ARTICLES

INTELLECTUAL PROPERTY AS A LAW OF ORGANIZATION

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ABSTRACT

The incentive thesis for patents is challenged by the existence of alternative means by which firms can capture returns on innovation. Taking into account patent alternatives yields a robust reformulation of the incentive thesis as mediated by organizational form. Patents enable innovators to make efficient selections of firm scope by transacting with least-cost suppliers of commercialization inputs. These expanded transactional opportunities reduce the minimum size of the market into which any innovator—or the supplier of any other technological or production input—can attempt entry. Disaggregation of the innovation and commercialization process then induces the formation of secondary markets in disembodied technology inputs. These organizational effects over transactional, firm, and market structure generate specialization economies that minimize innovation and commercialization costs. These efficiencies in turn exert incentive effects consistent with the standard thesis and market growth effects that extend beyond it. Conversely, the

* Associate Professor, University of Southern California Gould School of Law. This paper has benefited from comments by Jennifer Arlen, Douglas Baird, Oren Bar-Gill, Omri Ben-Shahar, Ryan Bubb, Dan Burk, Stephen Choi, Frank Easterbrook, Richard Epstein, David Gilo, Gillian Hadfield, Dan Klerman, Peter Leeson, Saul Levmore, Jonathan Masur, Ed McCaffery, Neil Netanel, Ariel Porat, Betsy Rosenblatt, Ted Sichelman, Christopher Stone, Lior Strahilevitz, Avi Tabbach, and other participants at the 2010 Annual Meeting of the American Law and Economics Association, the 2009 Intellectual Property Scholars Conference, and workshops at Chicago Law School, New York University School of Law, Tel Aviv University Faculty of Law, UCLA School of Law, and the University of Southern California School of Law. Research assistance was provided by Daniel Fullerton, Kawon Lee, and Jose Rodriguez. All errors are mine.

absence of patents, and the resulting obstacles to bargaining over ideas, can compel innovators to select overintegrated structures that inflate commercialization costs, resulting in distorted innovation investment and product output. These relationships are broadly consistent with organizational patterns in selected historical and contemporary technology markets, as illustrated in particular by disintegration processes in the "fabless" segment of the semiconductor market.

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I. INTRODUCTION

Conventionally, patents are understood to be critical instruments for supporting innovation. This incentive thesis is the basis for most legal, policy, and judicial discussions and applications of patent law. Hence, it is problematic (to say the least!) that 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 innovators[2] often have access to alternative mechanisms by which to capture returns on innovation: take away patents and innovators often fill the gap through nonpatent substitutes. In this Article, I offer an alternative account of the patent system that explicitly recognizes the "IP-unfriendly"[3] fact that patents are often not a unique instrument by which to capture innovation returns. In lieu of the traditional incentive thesis, I adopt an alternative approach that examines how patents influence innovation behavior by influencing organizational behavior. This approach pursues a two-part hypothesis: (1) patent strength[4] sometimes influences the organizational forms that entrepreneurs, firms, and other entities select in order to undertake innovation and commercialization activities and (2) those organizational effects influence the innovation incentives of entrepreneurs, firms, and other entities.[5] Organizational effects proxy for innovation effects: where patents alter organizational behavior, they alter innovation behavior; otherwise, patents are redundant as an incentive device. Contrary to other attempts to provide a sounder

1. *See infra* note 15 and accompanying text.

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

3. Throughout the Article, I use "intellectual property" and "IP" interchangeably. *See infra* note 153.

4. By "patent strength," I refer to the multiple factors that influence the strength of patent protection, including (among other things) duration, scope, cost of enforcement, anticipated damage awards, and so forth.

5. This approach builds upon and generalizes arguments set forth in Ashish Arora & Robert P. Merges, *Specialized Supply Firms, Property Rights and Firm Boundaries*, 13 INDUS. & CORP. CHANGE 451, 470–72 (2004). For other relevant contributions, see sources cited *infra* note 10.

basis for the patent system without reference to any incentive function,[6] I exploit patents' effects on transactional, firm, and market structures as a basis for reinvigorating the incentive thesis, as applied in mediated form to a targeted set of innovation environments. The result is a nuanced reformulation of the incentive thesis. Contrary to unqualified "IP-abolitionism," it anticipates circumstances in which patents exert marginal incentive effects; but contrary to unqualified "IP-advocacy," it anticipates circumstances in which patents do not exert such effects.

To develop this proposition, I pursue the intellectual equivalent of a pruning strategy. I remove contestable or disputed propositions and assumptions in order to build the least controversial basis for a revised formulation of the incentive thesis. First, I intentionally overstate empirical evidence that casts doubt on patents' incentive effects by assuming that reverse-engineering barriers or other nonpatent mechanisms sufficiently delay imitation in the goods market. Second, I constrain the scope of application of the incentive thesis to limited circumstances in which 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 well-supported position that small firms and individual inventors most clearly depend on the patent system, a view that has a strong historical pedigree in the U.S. patent system,[7] rests on considerable empirical support,[8] and is reflected in several existing policy commitments.[9] Third, I move beyond this proposition by arguing that first-order effects over the innovation behavior of weakly integrated entities imply higher-order effects over supply chain configurations, entry

6. *See* Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473, 473–78 (2005) (arguing that, independent of any exclusionary function, patents reduce transaction costs of organizing and monitoring team production of research and development ("R&D") and other innovation assets); Clarisa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 643–55 (2002) (arguing that, independent of any exclusionary function, patents perform a signaling function that relieves informational asymmetries, especially between firms and investors).

7. For the leading account, see B. ZORINA KHAN, THE DEMOCRATIZATION OF INVENTION: PATENTS AND COPYRIGHTS IN AMERICAN ECONOMIC DEVELOPMENT, 1790–1920, at 106–27 (2005) (noting the significance of the U.S. patent regime in providing incentives for advancement of technology, as well as equal access to disadvantaged groups such as blacks and women).

8. *See infra* notes 57, 132.

9. See, for example, the Patent and Trademark Office's ("PTO's") reduced fee schedule for small entities, 37 C.F.R. § 1.27 (2010); the Small Business Innovation Development Act of 1982, Pub. L. No. 97-219, 96 Stat. 217 (codified as amended at 15 U.S.C. §§ 631, 638 (2006)); the Small Business Research and Development Enhancement Act of 1992, Pub. L. No. 102-564, 106 Stat. 4249 (codified as amended at 15 U.S.C. § 631); and, in the case of academic research institutions, the University and Small Business Patent Procedures (Bayh-Dole) Act of 1980, Pub. L. No. 96-517, 94 Stat. 3015 (codified as amended at 35 U.S.C. §§ 200–212 (2006)) (implemented by 37 C.F.R. pt. 401).

conditions, and market formation 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 research and development ("R&D") suppliers are symptomatic of a generalized bargaining process that continuously reallocates supply chain functions among the least-cost combination of external and internal providers. The specialization gains resulting from this division of labor in turn yield effects on market growth that extend beyond the conventional link between "more IP" and "more innovation." For the incentive thesis, less is more. Initially confining the thesis to the firm categories and market settings in which it is most robust ultimately reinstates it as an empirically grounded account of the manner in which patents can exert far-reaching effects over firm and market structure. Those structural effects in turn yield incentive effects consistent with the standard rationale and market growth effects that go beyond it.

This project builds on work by legal and management scholars, and economic historians, who have pioneered inquiry into the interactions among intellectual property, transactional design, firm boundaries, and market structure.[10] Examining the patent system through the lens of

