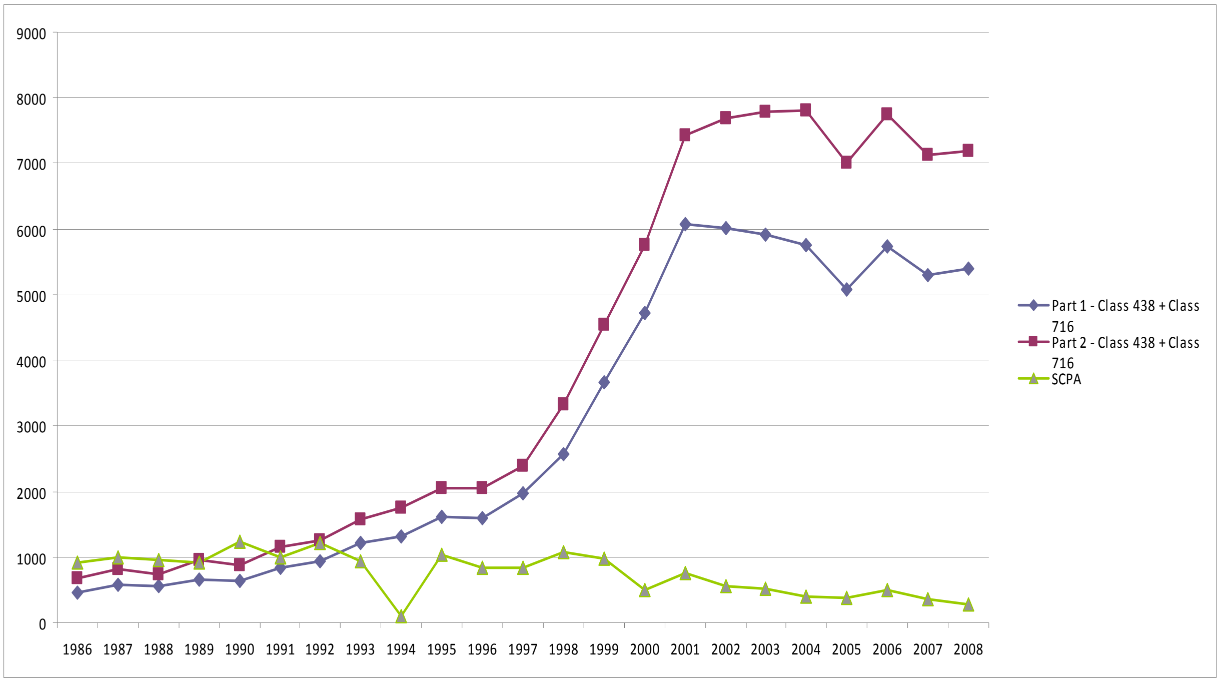
82 Semiconductor Chip Protection Act of 1984, Pub. L. No. 98-620, tit. III, 98 Stat. 3347 (codified at 17 U.S.C. §§ 901-914 (Supp. II 1984)).

83 Adjusted relative to R&D dollars, this rate (i.e., the *propensity* to patent) doubled during 1982-1992. *See* Bronwyn H. Hall & Rosemarie Ham Ziedonis, *The Effects of Strengthening Patent Rights on Firms Engaged in Cumulative Innovation: Insights from the Semiconductor Industry*, *in* 13 ENTREPRENEURIAL INPUTS AND OUTCOMES (2001).

84 In particular, Texas Instruments is (in)famous for having broken from the industry norm of underenforcement of patent rights. *See* Bronwyn H. Hall, *Exploring the Patent Explosion*, in ESSAYS IN HONOR OF EDWIN MANSFIELD: THE ECONOMICS OF R&D, INNOVATION AND TECHNICAL CHANGE 201-02 (eds. Albert A. Link and Frederic M. Scherer 2005).

85 *See* Hall & Ziedonis, *supra* note ___. Note that the Figure also depicts registration rates under the Semiconductor Chip Protection Act ("SCPA"); as is evident, the Act has been underused. This is generally attributed to technological developments that have frustrated third-party imitation that relies solely on reverse engineering the layout design. *See* Leon Radomsky, *Sixteen Years After the Passage of the U.S. Semiconductor Chip Protection Act: Is International Protection Working?*, 15 BERKELEY TECH. L.J. 1049, 1077-79 (2000). Others argue that the Act nonetheless retains some residual function in facilitating licensing of "IP blocs" among chip design firms. *See* Jeffrey T. Macher, David C. Mowery & David A. Hodges, *Reversal of Fortune? The Recovery of the U.S. Semiconductor Industry*, 41 CAL. MGMT. REV. 107, 127 (1998).

Figure VI: Semiconductor Patenting Rates (1986-2008)[86]



2. *The Fabless Challenge*

The onset of vigorous patent adoption and enforcement in the semiconductor industry has been followed by an organizational change: in certain segments of the industry, firms have migrated away from the uniform practice of vertical integration to an increased diversity of organizational forms. The largest firms that still conform to the integrated model now compete in the most design-intensive segments with "fabless" companies, which constitute roughly 30% of the worldwide semiconductor chip market.[87] These companies have no manufacturing (or "fabrication") capacity and specialize in the design of systems on a chip (also known as application-specific integrated circuits ("ASICs")), which are designed to be used in specific types of devices (e.g., multimedia mobile phones and portable devices, flat-screen televisions, multimedia and graphics

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86 Note that the "higher" curve for patent rates is based on the number of issued patents classified under Class 438 and Class 716 of the Patent Classification System as a matter of both original classification and "cross-reference" classification. The "lower" curve only includes patents so classified based on the original classification.