10. Asish Arora and colleagues in management literature, Robert Merges in legal literature, and Kenneth Sokoloff and Naomi Lamoreaux in economic history literature have pioneered this line of inquiry. *See generally* ASHISH ARORA, ANDREA FOSFURI & ALFONSO GAMBARDELLA, MARKETS FOR TECHNOLOGY: THE ECONOMICS OF INNOVATION AND CORPORATE STRATEGY (2001) (discussing the role of intellectual property rights in defining markets for technology); Arora & Merges, *supra* note 5 (discussing the role of intellectual property rights in emerging trends in choices of firm boundaries); Robert P. Merges, *A Transactional View of Property Rights*, 20 BERKELEY TECH. L.J. 1477 (2005) [hereinafter Merges, *Transactional View*] (discussing the role of intellectual property rights in facilitating contracting between "legal strangers" by creating both precontractual liability and enforcement flexibility); Robert P. Merges, Intellectual Property Rights, Input Markets, and the Value of Intangible Assets (Feb. 9, 1999) (unpublished manuscript) [hereinafter Merges, Input Markets], *available at* http://www.law.berkeley.edu/files/iprights.pdf (discussing how strong intellectual property rights incentivize firm specialization and enable the formation of distinct input markets). For contributions in economic history literature, see *infra* notes 79–86 and accompanying text. For other contributions in legal literature on intellectual property and firm structure, see Oren Bar-Gill & Gideon Parchomovsky, *Law and the Boundaries of Technology-Intensive Firms*, 157 U. PA. L. REV. 1649, 1650 (2009) (discussing how the availability of intellectual property protection, rather than economic considerations, determine the boundaries of technology-intensive firms), 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, 633–36 (arguing that intellectual property rights should be calibrated between firms and within firms to address internal and external transaction costs). On intellectual property and market structure, see MARTIN J. ADELMAN ET AL., CASES AND MATERIALS ON PATENT LAW 38 (2d ed. 2003) ("In effect the existence of a patent system makes the industrial structure of a particular industry essentially irrelevant to the innovation process."), and Martin J. Adelman, *The Supreme Court, Market Structure, and Innovation:* Chakrabarty, Rohm *and* Haas, 27 ANTITRUST BULL. 457, 460 (1982) (arguing that the relationship between market structure and innovation is unknowable, but that a strong patent regime is valuable because "it reduce[s] any diversity in incentives to innovate

organizational form yields surprising insights that challenge current skepticism among some economists, academic lawyers, judges, and other policymakers over patents' incentive function. These insights are grounded in two uncontroversial observations that are familiar to the inventors, investors, lawyers, and business people who participate on a day-to-day basis in technology markets. First, a firm must commercialize innovations in order to realize any payoff on its R&D investment (and, more generally, for everyone else to realize a social payoff on the firm's R&D investment), which commercialization necessitates executing capital-intensive and skill-intensive actions to reach market. Any practically compelling theory of intellectual property, therefore, must 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. Bargaining over an intangible resource is frustrated by a chicken-and-egg problem: negotiation to agree on valuation necessitates disclosing the invention, allowing the listener to seize it at will.[11] That problem means that innovators who have an idea may have difficulty getting it to market: expropriation threats preclude contracting out commercialization functions without risking forfeiture of the innovation. Any practically compelling theory of intellectual property must address this obstacle to market release.

This shift in focus to the commercialization stage that lies between invention and market release—a reorientation of perspective promoted by other patent scholars in recent work[12]—is the key to identifying the role

with respect to different market structures"). Inquiry into the relationship between intellectual property and firm structure traces back to David J. Teece, *Firm Organization, Industrial Structure, and Technological Innovation*, 31 J. ECON. BEHAV. & ORG. 193, 222 (1996) (recognizing "firm organization . . . [as] an important determinant of innovation"). This Article advances these bodies of scholarship in several respects: (1) it views specialized R&D suppliers (the focus of much of the existing literature) as a subset of a general case in which patents enable the efficient allocation of innovation and commercialization functions among least-cost providers; (2) it provides a consolidated framework 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 inputs; (3) it exploits these relationships in order to isolate the circumstances in which patent coverage exerts marginal incentive effects, even assuming the existence of alternative instruments by which to capture innovation returns; and (4) it moves beyond theoretical argument by identifying organizational tendencies in technology markets that are consistent with these relationships.

11. *See* Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* NAT'L BUREAU OF ECON. RESEARCH, THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 614–16 (1962).

12. F. Scott Kieff in particular has emphasized this point. *See* F. Scott Kieff, *IP Transactions: On the Theory & Practice of Commercializing Innovation*, 42 HOUS. L. REV. 727, 736–37 (2005) (exploring the role of intellectual property rights in crossing between innovation and market release); F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV.

that patents can play in influencing innovators' configuration of the supply chain by which innovations reach market. Those organizational effects in turn can promote innovation consistent with the conventional thesis. Recall the starting assumption: an "IP-unfriendly" environment in which reverse-engineering barriers or other extrapatent mechanisms delay imitation in the goods market. That environment would appear to threaten patents with redundancy. But expropriation risk persists at any point in the commercialization process at which innovators must disclose information to external providers of the functions that must be implemented in order to reach market. It is precisely at this stage that patents can be critical. Without patents, innovators must integrate forward so as to implement commercialization independently and minimize interaction with third parties. Integration would appear to resolve the expropriation threat (which would again appear to threaten patents with redundancy). But integration can impose a subtle but important cost. Where expropriation risk compels an innovator to select higher levels of integration than it would otherwise have preferred, the innovator forfeits specialization gains that could have been accrued by allocating one or more supply chain functions to lower-cost providers. In the extreme case, those specialization losses are so great that entry is no longer cost feasible. Even in the moderate case in which the innovator reaches market, it—and society in general—has still suffered a loss in the form of inflated commercialization costs. 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 suppliers. Contrary to standard commentary that laments patents' entry-preclusive effects, the organizational approach identifies circumstances in which patents enable entry (and the absence of patents disables entry) by specialized providers of technological and production inputs along the supply chain running from idea to market.

In short, transactional, firm, and market structures sometimes look much different under stronger or weaker patent protection, and these organizational effects sometimes matter—as I will argue, usually matter—for the underlying objective of supporting innovation.[13] This is not to say

697, 703–04, 707–12 (2001) (same). The recent focus on commercialization revives themes promoted by Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 265–67, 289–90 (1977) (defining the "prospect function" of patents as a claim system through which rights to innovate are auctioned off, thus lowering transaction costs in transmission of information between firms).

13. Properly speaking, the underlying objective is to induce efficient (not maximal) allocation of resources to innovative activity, relative to all alternative activities. Consistent with most economic and all legal commentary on intellectual property, I will, as a matter of shorthand, often refer to the

that strong patents do not give rise to opportunistic litigation and other social costs that may ultimately recommend against them "on net" in any particular market. The organizational approach is ambitious as a positive matter but modest in its normative aspirations. It simply identifies on a gross basis an important set of social gains generated by the bargaining processes secured by patents. These social gains encompass but extend beyond the independent R&D suppliers—individual inventors, technology start-ups, academic institutions, and other research-dedicated entities—that most clearly depend on the patent system. First, the same specialization logic that drives upstream R&D firms to outsource downstream production functions can induce—actually, by competitive pressure, it will compel—ongoing adjustments throughout the supply chain. This 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. 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, giving rise to informational complexities that induce reintermediation by transactional entrepreneurs that facilitate trade in intangible goods.

These relationships between patent strength on the one hand, and firm scope and market structure on the other hand, extend intellectual property analysis toward microlevel issues of supply chain design and macrolevel issues of market structure and growth. These issues have received little attention from legal scholars.[14] The "micro" and the "macro" are linked: intellectual property influences market structure and growth by regulating the opportunity set of transactional and organizational choices available to the suppliers of complementary technology and production inputs. To be sure, the virtuous circle of strong patents, adaptive supply chains, and specialization economies does not tell the whole story of the patent system. But it represents an important and overlooked part of the story that recurs in industries and periods characterized by intensive adoption and enforcement of patents. In particular, the organizational approach identifies an important role that patents appear to play in the widespread disintegration of supply chains in technology markets that had formerly been dominated by vertically integrated firms. This process—a

objective of "promoting" or "supporting" innovation, it being understood that there must exist some upper bound to the socially optimal level of innovative investment.

14. For exceptions, see sources cited *supra* note 10.

fundamental change in industrial organization—is described in detail through a case study of the "fabless" segment of the semiconductor market. Since roughly the mid-1990s, this patent-intensive market, which develops designs for chips widely used in computing, communications, and other electronic devices, has migrated from almost exclusive reliance on integrated structures to substantial use of disintegrated structures in which fabless firms that specialize in chip design contract with "foundries" that specialize in production. Vertical disintegration has in turn induced reintermediation by entities that facilitate transactions in design components. This transformation of firm and market structure offers a 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 rarely documented) claim that intensive patenting, and the resulting fragmentation of intellectual resources, impedes innovation in technology markets. To the contrary, the fabless chip market, and the challenge it has mounted to incumbents, almost certainly could not have arisen without it.

This Article proceeds as follows. In Part II, I situate the innovation process within the supply chain context and explore the extent to which innovators can mitigate expropriation risk through contractual, reputational, and organizational solutions. In Part III, I describe how patents promote specialization gains and reduce entry costs by enabling innovators to select least-cost organizational forms. In Part IV, I illustrate these relationships through evidence on organizational tendencies in technology markets in general and the fabless semiconductor market in particular. Part V concludes.

II. THE COMMERCIALIZATION DILEMMA

Incentive-based discussions of the patent system typically focus on expropriation risk in the goods market, which risk is presumed to result in underinnovation in the absence of legal protections against imitation. But empirical evidence tells a more complex story. Outside 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.[15]

15. The leading evidence is found in survey studies covering large U.S. manufacturing firms, finding that, among legal and extralegal mechanisms for appropriating returns from R&D projects, firm managers (outside 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

Even if we overgenerously accept this body of evidence without qualification,[16] expropriation risk still confronts innovators before a consumption good embodying the innovation reaches the market.[17] In an early contribution, Arrow drew attention to this sensitive juncture—postinvention but precommercialization—by describing a dilemma that has since become known as "Arrow's Paradox" or the "disclosure paradox."[18] Absent a 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 on release in the goods market. This proposition implies a broad scope of application for patents to support the commercialization process. It is important to observe, however, that innovators are not helpless: even without patents, expropriation risk in precontractual bargaining can sometimes be limited through some combination of reputation effects, graduated disclosure, and organizational integration. If we take into account these imperfect but often meaningful defenses, we can then define more precisely the set of circumstances in

project. *See* 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, 789–91, 793–98 (Martin Neil Baily & Clifford Winston eds., 1987) (surveying R&D managers in all publicly traded firms in the United States with substantial R&D expenses); Wesley M. Cohen, Richard R. Nelson & John P. Walsh, *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)* 4, 14–23 (Nat'l Bureau of Econ. Research, Working Paper No. 7552, 2000), *available at* http://www.nber.org/papers/w7552 (surveying R&D managers randomly drawn from a sample of all R&D labs in the United States operating as part of a manufacturing firm). Note that neither of these studies addresses the value placed by small firms on patent protection; that is an important limitation, as will become apparent in the ensuing discussion. For a survey of small firms that reaches largely contrary results in selected industries, see *infra* note 57 and accompanying text.

16. Elsewhere I have reviewed in detail this evidence and other related studies, which show substantial industry-specific and firm-specific variation. *See* Jonathan M. Barnett, *Do Patents Matter? Empirical Evidence on the Incentive Thesis*, *in* HANDBOOK ON LAW, INNOVATION AND GROWTH 178, 182 (Robert E. Litan ed., 2011) ("[T]he incentive effects of patent protection operate along market-specific, firm-specific and order-specific dimensions."); Jonathan M. Barnett, *Private Protection of Patentable Goods*, 25 CARDOZO L. REV. 1251, 1257–69 (2004) (reviewing extralegal substitutes for patents).

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

18. *See* Arrow, *supra* note 11, at 615 ("[T]here is a fundamental paradox in the determination of demand for information; its value for the purchaser is not known until he has the information, but then he has in effect acquired it without cost.").

which 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. There was a "lag of an entire millennium between the invention of the water mill and its widespread adoption."[19] 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. Both medieval China and the Soviet Union conformed to this tendency: invention was forthcoming but dissemination was stalled.[20] Any practically meaningful inquiry into the patent system, therefore, must assess how it supports the long path that runs from idea generation through the various tasks that must be completed to embody an idea in a consumption good. Research is typically only a portion, and usually the far smaller portion, of the capital-intensive and knowledge-intensive activities that must be undertaken in order to bring an innovation to market.[21] Innovation and commercialization costs for some of today's most important innovations reach infrastructural proportions: these amounts exceed a billion dollars in the case of a new pharmaceutical product[22] and several billion dollars in plant construction costs alone in the

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

20. *See* William J. Baumol, *Toward Analysis of Capitalism's Unparalleled Growth: Sources and Mechanism*, *in* ENTREPRENEURSHIP, INNOVATION, AND THE GROWTH MECHANISM OF THE FREE-ENTERPRISE ECONOMIES 158, 164–65 (Eytan Sheshinski et al. eds., 2007) (noting the presence of innovation in both China and the Soviet Union, but rarely the widespread use of these innovations); Maurizio Iacopetta, *Dissemination of Technology in Market and Planned Economies*, B.E. J. MACROECONOMICS 24–26, Feb. 3, 2004, *available at* http://www.bepress.com/bejm/contributions/vol4/iss1/art2 (emphasizing how in a planned economy loans are only available for specific production goals, but not for consumption, creating an "output rule" that rewards managers who preserve stable outputs and limit innovation).

21. *See* OFFICE OF TECH. ASSESSMENT, U.S. CONGRESS, NO. OTA-BP-ITC-165, INNOVATION AND COMMERCIALIZATION OF EMERGING TECHNOLOGIES 49–50 (1995), *available at* http://www.fas.org/ota/reports/9539.pdf (noting that R&D costs are significantly lower than the cost of commercialization activities); FREDERIC M. SCHERER ET AL., PATENTS AND THE CORPORATION: A REPORT ON INDUSTRIAL TECHNOLOGY UNDER CHANGING PUBLIC POLICY 35 (1959) ("A wide variety of case examples is available to show that the costs connected with innovation tend to be much greater than those of the original invention."); *id.* at 29–32 (illustrating a specific case example and charting the R&D and commercialization expenditures). For similar views, see, for example, JOHN JEWKES, DAVID SAWERS & RICHARD STILLERMAN, THE SOURCES OF INVENTION 152–53 (2d ed. 1969), and JACOB SCHMOOKLER, INVENTION AND ECONOMIC GROWTH 3 (1966).

22. *See* Joseph DiMasi, Ronald W. Hansen & Henry G. Grabowski, *The Price of Innovation: New Estimates of Drug Development Cost*, 22 J. HEALTH ECON. 151, 166 (2003) (estimating, for drugs that underwent the Food and Drug Administration approval process in the 1990s, average costs of $800

case of a new semiconductor chip.[23] Absolute cost outlays are magnified by the long "dry period" that typically runs from invention to market release, ranging from several years to several decades in the case of some of the most important innovations.[24] Without some mechanism by which to fund and implement commercialization tasks during this prolonged gestation period, innovator firms will decline by anticipation to invest in the R&D that gets 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. Distribution 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—required to deliver an innovation to market. 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. These options correspond to what the "theory of the firm" literature calls the "make/buy" decision: that is, with respect to any task, a firm must elect to implement that task internally or purchase it externally.[25] Where the innovator does not elect to contract for any particular function or input ("buy"), it must integrate forward and implement that function or generate that input independently ("make"). To the extent that precontractual bargaining (or infracontractual interaction in the course of performance)[26] at any point on the supply chain necessitates disclosure of information that can then be used or transferred by the counterparty to the innovator's disadvantage, the disclosure paradox may

million from molecule identification through testing (as calculated on a fully capitalized basis in 2000 dollars)). This figure does not include production, distribution, or marketing costs; hence, total capitalized costs almost certainly exceed $1 billion, as stated above.

23. *See infra* note 129.

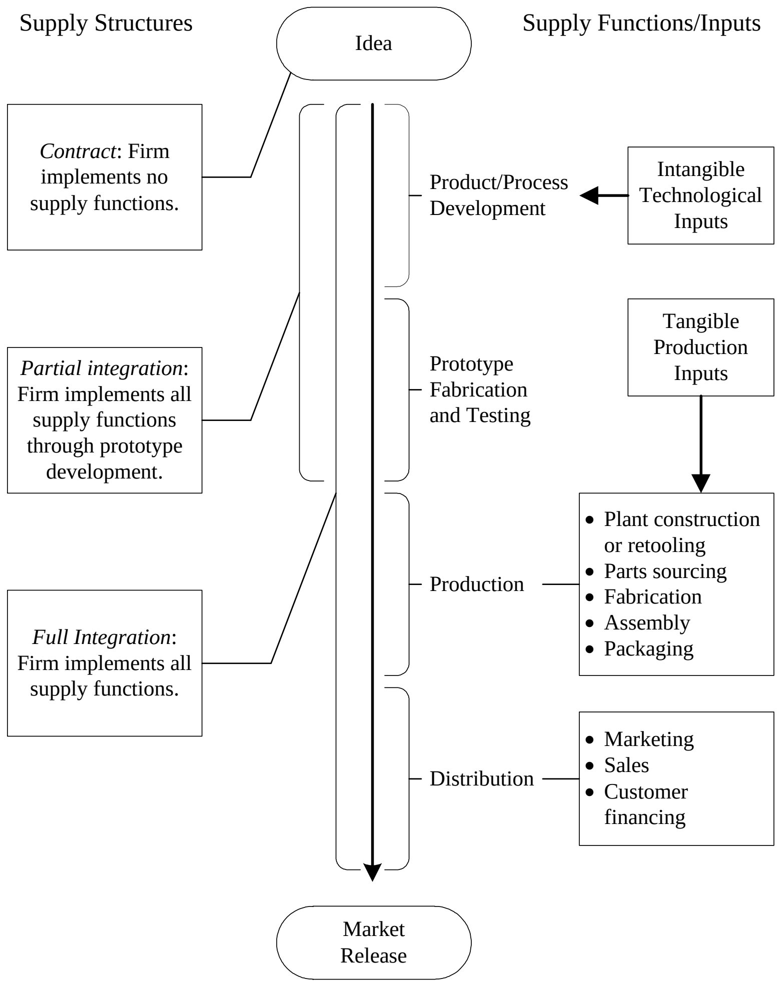
24. For an extensive listing of the commercialization timelines of leading inventions, see Kitch, *supra* note 12, at 272.