87 *See* Global Semiconductor Alliance ("GSA"), avail. at www.gsa.org. For a list of the leading fabless firms, see *infra* Appendix A.

applications, digital cameras and others).[88] Generally speaking, these design firms license a proprietary chip design to "foundries" that specialize in wafer fabrication[89], thereby avoiding the several billion dollar expenditure required to construct a rapidly depreciating fabrication facility.[90] The fabless firm then recovers the wafers for testing, assembly and packaging (technical functions which are in turn outsourced to third parties) and, finally, distribution and marketing to intermediate users (usually, component manufacturers or system integrators).[91] Operating at a further distance from the production process, so-called "chipless" firms (also known as "IP suppliers" or "IP aggregators") assemble "IP blocs" or "IP modules"[92] (some of which are in turn obtained from smaller third-party IP providers), which are then licensed to (i) fabless firms, who complete the chip design process, (ii) foundries, who complete both the chip design and fabrication processes, or (iii) integrated firms (or less commonly, system integrators), who use the licensed designs as inputs into in-house chip design processes.[93]

Design firms rely on a combination of technology, contract, and patent protection in order to control knowledge leakage at each point of technology transfer in the supply

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88 Note that ASICS can be divided into two categories: (i) off-the-shelf devices that can be programmed by the user to implement certain functions as desired, and (ii) devices that are supplied by an integrated circuit manufacturer. *See* RAKESH KUMAR, FABLESS SEMICONDUCTOR IMPLEMENTATION 67 (2008). This discussion focuses on category (ii), which in turn encompasses a number of sub-categories (which are generally not distinguished in the remaining discussion).

89 For a list of leading foundries, see *infra* Appendix B.

90 As of 2003, total investment costs for a 200mm fabrication facility using 0.13 micron process technology is $1.96 billion in Taiwan, the world's leading venue for foundry production. *See* THOMAS R. HOWELL ET AL., CHINA'S EMERGING SEMICONDUCTOR INDUSTRY (report prepared by Dewey Ballantine LLP for the Semiconductor Industry Association) (Oct. 2003), at 14. These costs are compounded by the fact that plant technology is usually obsolete within a few years due to the pace of technological advance. *See* Hutcheson, *supra* note __, at 35-14.

91 *See* Hall & Ziedonis, *supra* note __, at 136; Attia et al., *supra* note __, at 145-46; Wim Roelandts, *Programmable Logic: Enabling the Digital Revolution,* in INSIDE THE MINDS: THE SEMICONDUCTOR INDUSTRY 57-58 (2001).

92 Other terms include: "design blocs" or "SIPs", an abbreviation for "silicon intellectual properties". Note that "IP" is used in a broad sense in the industry and refers to cell libraries, input-output devices, memory devices, and analog mixed signal blocks, some but not all of which may be covered by patents or other forms of intellectual property. However, the "IP" is always licensed subject to contractual and/or technological restrictions.

93 *See* Raja Attia, Isabelle Davy & Roland Rizoulieres, *Innovative Labor and Intellectual Property Market in the Semiconductor Industry,* in TECHNOLOGY AND MARKETS FOR KNOWLEDGE: KNOWLEDGE CREATION, DIFFUSION AND EXCHANGE WITHIN A GROWING ECONOMY 146, 165-67 (ed. Bernard Guilhon 2001).

chain. In particular, fabless firms often engage in aggressive adoption and enforcement of patent rights[94], which contrasts with the "gentler" practices of vertically-integrated incumbents, who engage in limited enforcement as a general matter[95] and have widely entered into cross-licensing arrangements with peer competitors.[96] As shown below, the fabless business model has experienced rapid success since its introduction, reaching over $50 billion in worldwide revenues for publicly-traded fabless firms in 2008 (which compares with $259 billion in worldwide revenues for the semiconductor industry as a whole in 2008).[97]

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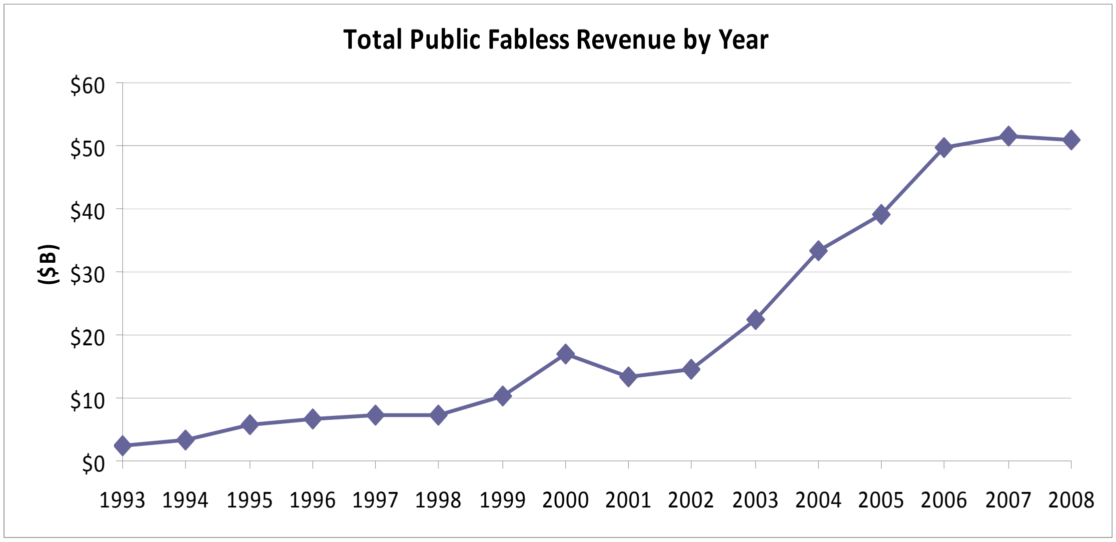
94 *See* Adam B. Jaffe, *The U.S. Patent System in Transition: Policy Innovation and the Innovation Process*, 29 RES. POLICY 531, 540 (2000) (stating that semiconductor patents held by small "design" firms are disproportionately the subject of patent litigation); Rosemarie H. Ziedonis, *Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisitions Strategies of Firms*, 50 MGMT. SCI. 804, 817-18 (2004) (finding that large vertically-integrated semiconductor firms tend to cross-license patents while small design firms tend to adopt more litigious and exclusionary strategies). *See also* Hall & Ziedonis, *supra* note ___, at 137, 159 (finding that firms that entered the semiconductor industry after 1982 patent more intensively than pre-1982 entrants, where 1982 is used as a "marker" for strengthened patent rights based on creation of Federal Circuit; in particular, finding that small firms are *five times* more likely to patent than all other firms in the sample, which excludes, however, some of the largest diversified semiconductor manufacturers).