25. For the classic sources, see Ronald H. Coase, *The Nature of the Firm*, 4 ECONOMICA (n.s.) 386, 395 (1937), *reprinted in* THE NATURE OF THE FIRM: ORIGINS, EVOLUTION, AND DEVELOPMENT 18 (Oliver E. Williamson & Sidney G. Winter eds., 1993), and Oliver E. Williamson, *The Logic of Economic Organization*, *in* THE NATURE OF THE FIRM: ORIGINS, EVOLUTION, AND DEVELOPMENT, *supra*, at 90.

26. Even if the innovator enters into a contract to outsource a commercialization function, the innovator 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.

block efficient outsourcing transactions. Contracting obstacles in turn inflate commercialization costs and by anticipation discourage 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 1. Generic Supply Chain



B. CONTRACTUAL SOLUTIONS

It is important to understand why contractual solutions cannot reliably overcome the disclosure paradox. Suppose the typical scenario in which an inventor has formulated an idea and wishes to sell it to a large integrated firm. As Arrow observed, the idea seller will decline to bargain with the idea buyer given the buyer's rational unwillingness to purchase an idea without disclosure. Nondisclosure agreements ("NDAs") cannot resolve this dilemma adequately. As practicing lawyers are widely aware, that is because NDAs typically protect against subsequent disclosure by the idea buyer to third parties, but not use by the idea buyer.[27] No idea buyer will 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 trade secret or misappropriation claims against the recipient party;[28] why venture capitalists and many large firms typically refuse to sign any form of NDA;[29] and why, given exposure to state-law misappropriation claims, Hollywood studios generally refuse to receive unsolicited idea submissions.[30] Rational unwillingness by buyers and sellers to enter into idea transactions reflects 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.

Writing a contract contingent on postdisclosure appraisal of the idea (for example, "Buyer agrees to pay Seller $X for Buyer's idea if it is good and not already within the Buyer's possession prior to disclosure of the idea") is not feasible because any adjudicative agent (or third-party expert) will have poor information to determine its value or novelty. Idea submission claims tend to founder on just this type of indeterminacy: the plaintiff fails to persuade a court that its allegedly misappropriated idea was not already known to the defendant, in which case the defendant prevails by arguing that it independently developed the disputed product.[31] Writing an "earnout" contract contingent on an objective metric (for example,

27. This statement is based on my experience in drafting and negotiating NDAs in legal practice.

28. This statement is based on my experience in drafting and negotiating NDAs in legal practice.

29. *See* THERESE H. MAYNARD & DANA M. WARREN, BUSINESS PLANNING: FINANCING THE START-UP BUSINESS AND VENTURE CAPITAL FINANCING 400 (2010).

30. This statement is based on personal knowledge, confirmed in discussion with an entertainment industry executive.

31. *See, e.g.*, Nadel v. Play-By-Play Toys & Novelties, Inc., 208 F.3d 368, 378–81 (2d Cir. 2000) (finding a genuine issue of material fact as to whether a toy idea was "original" in absolute terms, for purposes of summary judgment in a misappropriation claim by an inventor against a toy manufacturer, on the ground that the plaintiff failed to establish the idea's novelty); Sellers v. Am. Broad. Co., 668 F.2d 1207, 1210 (11th Cir. 1982) (rejecting a claim that the defendants misappropriated the plaintiff's idea for a television show on the death of Elvis Presley on the ground that the plaintiff's idea was not novel, unique, or original).

revenues from use of the idea) that reveals the value of the innovation over time is problematic if the application of any such metric is either inherently nonverifiable or subject to moral hazard to the extent that revealed valuation depends on investments by the idea buyer.[32] This is not to deny that it may be possible to devise contracts that might mitigate expropriation risk. A small economics literature is occupied precisely with that task.[33] But the (mostly theoretical) fixes devised by that literature usually require some entrepreneurial wealth that must be put at stake in order to signal idea quality to outside financiers, who otherwise face a severe information asymmetry.[34] Trade secret protections (outside the industries in which these are customarily waived by the idea submitter), which effectively supply implied contractual terms for confidential communications, are even shakier. Any trade secret litigant faces an uphill battle in defending its rights in court: it must show that it undertook reasonably effective measures to maintain secrecy (or, in the words of one court, "exercise[d] eternal vigilance" in protecting its trade secret)[35] and that the defendant acquired the trade secret by "improper means," including a "breach of confidence."[36] Not surprisingly, commentators counsel against any substantial reliance on trade secrecy protections in precontractual negotiation.[37]

In short, both buy-side and sell-side opportunism, coupled with the

32. For the classic case that addresses this defect in earnout mechanisms, see *Bloor v. Falstaff Brewing Corp.*, 601 F.2d 609 (2d Cir. 1979) (affirming a breach of a contractual best efforts clause where the contract required the buyer to promote and sell beer and, due to a variety of managerial and industry factors, little was sold).

33. In the most well known contribution, James Anton and Dennis Yao have proposed that the idea seller can protect against expropriation by the idea buyer, firm A, by threatening to provide its idea to rival firm B, which 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 AM. ECON. REV. 190, 191–92 (1994). This argument relies on two assumptions. First, it must be the case that the idea seller can credibly commit to either firm A or B that it will not subsequently resell the information to other parties. Second, it must be the case that firms A and B can preserve duopoly 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.

34. *See, e.g.*, James J. Anton & Dennis A. Yao, *The Sale of Ideas: Strategic Disclosure, Property Rights, and Contracting*, 69 REV. ECON. STUD. 513, 513–14 (2002) (presenting a model in which an idea seller can extract value from the sale of an idea through a partial disclosure mechanism but noting that the result is dependent on seller wealth, which can be used as a bond to signal the value of the to-be-disclosed portion of the idea).

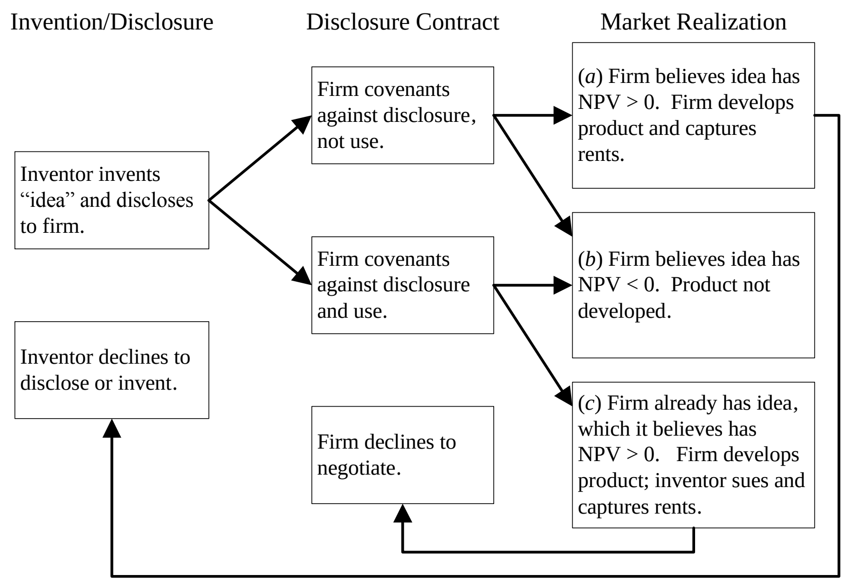
35. DB Riley, Inc. v. AB Eng'g Corp., 977 F. Supp. 84, 90 (D. Mass. 1997) (quoting J.T. Healy & Son, Inc. v. James A. Murphy & Son, Inc., 260 N.E.2d 723, 731 (Mass. 1970)).

36. 1 MELVIN F. JAGER, TRADE SECRETS LAW § 4.2, at 10.1 (2010).

37. For a more complete discussion of cases that illustrate the uncertainty of trade secrecy protections in precontractual negotiation, see generally Merges, *Transactional View*, *supra* note 10.

absence of any reliable contractual or trade secret protections, frustrates or complicates any idea transaction. By anticipation, expropriation risk may deter the initial investment required to generate the idea. As shown in the figure below, whether this two-sided expropriation threat yields a net social loss depends on the net present value ("NPV") 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 NPV are not realized.[38] Case (*b*), which anticipates no social loss as a result of inability to contract, is included for completeness.