95 Controlling for increases in the number of patents held and/or amount of R&D spending, large firms have not *initiated* more patent litigation since the early 1980s. *See* Hall, *supra* note __.

96 *See* TEECE, *supra* note ___, at App. A; John H. Barton, *Antitrust Treatment of Oligopolies with Mutually Blocking Patent Portfolios,* 69 ANTITRUST L. J. 851 (2001); GRINDLEY & TEECE, *supra* note ___; *see also* Bronwyn H. Hall & Rosemarie Ham Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995,* 32 RAND J. ECON. 101, 125 (2001) (finding that large firms appear to expand patent portfolios largely for the defensive purpose of preventing hold up or infringement claims by rivals holding potentially overlapping patents).

97 Source: Global Semiconductor Alliance ("GSA"), avail. at www.gsa.org.

Figure VII: Growth of "Fabless" Semiconductor Firms[98]



B. Supply Chain: Application-Specific Integrated Circuits

Generally speaking, the supply chain leading to distribution of an ASIC device[99] can be divided into two broad segments: *design* and *production,* where the former demands a substantially lower fixed-cost investment and substantially higher exposure to expropriation risk relative to the latter.[100] At a significant degree of simplification, these stages can be described as shown in the Table below.

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98 Source: Global Semiconductor Alliance ("GSA"), avail. at www.gsa.org.

99 Note that the ASIC market distributes to intermediate users and hence constitutes an intermediate segment of an even larger supply chain that terminates in the retail distribution of electronic components to business and consumer end-users. For purposes of this discussion, I will consider the supply chain of the semiconductor market as terminating in wholesale distribution to an electronics producer (typically, a systems integrator in the form of an OEM or a component manufacturer that supplies OEMs).

100 The logic behind the second assumption is that products or prototypes delivered at production stages of the supply chain tend to embody private knowledge without making it fully transparent to the recipient; this tends not to be the case in upper portions of the supply chain. For this reason, fabless firms are often reluctant to provide "soft" design modules (i.e., chip designs that have not yet been embodied in an informationally opaque physical prototype) to foundries that can be more easily adapted to customer uses, due to the risk of reverse-engineering. *See* Linden & Somaya, *supra* note __, at 559-61.

Table II: "System on a Chip" Supply Chain

Task	Description
Design	Firm designs the "system-level" architecture, which is a conceptual design of the functions to be included on an ASIC device.
Specification	Architectural design is implemented in the form of a chip-level specification using a variety of "IP modules" (often obtained from outside suppliers).
Prototyping	Specification is implemented in the form of an electronically-deliverable prototype to test conformity to fabrication process parameters prior to commencing "mask-making" (equivalent to producing a mold in traditional manufacturing) and a full-scale production run.[101]
Fabrication; Packaging	Chip is manufactured, after which it must be tested, packaged and assembled (each being an industry term of art describing a specific technical process).
Distribution	Chip is distributed and marketed to the target customer population.
Support	Customers are provided with support services and warranty guarantees to back up performance of the chip.

Following the *Integrate/Contract* construct, we can envision a theoretical range of business models, ranging from complete integration where a single entity carries out all of these functions to complete disintegration where multiple entities carry out these functions, as coordinated by a final distribution agent. As shown below, outsourcing opportunities exist for virtually every stage of this supply chain and business models exist that exploit these outsourcing possibilities to different degrees.[102]