FIGURE 2. The Disclosure Paradox



C. EXTRACONTRACTUAL 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 difficulty of contracting with any buyer. Second, on the demand side, it discourages investment by prospective

38. Note that case (*c*) would not result in a social cost if the buyer anticipates seller opportunism, declines to negotiate, and nonetheless develops the product based on its own preexisting idea.

buyers in identifying new ideas, given the difficulty 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.[39] But this unqualified picture is overstated: scholars have documented informal exchanges of professional know-how in settings in which intellectual property is largely absent.[40] These studies confirm casual empiricism: practicing lawyers engage in "shop talk" over transactional solutions and, with specific waivers of any contractual or statutory protections (as noted above), unpatented business proposals are pitched to venture capitalists in Silicon Valley, and unprotected movie ideas are presented to production executives. It would be an exaggeration to contend that these informal markets operate with the liquidity and sophistication of a formal trading market in tangible goods. As I have shown elsewhere, unprotected idea exchange tends to emerge most robustly in specialized settings that demand low levels of capital investment, are populated by close-knit professional communities, provide some capacity to constrain access to the most valuable ideas or complementary assets, or a combination of the above.[41] 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 positive but limited levels of idea exchange even without property rights.

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 being provided by the idea seller.[42] If that is the

39. This point has long been recognized. *See* JEWKES, SAWERS & STILLERMAN, *supra* note 21, at 191 (noting that "[t]he market for new inventive ideas is imperfect" and subject to various deficiencies).

40. *See, e.g.*, Gerda Gemser & Nachoem M. Wijnberg, *Effects of Reputational Sanctions on the Competitive Imitation of Design Innovations*, 22 ORG. STUD. 563, 576–77 (2001) (documenting the exchange of technical and style information among designers in the luxury European custom furniture industry); Eric von Hippel, *Cooperation Between Rivals: Informal Know-How Trading*, 16 RES. POL'Y 291, 292–97 (1987) (documenting the reciprocal exchange of know-how among engineers in the steel minimill industry). Elsewhere I have discussed a large number of other examples. *See* Jonathan M. Barnett, *The Illusion of the Commons*, 25 BERKELEY TECH. L.J. 1751, 1793–1813 (2010).

41. *See* Barnett, *supra* note 40, at 1793–1813 (noting examples of craft guilds, academic research, and open-source software).

42. This opacity often seems to be the case. *See* D.J. Teece, *Technology Transfer by*

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 know-how (which disclosures, 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 know-how, the seller can 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 in which 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 credibly to commit against expropriation so long as idea sellers believe that a repeat-player firm will seek to maintain a reputation for fair dealing in order to attract future idea submissions. Hence, a venture capitalist forfeits single-period gains from expropriation in order to maximize multiperiod 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 number of factors limit (but do not extinguish) the disciplining effect of reputational capital: (1) reputation effects are ineffective against one-shot or first-time entrants into an idea market; (2) "noise" in the reputation market can mute reputational penalties (in particular, sellers' expropriation claims may be perceived as noncredible "sour grapes"); (3) agency costs may drive a buyer's agent to expropriate an idea submission even if doing so depletes the principal's reputational capital; and (4) buyers may have access to a variety of discrete mechanisms

Multinational Firms: The Resource Cost of Transferring Technological Know-How, 87 ECON. J. 242, 247–48 (1977) (studying twenty-six international technology transfer projects and finding that transfer costs vary widely, ranging from 2% to 59% of total project costs, and averaging 19%).

by which to siphon value from sellers short of outright expropriation.[43] Most importantly, reputational penalties—which often fall short of the irreversible exit posited by game-theoretic models of indefinite repeat-play behavior[44]—may be insufficient to restrain counterparties who expropriate an especially valuable idea in order to accrue extraordinary one-time gains. In short, reputation effects can mitigate, but cannot eliminate, expropriation risk in idea transactions. 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: (1) reverse-engineering costs and other imitation barriers limit expropriation risk in the goods market and (2) reputation effects and informational opacity limit expropriation risk in the commercialization process.[45] Let us suppose a market in which 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 in which disclosed ideas are transparent and recipients are immune to reputation effects. As a result, expropriation risk blocks arm's-length negotiation, and innovators cannot achieve

43. Elsewhere I have discussed at length 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. 95, 100–06 (2007). For an optimistic view of the ability of reputation effects to facilitate bargaining over ideas, see Burk & McDonnell, *supra* note 10, at 602 ("Bargaining in the marketplace is a multi-round game rather than a single shot, and there are likely to be substantial reputational penalties for 'defecting' from the game by misappropriating intellectual property. This is particularly true in concentrated industries, where opportunities for partnerships are limited, and today's competitor may be tomorrow's essential resource.").

44. I am referring to a standard model of indefinite or infinite repeat play in which a single defection results in irrevocable ejection from the game and the loss of all future cooperative gains. For example, in the most well-known formulation, the "Tit for Tat" game, a successful player elects *cooperate* in the initial round of an iterated sequence and each round thereafter, but then reverts irrevocably to *defect* if the other player ever elects *defect*. For further discussion of this and other iterations, see Jean Tirole, The Theory of Industrial Organization 245–47, 258–59 (3d ed. 1989).

45. The second assumption is consistent with empirical evidence showing that the extent to which patent grants facilitate consummation of licensing transactions is strongest in environments in which reputation effects are weakest (or the technology lifecycle is long) and vice versa. *See* Joshua S. Gans, David H. Hsu & Scott Stern, *The Impact of Uncertain Intellectual Property Rights on the Market for Ideas: Evidence from Patent Grant Delays*, 54 Mgmt. Sci. 982, 994–96 (2008).

commercialization and, by anticipation, decline to innovate. But even in this hostile setting, property rights are a possible but not unique remedy to bargaining 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 without patents. That limitation does not preclude the innovator from independently implementing the commercialization process, however, and thereby avoiding disclosure to third parties.[46]

46. 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." Arrow, *supra* note 11, at 617. Later commentators have made similar observations. *See* Bar-Gill & Parchomovsky, *supra* note 10, at 1664 (noting that a "research unit" can protect against expropriation by a "customer" through vertical integration); Richard Zeckhauser, *The Challenge of Contracting for Technological Information*, 93 PROC. NAT'L ACAD. SCI. USA 12743, 12744 n.e (1996) (noting integration as an 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 expropriation by employees who can depart for rivals or set up competing operations. *See* Burk & McDonnell, *supra* note 10, at 591–92. That is certainly an important contingency, although a firm can use a variety of means, including confidentiality agreements, reputation effects in the labor market, internal organizational practices, deferred compensation and equity-based incentive schemes, acculturation methods, and threats of dismissal by which to constrain employees from expropriating information. Critically, a firm can condition employment on entry by the prospective employee into an invention assignment contract whereby the firm obtains prospective ownership rights in the idea stock generated by the employee during his or her tenure at the firm. That contractual obligation is bolstered by the duty of loyalty owed by employees to employers as a matter of state common law, which prohibits employees from competing with the principal, assisting the principal's competitors, or using the principal's confidential information for the employee's own purposes. *See* RESTATEMENT (THIRD) OF AGENCY §§ 8.04–.05 (2006). I am grateful to Jennifer Arlen for bringing this point to my attention.

These instruments are not perfect but, in the aggregate, would 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 similar views, see OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS 10 (1975) (arguing that opportunism risk is reduced within firms, relative to markets, due to superior "incentive and control" mechanisms and more limited opportunities to capture rents); Arora & Merges, *supra* note 5, at 452 ("[G]reater control over disclosure of internal information is a well-recognized feature of the employment relationship, as compared with independent contractor status . . . ."); Julia Porter Liebeskind, *Knowledge, Strategy, and the Theory of the Firm*, 17 STRATEGIC MGMT. J. (SPECIAL ISSUE) 93, 102 (1996) ("[F]irms have generalized institutional capabilities that may allow them to protect knowledge from expropriation and imitation more effectively than the limited and costly legal protections tha[t] are available in markets."); and Michael H. Riordan & Oliver E. Williamson, *Asset Specificity and Economic Organization*, 3 INT'L J. INDUS. ORG. 365, 376 (1985) (noting that forward integration from manufacturing into distribution is a strategy available to firms to limit expropriation of knowledge in human assets). 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 or, alternatively, if they anticipate competing with their employer (in which case no supracompetitive rents would be available). At a bare minimum, so long as firms can control internal expropriation risk at some lower cost relative

If we take into account this organizational remedy, then we can appreciate more precisely the implications of the disclosure paradox for the scope of application of the incentive thesis. 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 have effects over innovation behavior. This 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.