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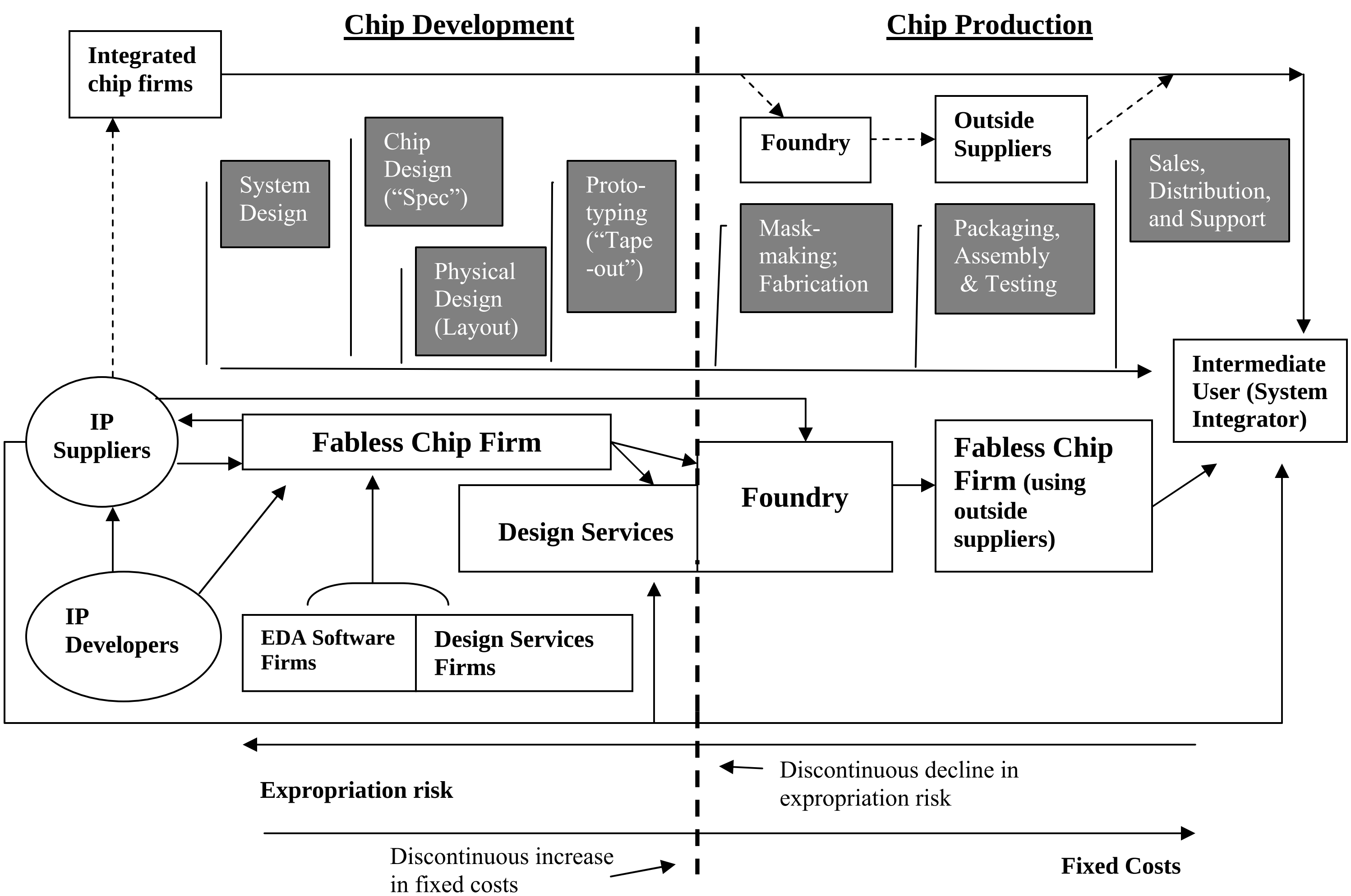
[101] In total, design costs of an ASIC device run into the millions of dollars and have been estimated as high as $45 million. *See* KUMAR, *supra* note __, at §7.3.3. Other sources give estimates at the very high end of up to $80 million for a highly-customized design. *See* Ernst, *supra* note __, at 8 n.21 (citing various industry sources). Note that even that upper-bound estimate pales by comparison to the multi-billion dollar fixed-cost investment required to set up a manufacturing facility.

[102] Note that supply chain functions are shaded. Providers of supply chain functions are then shown principally in the lower half of the graphic.

Figure VIII: Partially Disintegrated Supply Chain
("System on a Chip" Device)[103]



C. Supply Chain Reconfiguration

Recall my core framework: assuming secure property rights that substantially mitigate the expropriation risk inherent to precontractual and infracontractual interaction,

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103 This Figure reflects in part information contained in RAKESH KUMAR, FABLESS SEMICONDUCTOR IMPLEMENTATION Figs. 4.8-4.10, 6.1, 6.8 (2008). Note that (i) the protruding area in the box for "Foundry" reflects the fact that foundries will sometimes backward integrate and implement physical design (layout) services for fabless firms, and (ii) the dashed arrows at the top of the Figure indicate that integrated firms sometimes partially outsource by obtaining design inputs from third-party providers and/or using external foundries to expand fabrication capacity. For expositional simplicity, I do not reflect backward integration by foundries into chip development through the provision of "IP modules" and "cell libraries" fabless firms (who must conform designs to these process specifications). For further discussion, see KUMAR, *supra* note __, at § 6.4.

the opportunity to extract specialization gains (if any) will induce disaggregation of the supply chain, which in turn induces entry by providers of supply chain functions and inputs, which in turn induces entry by intermediaries that facilitate trading in those functions and inputs. This theoretical progression of supply chain reconfiguration closely tracks the actual reconfiguration of supply chains in the fabless market, a process that has rapidly changed part of the industry's structure. Together with important technological and standardization advances that facilitated segregation of the design and/or production functions along the supply chain[104], the legal building blocks of property rights (as supplemented by technology, reputation effects and/or informational opacity) supply a secure environment in which technology holders can exchange information with third parties. Consistent with the link between organizational effects and innovation effects, this disaggregation process has resulted in a diversity of configurations by which to allocate the commercialization functions required to deliver a semiconductor chip to market, an outcome that in turn yields social gains in the form of increased entry, lower innovation and commercialization costs, and increased output and product variety.[105]

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[104] Two developments were of particular importance. First, in 1979, a technical achievement in semiconductor design methodology, known as "VLSI" (Very Large Scale Integration), enabled assembling working prototypes of chip design at relatively low cost and without any involvement in the far more costly fabrication process. For further discussion, see BALDWIN & CLARK, *supra* note __, at 77-88; Nathan Rosenberg & W. Edward Steinmuller, *The economic implications of the VLSI revolution,* in NATHAN ROSENBERG, INSIDE THE BLACK BOX: TECHNOLOGY AND ECONOMICS (1982). Second, in the 1980s, the industry converged on silicon-based "CMOS" (complementary metal oxide semiconductor) as the dominant design in semiconductor process technology. This facilitated standardization of the interfaces that allow design modules to be designed independently by multiple providers. *See* Linden & Somaya, *supra* note __, at 555. For fuller explanations of these technological developments, see BALDWIN & CLARK, *supra* note __, at 77-88.

[105] Note that I do not cover what appear to be important social gains in the form of the development of technology-intensive markets in emerging markets—most notably, Taiwan and increasingly China (principally, as a source of fabrication capacities) and Israel and increasingly Taiwan (principally, as a source of design inputs), which operate as spokes connected by the 'Silicon Valley" hub. This international diffusion of technological development is ultimately rooted in the robust enforcement of patent rights in the target U.S. market (and, in some cases, the local jurisdiction, *see infra* note __, with respect to Taiwan). This fact seems to be ignored by the mostly-skeptical commentary on the extension of patent rights to developing markets, which is commonly viewed as an attempt by Western firms to monopolize developing markets. In the semiconductor industry, precisely the contrary outcome results: secure property rights enable emerging-market providers to challenge the dominance of incumbent firms in developed economies (U.S. and Japan). This appears to be a promising line of inquiry for future research.

1. *The Disintegration Process*

Disintegration of supply chains in the ASIC market began in the mid-1980s with upstream entry by small firms that specialized in design functions and wished to shift the costs and risks of downstream production to large integrated firms.[106] In response, manufacturing-only firms (known as "foundries") entered at downstream portions of the supply chain, which allowed fabless firms to bypass incumbents in order to reach the target customer base of system integrators and component manufacturers.[107] This symbiosis between knowledge-intensive fabless firms and production-intensive foundries[108] has resulted in a flowering of small design firms that challenge incumbents who would otherwise be protected by the exorbitant capital costs required to fund a fully-integrated supply chain. There are currently more than 1800 fabless companies worldwide[109], located predominately in Silicon Valley (but with substantial representation in Israel and Taiwan), who outsource manufacturing functions to roughly 10 wafer foundries, located principally in Taiwan (but with some representation in China and other Asian countries).[110] Both smaller and larger fabless firms (the largest being

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106 *See* Macher et al., *supra* note __.

107 *See* BROWN & LINDEN, *supra* note __, at 47. The foundry option initially became available through the founding of TSMC (in part through an investment by Philips, the European electronics manufacturer), which is still the market leader. *See* JEORGE S. HURTARTE, EVERT A. WOLSHEIMER & LISA M. TAFOYA, UNDERSTANDING FABLESS IC TECHNOLOGY, at xvii (2007); MATHEWS & CHO, *supra* note __, at 171.

108 More precisely: "production-mostly". To secure manufacturing contracts, some foundries have integrated backwards to a partial extent, offering brokering services, module libraries and limited design services to facilitate development of system-on-a-chip designs by upstream suppliers. *See* KUMAR, *supra* note __, at 131; Linden & Somaya, *supra* note __, at 569-70; Waldman, *supra* note __, at 160. Some Taiwanese foundries have gone further and developed capacities to originate new process technologies and chip designs. *See* Howell et al, *supra* note __, at 44.

109 Source: Global Semiconductor Alliance ("GSA"), avail. at www.gsa.org.

110 On Taiwanese and Chinese foundry activity, see Howell, *supra* note __. Some readers may be surprised that design houses would transfer technology to Asian jurisdictions where patent protections are generally thought to be insecure. The underlying assumption (weak patent rights) is inaccurate, however, in the case of Taiwan, the chief location of the largest foundries, which explicitly adopted a policy of strongly-enforced patent rights in 1986, consisting principally of increased infringement awards and creation of a specialized court to hear patent disputes. (The same is true of Korea since roughly the same time.) That almost precisely coincides with the rise of the foundry industry and provides highly suggestive evidence consistent with this Article's core thesis: strong intellectual property rights (both as a formal and effective matter) enabled Taiwanese foundries to commit credibly against expropriation, enabling mutually efficient technology-transfer transactions with Western (mostly U.S.-based) design houses to go forward. *See* Howell et al., *supra* note __, at 111. For further discussion, see Shih-Tse Lo, *Strengthening Intellectual Property Rights: Experience from the 1986 Taiwanese Patent Reforms* (Working Paper 2008), who describes the reforms and documents the positive effects both on domestic innovation by R&D-intensive

multi-billion dollar companies traded on public exchanges, such as Qualcomm, Broadcom and Rambus) pose a competitive threat to large integrated firms in the ASIC market segment,[111], who themselves now obtain some design inputs from upstream fabless and chipless firms.[112] This behavior implies some cost or quality advantage of specialized design-only firms relative to large integrated firms. At least in some segments, the market is apparently rewarding firms that select *Contract* over *Integrate*, which, absent countervailing advantages or transactional frictions, ultimately must result in a "universal outsourcing" outcome that compels all firms to pursue these same disaggregation strategies.[113]

Just as the upstream suppliers of design inputs place competitive pressure on the in-house design divisions of integrated firms, the downstream suppliers of manufacturing services place competitive pressure on the production divisions of integrated firms, an "efficiency cocktail" that nicely illustrates the virtuous cycle unleashed by property-based fragmentation of the supply chain. Subject to the transaction costs associated with patent litigation (an important issue in this market, as evidenced by the widely-publicized litigations involving Rambus, a leading fabless firm), this is an uncontroversially attractive development from a social point of view. Strong property rights, together with technological developments that enable modularized chip design[114], have secured a

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Taiwanese firms (as measured by R&D investment and patenting in the U.S.) and foreign direct investment into Taiwan. Protection of patent rights has a mixed record in China, notwithstanding (i) Chinese foundries' contractual commitments to protect the intellectual property transmitted to them for production purposes (although it should be noted that the loss of future business may provide strong incentives not to pirate) and (ii) the Chinese government's adoption of intellectual property rights specifically covering chip layout designs. *See* Howell et al., *supra* note ___, at 8, 109-12.

111 *See* Linden & Somaya, *supra* note _, at 555 n.14.