1. Organizational Selection

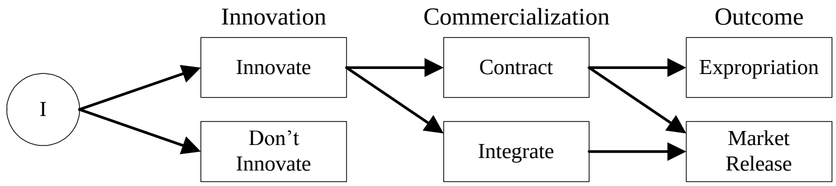
Conventional legal and economic analysis focuses on the connection between patent protection and an innovator's decision whether to invest in R&D. Realism, however, demands that the innovator's decision process take into account the full sequence of R&D and commercialization activities that will be required to reach market and realize any positive payoff. To capture both stages, we can construe the innovator's decision process as follows. The innovator selects the organizational form by which to deliver an innovation to market, which form implies a certain commercialization cost. That commercialization cost is added to the initial R&D cost, which is then set off against expected revenues: the resulting positive or negative net amount determines whether the innovator rationally elects to innovate. The figure below depicts this sequence, where the innovator (denoted by "I") can elect between two organizational options, *Contract* or *Integrate*, which election, by anticipation, determines its choice between two investment options, *Innovate* or *Don't Innovate*. 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* implies 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.[47] The

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.

47. In greater detail, if an innovator elects *Contract*, two outcomes are possible: (1) 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 (2) 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

innovator, therefore, faces a choice set consisting of three options: *Innovate*/*Contract*, *Innovate*/*Integrate*, or *Don't Innovate*.

FIGURE 3. The Innovator's Decision Sequence



Let us assume that the innovator seeks to maximize expected profits, which are expected revenues on market release (discounted by the probability of third-party expropriation), less commercialization costs and R&D costs.[48] Absent expropriation risk, the innovator will always elect the lowest-cost organizational form by which to deliver the innovation to market. Assuming a competitive market of external providers of supply chain functions and inputs, an innovator's outsourcing costs (equivalent to the commercialization 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 cannot demand more than the cost of its commercialization services plus a competitive return.[49] In making its

earned at market release, leaving it with a net loss equal to its R&D costs. The latter outcome assumes that the innovator cannot independently commercialize the idea (or, more plausibly but equivalently, cannot independently commercialize the idea at the same or lower cost as the counterparty).

48. 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: (1) *Contract* under patent protection (which I assume for simplicity can be enforced at zero cost) and (2) *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).

49. Assuming a market in which suppliers exert some bargaining power would introduce two complications. First, it would mean that innovators could not rely on submitted bids as a perfect reflection of supplier cost, which inability in turn could prevent innovators from selecting the cost-minimizing level of integration. This simplifying assumption does not necessarily impugn the realism of this framework since anecdotal evidence indicates that firms are often well equipped to evaluate supplier costs even in the absence of perfectly competitive supplier markets. *See* William S. Lovejoy, *Conversations with Supply Chain Managers* 5 (Ross Sch. of Bus., Working Paper No. 1145, 2010), *available at* http://ssrn.com/abstract=1621864 (noting that "[m]ost of the interviewees expressed confidence that . . . they could accurately estimate what the [supplier] costs should be" and describing several methods used). Second, it would mean that uncoordinated pricing by dominant holders of R&D, production, or other inputs into a single consumption bundle might result in double marginalization inefficiencies that compel innovators or other market participations to select *Integrate* even where

organizational election, an innovator simply assesses the positive difference between its "own-commercialization" costs and the commercialization costs 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 after subtracting R&D and commercialization costs from expected revenues. Where that assumption is not satisfied, there is no feasible commercialization option and the innovator by anticipation will elect the remaining option of *Don't Innovate*.

2. Organizational Distortion

The innovator's ability to select organizational forms so as to minimize commercialization costs rests on a critical predicate: there is no expropriation risk in transferring information to outside providers of supply chain functions or inputs. That predicate is not satisfied in the high-risk contracting environment in which the disclosure paradox is most severe: suppliers pose a competitive threat through the use or transfer of disclosed information, and no combination of reputation effects or informational opacity sufficiently protects against that threat. In that environment, withdrawing patent protection has a dramatic effect on an innovator's organizational choice set. The *Contract* option is precluded and the innovator's options reduce to *Innovate/Integrate* or *Don't Innovate.* 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 state of affairs does not necessarily mean that innovative output ceases or even declines in the absence of patent protection. Innovators may protect against expropriation risk by adopting

Contract would otherwise minimize total innovation plus commercialization costs. In that case, observed supply chain configurations may reflect a trade-off between minimizing product innovation and commercialization costs and minimizing double marginalization inefficiencies. I am grateful to Richard Epstein for emphasizing the latter point. For further discussion, see *infra* notes 73 and 76.

integrated structures that minimize interaction with third parties prior to market release.

These adaptive responses might be viewed as grounds for rejecting the incentive thesis. Even in high-risk contracting environments, firms still close shortfalls in patent coverage and achieve commercialization by migrating to nonpatent alternatives. But that would be a hasty conclusion. Even if innovators can close shortfalls in patent coverage through nonpatent substitutes on a cost-feasible basis, 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. If the market is the least-cost provider at even a single point on the supply chain (and transacting with that provider would subject the innovator to expropriation risk), then incomplete patent coverage prevents the innovator from reaching market at the lowest possible cost. The inflated commercialization costs that result from the inability to contract constitute a private loss that translates into at least one and potentially two additional social losses: (1) with certainty, integration is productively inefficient to the extent it depletes net social returns by overallocating resources to deliver an innovation to market; (2) depending on supply elasticity, it is "innovatively" inefficient to the extent the firm reduces its R&D expenditures in anticipation of reduced profits; and (3) depending on demand elasticity, it is allocatively inefficient to the extent that inflated commercialization costs are reflected in higher prices or reduced output for intermediate users or end users.[50] Where it is not the first-best organizational option, the integration "solution" to controlling expropriation risk becomes an integration "problem": it distorts R&D investment in the upstream market, commercialization expenditures in the intermediate market, and product output in the downstream market.

3. The Incentive Thesis Revisited

The conventional formulation of the incentive thesis is discontinuous:

50. On these three types of economic efficiency, see Joseph F. Brodley, *The Economic Goals of Antitrust: Efficiency, Consumer Welfare and Technological Progress*, 62 N.Y.U. L. REV. 1020, 1025 (1987) (analyzing the economic problem of antitrust enforcement in terms of three efficiency goals, "production efficiency, innovation efficiency, and allocative efficiency," and concluding that innovation efficiency is the leading goal in terms of social importance); F.M. Scherer, *Antitrust, Efficiency, and Progress*, 62 N.Y.U. L. REV. 998, 1011 (1987). Note the surprising implication of the allocative efficiency loss mentioned above: the absence of patent protection imposes deadweight losses by preventing efficient transactions with end users that would have taken place under a lower-cost commercialization path.

with patent protection, innovation proceeds; without it, innovation halts. Taking into account organizational substitutes for patent protection yields a more nuanced proposition: reductions in patent coverage yield a continuous range of disincentive effects 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 this proposition in a stylized setting, 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 relative 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. Relative integration costs are assumed to be a function of the innovator's existing level of supply chain integration. In other words, where an innovator already has an established integrated supply chain, its relative integration costs are zero or negative relative to the market; where it does not, those costs are moderately or highly positive relative to the market. The table and subsequent discussion set forth a simple relationship: as relative 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.

TABLE. Disincentive Effects of Reductions in Patent Protection

Type	*Existing Integration*	*Relative Integration Costs*	*Disincentive Effect*
Large Firm A	Complete	Negative or Zero	None
Large Firm B	Partial	Moderate	Weak
Small Firm	None	High	Strong

Large Firm A (*No Disincentive Effect*): *Integrate* is not costly; *Contract* is more costly. Suppose a large integrated firm 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 available patent coverage and the resulting level of expropriation risk. Patents make no difference: the firm's organizational choices and innovation incentives are constant.

Large Firm B (*Weak Disincentive Effect*): *Integrate* is moderately costly; *Contract* is less costly. Suppose another large firm 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 extended at some significant cost to produce and distribute the relevant innovation. Therefore, it will elect *Contract* as its first-best organizational option. As patent protection declines and expropriation risk rises, however, 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*. That effect inflates the firm's commercialization costs and reduces, but does not extinguish, its innovation incentives.

Small Firm (*Strong Disincentive Effect*): *Integrate* is extremely costly; *Contract* is much less costly. Suppose a start-up 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 (for example, an intermittent windshield wiper for an automobile) that it has no capacity to produce, distribute, or support independently. That fact 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. By anticipation, the innovator must decline to 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 reduce to a function of the difference between own-commercialization and market-commercialization 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 makes a difference in the firm's innovation behavior. Otherwise, it makes no difference. For highly integrated entities (and any other entities that have 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, an innovator will elect *Integrate* as its first-best commercialization option. For more weakly integrated entities (and any other entities that have 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, it must elect *Don't Innovate*.

III. INNOVATION AS ORGANIZATION

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), exerting disincentive effects of varying magnitudes on innovation activity. Following this revised formulation of the incentive thesis, patents exert three efficiency gains—each corresponding to an organizational effect—over a broad set of innovation types that includes both the "easy" case of the specialized R&D supplier (in which the incentive thesis clearly applies) and the "harder" case of more highly integrated entities (in which the incentive thesis otherwise does not clearly apply). First, the contracting environment secured by patents enables innovators—both weakly and strongly integrated entities—to adjust firm scope without reference to expropriation risk. This flexibility allows innovators to extract specialization gains by transacting with lower-cost suppliers of any required commercialization input. Conversely, it also allows those suppliers to extract specialization gains by transacting with innovators, who are simply lower-cost suppliers of R&D inputs.[51] 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 innovator (and, more generally, any supplier of any other technological or production input) must attempt entry. Third, the resulting pool of disembodied technology and other supply chain inputs induces entry by intermediaries that provide transactional technologies to reduce the costs of trading and evaluating those inputs.

These linked organizational effects on transactional, firm, and market

51. As this sentence suggests, the most general analysis would view even innovators as a supplier to the combination of inputs constituted by a commercially viable end product. Consistent with my general framework, however, I will continue to reserve the term "supplier" for entities that provide all non-R&D inputs in the supply chain.

structures translate into innovation effects through the same mechanism. Interfirm bargaining over intellectual resources—which bargaining would be precluded without property rights in high-risk contracting environments—yields efficient adjustments to supply chain configurations and facilitates the growth of secondary markets in intellectual assets. Together, these organizational effects promote R&D investment consistent with the standard rationale and create positive effects on market turnover and expansion that go beyond it.

A. ORGANIZING FIRMS

So far I have proposed a loosely inverse correlation between patent strength and firm scope. Everything else being equal, weaker patents tend to induce integration in order to protect against expropriation risk and stronger patents enable innovators to extract specialization gains by transacting with outside providers. But these organizational effects are a matter of indifference from a social point of view unless they translate into adverse effects over innovation behavior. Adverse effects will necessarily occur in every case in which weak patent coverage compels an innovator to incur commercialization costs that it would not otherwise bear under lower levels of expropriation risk. Those inflated commercialization costs impose a subtle social cost that can distort the entire supply chain running from idea to market.

1. Specialization Obstacles

To appreciate this point requires application of the basic principle of division of labor. As originally set forth in Adam Smith's famous "pin factory" example,[52] the division of labor within a single enterprise promotes efficiency gains through individual-level specialization of tasks. This claim can be reconstrued in terms of innovation incentives. Specialization induces productivity gains by encouraging workers to invest in task-specific process innovation.[53] As modern commentators

52. *See* ADAM SMITH, AN INQUIRY INTO THE NATURE AND CAUSES OF THE WEALTH OF NATIONS 4–8 (Edwin Cannan ed., 1937) (1776); *id.* at 5 ("The division of labour, however, so far as it can be introduced, occasions, in every art, a proportionable increase of the productive powers of labour.").

53. Smith was aware of the connection between specialization and invention incentives. *See id.* at 9 (noting that the concentration of effort on a single task encourages workers to "find out easier and readier methods of performing their own particular work"). Smith then explicitly extends the concept of division of labor to "philosophers or men of speculation" (that is, inventors) who, "[l]ike every other employment too, [are] subdivided into a great number of different branches . . . and this subdivision of employment in philosophy, as well as in every other business, improves dexterity, and saves time." *Id.* at 10.

subsequently observed, this same logic anticipates efficiency gains through specialization of tasks across firms within a single industry or across firms within multiple industries.[54] Firm-level division of labor yields specialization gains by facilitating disaggregation of the supply chain among the least-cost combination of internal and external suppliers.

But there is a crucial obstacle to achieving those specialization gains. To the extent that firm-level specialization necessitates precontractual negotiation (or infracontractual interaction in the course of performance, or both), it is inherently constrained in any setting in which contractual and reputational technologies cannot sufficiently control expropriation risk. An innovator will be reticent to disclose information to suppliers, who may exploit that information to integrate forward or share it with the innovator's competitors. A supplier will be reticent to disclose information to innovators, who may exploit that information to integrate backward or share it with the supplier's competitors. As management scholars commonly observe,[55] a supplier or a customer can often easily forward or backward integrate, respectively, to become an innovator's competitor or a supplier's competitor.[56]

This contracting obstacle yields a fundamental social cost of weak patent coverage: it suppresses specialization gains that could be accrued through transactions between least-cost providers of technology and

54. *See* George J. Stigler, *The Division of Labor Is Limited by the Extent of the Market*, 59 J. POL. ECON. 185, 187–93 (1951). George Stigler's thesis builds on ideas set forth in Allyn Young, *Increasing Returns and Economic Progress*, 38 ECON. J. 527, 529–36 (1928). Smith himself made similar suggestions. *See* SMITH, *supra* note 52, at 6–7 (noting the specialization advantages across trades, regions, and countries). For other discussion of the division of labor across technology industries, see ARORA, FOSFURI & GAMBARDELLA, *supra* note 10, at 6–7 (describing gains from the division of innovative labor); Ashish Arora & Alfonso Gambardella, *The Changing Technology of Technological Change: General and Abstract Knowledge and the Division of Innovative Labour*, 23 RES. POL'Y 523, 527–31 (1994) (arguing that the increasing reliance on general and abstract information in industrial research and innovation allows for greater specialization among firms).

55. *See generally*, *e.g.*, Benito Arruñada & Xosé H. Vázquez, *When Your Contract Manufacturer Becomes Your Competitor*, HARV. BUS. REV., Sept. 2006, at 135 (noting and illustrating by examples the risk of forward integration by suppliers).

56. Examples exist for both cases. As an example of forward integration by suppliers, several Taiwanese manufacturers in the electronics industry have started out as third-party component suppliers and then entered the market independently as manufacturers of branded devices. *See* DAVID B. YOFFIE & RENEE KIM, HTC CORP. IN 2009, at 1 (Harvard Bus. Sch. Case Study No. 9-709-466, 2009). Apple provides an example of backward integration by a customer. Normally a user of chip technology, Apple, in the case of the iPad device, adopted a backward integration strategy and independently developed a customized semiconductor chip. *See* Ashlee Vance & Brad Stone, *A Little Chip Designed by Apple Itself*, N.Y. TIMES, Feb. 1, 2010, *available at* http://www.nytimes.com/2010/02/02/technology/business-computing/02chip.html. For further discussion of Apple's strategy, see *infra* note 159 and accompanying text.

production inputs required to bring an innovation to market. In the "easy case" of the technology start-up, these specialization losses have a catastrophic effect: commercialization is blocked and both private and social payoffs fall to zero. That effect may explain why, in the most extensive survey to date, small firms in selected industries rank patents as among the most important appropriability devices.[57] But even in the "harder case" in which a firm can protect against expropriation risk by using integrated structures to reach market (at which point, by our standing assumption, time advantages or some other barrier delay imitative entry), this cost persists to some extent at every point on the supply chain at which integration would not otherwise be the least-cost commercialization option. Even the largest firms suffer a loss whenever expropriation risk precludes contracting opportunities with lower-cost suppliers of technology, production, or other inputs required to generate an innovation or deliver it to market. By positive implication, it follows that patent protection confers gains over a broad if not complete range of innovator types whenever it enables contractual relationships that result in specialization gains that would otherwise be forfeited under higher levels of expropriation risk. The special case of the weakly integrated firm—to which the incentive thesis clearly applies—turns out to be a general case.