112 *See* Howell, *supra* note __, at 44 (noting that leading Taiwanese foundries have collaborative relationships with large Western semiconductor and other electronics firms); Ernst, *supra* note __, at 20-21 (noting that formerly integrated semiconductor firms are moving out of fabrication and specialization into higher-level design and system specification tasks); HURTARTE ET AL, *supra* note __, at xvii-xviii (noting that most major integrated manufacturers today have adopted outsourcing to some extent).

113 Certainly not *all* market segments. The integrated model is still the predominant business structure in the semiconductor market and has certain advantages, including sometimes superior performance as a result of proprietary interfaces and superior coordination with in-house fabrication capacities. *See* Linden & Somaya, *supra* note __, at 571-72. In addition, increasing design complexity threatens to exceed the budget constraints of smaller firms. *See* KUMAR, *supra* note __, at __.

114 *See supra* note __.

bargaining environment that has enabled firms to adjust allocations of supply chain functions so as to exploit comparative cost advantages.

2. *The Re-Intermediation Process*

The re-organization of technology markets governed by strong property rights to protect against expropriation risk, and a resulting secure background for contractual negotiation, follows a "Humpty Dumpty" logic: after the *firm* supply chain is broken apart, the *market* supply chain must be put back together. Disaggregation of the design and production functions of the supply chain and the resulting multiplication of the number of sources of, and increased variety of, supply chain functions and inputs, result in informational complexities that in turn induce entry by intermediaries that offer services that lower search and evaluation costs for buyers and sellers of functions and inputs. This re-intermediation process forms the basis for a "market in ideas", which in this case is represented by the growing market in licensing and trading design modules and design tools that support disaggregated processes for the design and production of ASIC devices. Below I describe the principal intermediaries that are promoting this still-nascent secondary market.

a. *Design Software Providers*

Supply chain disaggregation typically induces higher-order entry by firms that provide tools that can be applied by research-intensive firms in the upstream portion of the supply chain. This pattern emerges in the fabless market, where software tool providers play an indispensable role in permitting disaggregation of the design and production functions in the supply chain. These firms provide design firms with electronic design automation software[115] that automates certain stages of chip design, simulation and verification and allows the designer to stimulate the function of the circuit

[115] *See* Linden & Somaya, *supra* note __, at 568. Note that some EDA firms have moved further up the supply chain by acquiring design modules and then licensing them out together with support services. *See id.*, at 569. For further description of third-party design services, see KUMAR, *supra* note __, at 142. Leading EDA firms are Cadence Design Systems, Synopsys, Mentor Graphics and Magma Design Automation.

being designed.[116] That in turn facilitates vertical disintegration by limiting interdependency between design and production.

b. *Design Module Aggregators*

"IP suppliers" or aggregators accumulate libraries of performance-tested design modules for downstream licensing to chip design firms, foundries and integrated manufacturers.[117] An IP aggregator intermediates between small developers of design modules (as well as the aggregator's in-house R&D division, in some cases), on the one hand, and fabless firms and integrated firms, on the other hand, that incorporate "IP modules" into chip designs.[118] Through this form of a market clearinghouse, IP suppliers facilitate reuse of design modules across a variety of applications and, through planning and estimation tools, alleviate valuation obstacles to module trading, thereby pushing down the costs required to enter the fabless or chipless portions of the design market.[119]

c. *Design Module Standardization*

Buy/sell transactions of design modules are challenged by informational asymmetries relating to buyer concerns over the performance of modules consistent with the buyer's chip architecture and its customers' specifications. This inherent obstacle to a licensing market is alleviated in part by industry consortia that seek to promote standardized design, trading and/or licensing protocols. Almost concurrently with the emergence of the "system on a chip" market, software companies, fabless chip companies and other market participants established the VSI Alliance in order to establish

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116 More specifically, this software enables mapping circuit designs to chip layout and eventual fabrication. For more detailed discussion, see Chesbrough, *supra* note __, at 194 n.4; von Hippel, *Sticky Information, supra* note __, at 70-71; ARORA ET AL., *supra* note __, at 79; Linden & Somaya, *supra* note __, at 568-69.

117 *See* ARORA ET AL., *supra* note __, at 76-77; Linden & Somaya, *supra* note __, at 568-69; KUMAR, *supra* note __, at § 5.9.4, 9.4.2-3.

118 IP aggregators also intermediate between fabless firms and foundries by offering modules that are pre-tested for conformity to selected foundries' process specifications, which overcomes verification problems that can frustrate module transactions. This is a service offered by ARM, the leading IP supplier. See "ARM—Design Start", at http://www.arm.com/products/physicalip/index.html (last visited July 29, 2009).

119 *See* Ernst, *supra* note __, at 10.

standardized interfaces for the transmission of design modules from fabless firms to foundries and the circulation of design modules among chipless and fabless firms.[120] Multiple industry consortia have achieved progress in standardizing design languages and verification protocols that facilitate the circulation of design modules.[121] Nonetheless substantial transaction costs continue to impede the transfer of technology from IP aggregators to chip design houses, which may reflect an inherent technological constraint on the extent to which the highest reaches of the design portion of the supply chain can be disaggregated.

D. **Evaluation: The Potential Virtues of Resource Fragmentation**

It is widely asserted that strong patents, and the resulting fragmentation of intellectual resources, preclude entry into concentrated markets or engender dispute-resolution and other transaction costs that impede innovation.[122] The fabless market provides a tentative counterfactual to both propositions. While the causality is not certain, there appears to be a strong connection between widespread adoption of property rights and two attractive effects over market structure and formation. First, patents appear to enable entry by weakly-integrated firms at both the research and production

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[120] *See* Grant Martin, *The History of the SoC Revolution: The Rise and Transformation of IP Reuse,* in WINNING THE SOC REVOLUTION: EXPERIENCES IN REAL DESIGN 4-5 (ed. Grant Martin & Henry Chang 2003). VSI Alliance was disbanded in 2008, at which time its various missions were transferred to other industry organizations.

[121] Leading standardization initiatives are as follows (the entity's website address is listed in each case for further information): (i) OCP International Partnership, which provides an openly-licensed socket ("IP core interface") (OCP 2.2), www.ocpip.org; (ii) the SPIRIT consortium, which provides a "metadata" standard for describing design modules (IP-XACT 1.4), www.spiritconsortium.org; (iii) Accellera (to merge with SPIRIT in 2010), which provides design and verification standards, including hardware design language (SystemVeriLog; VHDL), www.accellera.org; (iv) Open System Initiative, which provides an open industry standard for system-level modeling, design and verification (SystemC 2.2) and interface standard enabling interoperability of models at transaction level (TLM Standard 2.0), www.systemc.org; and (v) Silicon Integration Initiative, which provides open interface standards for producing integrated silicon systems, www.si2.org.

[122] For the leading expression of this thesis, see Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets,* 111 HARV. L. REV. 621 (1998), which stated that excessively fragmented property rights can generate net social losses by impeding, rather than facilitating, investment; Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998), which advanced the same thesis with respect to gene patents. Subsequent efforts to identify the anti-commons thesis in the biomedical context have reached indeterminate to mildly adverse results. For a summary of that evidence, see Jonathan M. Barnett, *Property as Process: How Innovation Markets Select Innovation Regimes,* YALE L. J. (2009).

portions of the supply chain. Without patents, it is unlikely that start-ups could have challenged incumbents who were naturally protected by the exceptional capital costs of the fabrication process. History bears out this view: the fabless model was in part motivated by the inability of venture capital firms to fund the fabrication portion of the supply chain.[123] Second, and more tentatively, patents appear to facilitate reintermediation of the supply chain through the entry of licensing, trading and standardization entities. Reintermediation in turn lowers innovation costs by expanding the available pool of technological inputs and thereby induces further entry into the design stages of the supply chain.

To be clear, this does *not* imply—as the conventional formulation of the incentive thesis *would* imply—that the semiconductor market would have failed to sustain substantial innovative output without strong patents. That is highly unlikely: the industry would have sustained innovation by preserving the vertically-integrated structures that had captured innovation returns for several decades and continue to do so today in the case of the largest integrated firms. The market would have "looked" much different and infringement litigation would have been less prominent. But that organizational response to expropriation risk would have masked the counterfactual world of small-firm entry, disaggregated design and production processes, and module trading that has emerged thanks to a confluence of legal, economic and technological factors. It is important to beware of the "Nirvana fallacy" that would suppose without foundation the possibility of a world with higher innovative output at a lower transaction-cost burden. If the dispute-resolution costs inherent to a robust patent system are required to open up technology markets to competitive pressures that can minimize innovation and commercialization costs and thereby maximize innovative output, that may sometimes be a price worth paying.

Conclusion

The incentive justification for the patent system is challenged. Lacking strongly persuasive empirical support outside of selected markets, the incentive thesis in its conventional form has middling force against the view that the patent system is often

123 *See* Hutcheson, *supra* note __.

nothing other than a generalized exercise in rent-seeking. This Article provides a basis for reinvigorating the incentive thesis even in the most "IP-hostile" environments where some firms have access to alternative technologies by which to delay imitation in the goods market. *A fortiori* the case for patents is strengthened in all other environments. The key to this approach lies in construing intellectual property as an instrument for organizing innovation, not inducing it. Explicitly: *the patent system typically regulates firms' innovation incentives solely to the extent that it regulates firms' choices of organizational forms by which to implement innovations*. This proposition gives rise to two core implications. First, as a positive matter, it means that transactions, firms and markets "look different" under stronger or weaker levels of patent coverage. Strong patents provide firms with the opportunity to reconfigure supply chains through interfirm relationships, whereas weak patent rights foreclose that option outside environments characterized by strong reputation effects or informational opacity. Second, as a normative matter, adjusting firm scope in order to extract specialization gains facilitates entry into capital-intensive markets that are otherwise sheltered against competitive threats by the scale-efficiencies of integrated incumbents. The social gains from these organizational effects are most easily observed among specialized R&D firms but extend across virtually the entire innovator population. The same bargaining process that enables disaggregation of the upstream research functions of the supply chain can reconfigure the remainder of the supply chain, which ultimately yields a division of labor among least-cost providers that minimizes innovation and commercialization costs and multiplies entry opportunities. These organizational effects together support a guardedly sanguine view of the patent system. As an instrument for inducing even substantial levels of innovative output, patent protection may often or even typically have questionable added value outside of selected industries. As an instrument for promoting organizational diversity that can induce the highest levels of innovative output, it may often be essential.

Appendix A
Leading Firms in the Semiconductor "Fabless" Market[124]

Company (Ticker)	Principal Location; Date Established	2008 Annual Revenue [$M]	Market Capitali-zation [$M]	Chief Product Lines	Primary Client Types
QUALCOMM QCT Division (QCOM)	USA (Calif.) *1985*	6,477	72,670 (all divisions)	Mobile Phone Technology	Cell Phone Manufactures
Broadcom (BRCM)	USA (Calif.) *1991*	4,658	12,900	Computer and Telecommunication Networking	Computer and Cell Phone Companies
NVIDIA (NVDA)	USA (Calif.) *1993*	3,425	5,930	Visual Computing Technology	Computer, Memory, and Cell Phone Companies
Marvell Semiconductor (MRVL)	USA (Calif.) *1995*	2,951	6,900	Signal Processing and Embedded Microprocessor ICs	Electronic Storage and Networking Companies
MediaTek (TPE: 2454)	Taiwan *1992*	2,755	13,600	Wireless Communication, Optical Storage, HDTV, DVD	Cell Phone and Consumer Electronics Companies
LSI Logic (LSI)	USA (Calif.) *1980*	2,677	2,750	ASICs, Storage Systems, Computer Networking Products	Computer and Consumer Electronics Companies
Xilinx, Inc. (XLNX)	USA (Calif.) *1984*	1,906	5,770	Programmable Logic Devices	Industrial, Consumer, Automotive, Data Processing
Avago Technologies	USA (Calif.) *2005*	1,665	-	ASICs, LEDs, Optoelectronic Components	Cell Phones, Data Networking, and Solid State Lighting Companies
Altera (ALTR)	USA (Calif.) *1983*	1,367	4,900	Programmable Logic Devices	Consumer Electronics, Industrial, and Computer Companies
SanDisk OEM Division (SNDK)	USA (Calif.) *1988*	1,030	3,500 (all divisions)	Flash Memory Card Products	Consumer Electronics Companies

124 Ranking (by annual revenues) adapted from: HURTARTE ET AL., *supra* note __.; financial information from Yahoo! Finance and Business Week; and descriptions of products from respective companies' websites.

Conexant Systems (CNXT)	USA (Calif.) *1996*	502.7	55.25	Modems, Dial-Up Processors	Credit Card Swipers, Fax Machines
NovaTek (TPE:3034)	Taiwan *1997*	785.5	1,390	Display Driver ICs	Flat Panel Display Companies
Himax Technologies (HIMX)	Taiwan *2001*	832.8	640.6	Display Driver ICs	Flat Panel Display Companies
Cambridge Silicon Radio (LON:CSR)	England *1999*	694.9	817.2	Bluetooth ICs	Bluetooth Devices
VIA Technologies, Inc. (TPE:2388)	Taiwan *1987*	246	703.3	Motherboard Chipsets, CPUs, Memory	Computer, Cell Phone, and Personal Electronics Companies
QLogic Corporation (QLGC)	USA (Calif.) *1992*	597.9	1,680	Storage and System Infrastructure	Enterprises with Business Data Requirements
OmniVision Technologies, Inc. (OVTI)	USA (Calif.) *1995*	799.6	541	Image Sensor Devices	Cell Phone, Computer and Camera Companies
Zoran Corporation (ZRAN)	USA; Israel *1981*	438.5	570	Digital Imaging ICs	DVD Player and Recorder Companies, HDTV and HD Camera Companies
Silicon Laboratories (SLAB)	USA (Texas) *1996*	415.6	1,580	Analog-Intensive and Mixed-Signal ICs	Radio Frequency Products and Modems
Silicon Storage Technology, Inc. (SSTI)	USA (Calif.) *1989*	315.5	181	Flash Memory	Consumer Electronics, Networking, and Wireless Comm.
Total For Top 20 Firms		34,540			
Total for All Fabless Firms		51,000			

Appendix B
Leading Firms in the Semiconductor Foundries Market[125]

Entity (Ticker)	Principal Location; Date Established	2008 Revenue [$M]	2008 Market Share	Market Capitalization [$M]	Chief Manufacturing Lines	Primary Client Types
TSMC (TSM)	Taiwan *1987*	10,556	50%	52,940	Logic Chips, Memory	Hard Disk Drives, Wireless and Network Equipment
UMC Group (UMC)	Taiwan *1980*	3,400	16%	7,710	System on Chip ICs	Communication, Consumer Electronics, Computers, Memory
Chartered (CHRT)	Singapore *1987*	1,743	8%	624.6	Logic Devices and Graphics Chipsets	Communication, Consumer Electronics, Computers
SMIC (SMI)	China *2000*	1,354	6%	1,251	Logic Devices and Memory Technology	Hard Disk Drives, Wireless and Network Equipment
Vanguard (TPO:5347)	Taiwan *1994*	511	2%	725.3	Logic Devices and Memory Technology	Communication, Automotive Electronics, Consumer Electronics, Computers
Dongbu HiTek (SEO: 000990)	South Korea *1997*	490	2%	320.7	Signal Processing Chips	Display and Mobile Technology
X-Fab	Europe *1999*	400	2%	-	Analog and Mixed-Signal ICs	Consumer Electronics, Mobile Technology
HHNEC	China *1997*	350	2%	-	Smart Card Chips, RF Chips, LCD Drivers	Consumer Electronics, Smart Cards, Computer Products
He Jian	China *2001*	345	2%	-	Logic Devices, Memory Technology	Communications and Consumer Electronics

[125] Ranking of companies (by revenue and market share) adapted from www.semiconductor.net; financial data from Yahoo! Finance and Business Week; description of products from respective companies' websites.

SSMC	Singapore *2000*	340	2%	-	Embedded Flash and Analog Mixed Signal ICs	Communication, Multimedia, Consumer Electronics
Grace	China *2000*	335	2%	-	Memory, Logic Devices, Image Sensors	High-Volume Consumer Applications
Tower (TSEM)	Israel *1993*	252	1%	46.4	Mixed Signal and RF ICs, Image Sensors and Power Management Devices	Consumer Electronics, Computers, Automotive, Industrial, Medical Devices
Jazz	U.S. *2002*	190	<1%	-	Analog and Mixed-Signal ICs	Cell Phones, Wireless LAN, Digital TV, Gaming Devices, Routers, Modems
Silterra	Malaysia *1995*	175	<1%	-	Logic Devices, High Voltage and Mixed-Signal/RF Process Technology	Computation, Consumer, and Communication Electronics Applications
ASMC (HKG:3355)	China *1988*	149	<1%	288.4	Analog and Mixed-Signal ICs, Non-Volatile Memory	Computing, Communications and Consumer Electronics
Polar	Japan *1984*	110	<1%	-	Analog and Mixed-Signal ICs	Communications
Mosel-Vitelic (TPE:2342)	Taiwan *1991*	100	<1%	295.4	SRAM and Flash Memory	Consumer Electronics, Communications
Others		180	<1%			