2. Specialization Gains

Specialization economies arising from patent-enabled transactions most immediately translate into social gains by reducing the total costs incurred to generate and commercialize a given stream of innovative output. This benefit is an uncontroversial increase in social wealth that frees up scarce resources for alternative uses. But, more importantly, specialization economies translate into a compounding stream of social gains that promote innovative entry by promoting market expansion. This result follows from the basic principle (again, derived ultimately from Smith) that "the division of labor is limited by the extent of the market."[58] This principle can be illustrated in the simplest manner as follows. Suppose

57. *See* Stuart J.H. Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1290 fig.1, 1290 & n.110, 1290–94 (2009). Specifically, the authors report that biotechnology firms rank patents as the most important appropriability device and medical device firms and venture-backed information technology ("IT") hardware firms rank patents as the second most important device after first-mover advantage. *Id.* at 1290 fig.1, 1290–91. More generally, the authors find that patenting among start-ups and other small entities in these industries is "[w]idespread but [n]ot [u]biquitous," *id.* at 1274, although it is more common among venture-backed start-ups and in the biotechnology and medical device industries, and much less common among non–venture-backed start-ups and in the software industry, *id.* at 1274–78.

58. Stigler, *supra* note 54, at 185. For the classic exposition, see *id*.

a market has economies of scale in production—that is, average cost declines as output increases. Any innovator that integrates forward into production in order to protect against expropriation risk is likely to forfeit specialization gains that could have been obtained by contract with outside suppliers. Any specialized provider of that production function can spread its fixed costs over the unit volume of the entire pool of technology inputs, whereas the individual innovator can spread those costs over only its own unit volume.[59] These specialization economies promote a future stream of innovative output by positive feedback effects. As downstream specialization lowers production costs, prices for finished goods in the target user market fall, which in turn pushes up demand, which in turn induces further upstream entry by innovators to generate technological inputs to be embodied in consumption goods for the target market.[60] The same feedback effect can result in greater product variety as the costs of specialized inputs can be spread over a greater and increasing number of units. A specialized upstream firm may produce niche components in higher volumes because it services the entire market, whereas no individual producer would find it profitable to do so for its own purposes.[61]

Critically, this process of cost minimization, output expansion, and increased entry cannot get started—or, strictly speaking, cannot get started in high-risk contracting environments—without a property rights infrastructure by which to induce investment by innovators at the top of the supply chain and suppliers at all downstream points on the supply chain. Without patents, therefore, we cannot observe the counterfactual world that would potentially elicit entry by firms at any number of points on the supply chain to deliver discrete R&D, production, or other supply chain

59. It can be objected that the specialization gains arising from economies of scale could be accrued within an integrated organization that sells its excess output to third parties, which would achieve similar 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 46, at 18–19.

60. For the sake of brevity, I have omitted several other types of specialization gains: (1) economies of scope, through which a specialized provider realizes cost savings by spreading the fixed costs of a technology, production, or distribution input over a set of related but different products; and (2) diseconomies of scale, through which cost declines as output declines (for example, R&D productivity may increase in smaller organizations even though R&D expenditure is lower). Elsewhere I address the latter category of specialization gains. *See infra* note 68 and accompanying text.

61. *See generally* Paul M. Romer, *Growth Based on Increasing Returns Due to Specialization*, 77 AM. ECON. REV. (PAPERS & PROC.) 56 (1987) (using a theoretical model to demonstrate that a larger market will exhibit increased product variety because firms can spread the costs of specialized inputs over a larger volume of product units).

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 even if it appears that the relevant market "adequately" supports innovation by recourse to integration. Partial disincentive effects, therefore, may constitute a hidden (and, perhaps, the most widely distributed) cost of weak or zero patents: concentrated markets consisting of large firms that perform substantial R&D but operate at excessive levels of integration in order to eliminate expropriation risk. While integration may enable those firms to accrue returns sufficient to cover even substantial R&D costs, they may still be forfeiting specialization gains that could be accrued under contract-based organizational forms that would be feasible under lower levels of expropriation risk.[62] And the most weakly integrated firms that would have existed under stronger forms of patent protection cannot be observed at all.

This is a generalized form of survivorship bias that can substantially distort policy conclusions. 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 in which integrated firms appear to support substantial innovation (that is, there is no complete disincentive effect), we still cannot exclude the possibility that efficient investments in innovation—and entire classes of innovator entities—are being lost along with the precluded portion of the organizational choice set (that is, there is still a partial disincentive effect). In short, underprotection sometimes yields overintegration, which yields underinnovation.

B. ORGANIZING MARKETS

Patents yield organizational effects over firm scope by lowering the

62. This is not to say that all large firms are worse off under "excessive" levels of integration. But the reason why large firms may (sometimes) prefer excessive integration is immaterial from the public's point of view. An incumbent may prefer weak patent protection that increases entry barriers for specialist providers that threaten the incumbent's primary market, even if weak protection increases the incumbent's costs. This behavior is equivalent to adoption of a bundling strategy—in which innovation functions are bundled with all other functions in the supply chain—by a generalist firm for the purpose of deterring entry by specialist innovators who cannot bear the costs of that strategy. *See* Jay Pil Choi & Christodoulos Stefanadis, *Bundling, Entry Deterrence, and Specialist Innovators*, 79 J. BUS. 2575, 2582–87 (2006). That strategy in turn applies a more general predation rationale: an incumbent will rationally adopt strategies that inflate its costs if doing so makes entry more difficult by raising rivals' costs, thereby reducing short-term profits (in this case, by forfeiting specialization gains through relationships with outside suppliers) but maximizing long-term profits by extending the incumbent's tenure.

costs of contracting over intellectual resources, which yields innovation effects by allocating supply chain functions among the cost-minimizing combination of internal and external providers. These firm-level organizational and innovation effects provide the basis for drawing a link at a higher level of generality between patent strength and market structure, which in turn anticipates innovation effects from the market-level organizational effects of patent protection. This proposition can be stated as follows: absent reputational or contractual technologies by which to discipline precontractual and infracontractual expropriation, patent protection decreases the cost of entering markets for firms that have relatively higher commercialization costs but relatively lower innovation costs; the absence of patent protection increases the cost of entering markets for that same class of firms.

1. Entry Effects

This claim follows directly from the firm-level organizational effects of patent coverage. By expanding the organizational choice set, patents enable an innovator to use contractual instruments in order to enter the market at just those points on the supply chain at which it enjoys a comparative cost advantage. Without patents, the contracting option is foreclosed and, in the most extreme case in which expropriation risk is endemic, the innovator must enter the market at every point on the supply chain, even where the innovator bears an exorbitant cost disadvantage. Contrary to natural intuitions, a market with stronger patents will sometimes induce greater entry (and therefore pose a greater threat to incumbents) than a market with weaker or no patents by reducing the minimum size of the market into which entry can be feasibly attempted. Conversely, a market with weak or no patents will sometimes discourage entry (and therefore shelter incumbents) by inflating the minimum size of the market—potentially dramatically—into which entry can be feasibly attempted. So long as we reasonably assume anything other than perfect capital markets for funding R&D investments,[63] absolute increases in entry

63. This qualification addresses the obvious objection that raising the minimum cost of entry makes no difference in deterring efficient entry so long as outside capital markets will fund any positive NPV project. For arguments to this effect, see Robert H. Bork, *Vertical Integration and Competitive Processes*, *in* PUBLIC POLICY TOWARD MERGERS 139 (J. Fred Weston & Sam Peltzman eds., 1969). There are (at least) three uncontroversial reasons to believe external capital markets for R&D are substantially imperfect, in which case the qualifying assumption is never satisfied. First, discussions with potential investors and lenders that necessitate disclosure of technological information restore expropriation risk to some extent. This risk 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,

costs result in social losses by deterring entry by equally or more efficient innovators (or, more generally, equally or more efficient suppliers of any other technology or production input).[64]

These relationships run counter to the common argument that intellectual property—in particular, the increase in patent strength by U.S. courts and patent issuance by the Patent and Trademark Office over the past few decades—ties up innovation within the transaction cost web of contractual negotiation and dispute resolution, thereby discouraging innovation. By implication, relaxing intellectual property rights would unleash a free flow of knowledge, thereby encouraging innovation.[65] But this view assumes that firms have no means other than patents by which to restrain unauthorized imitation and, thus, removing patents necessarily improves access.

Paradoxically, taking into account those alternative means strengthens the incentive case for the patent system. If firms will respond to reductions in patent coverage by migrating to integrated organizational forms, there is no longer any certainty that weakening patents expands access or, even in

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 J. HIRSHLEIFER, INVESTMENT, INTEREST, AND CAPITAL 200–01 (1970); Oliver E. Williamson, *The Vertical Integration of Production: Market Failure Considerations*, 6 AM. ECON. REV. (PAPERS & PROC.) 112, 119–20 (1971) (discussing the vertical integration incentives that result from incomplete contracting and risks of opportunism in complex technological markets with unavoidable uncertainty). For empirical evidence on the signaling value of patents to start-ups in seeking external funding, see Graham et al., *supra* note 57, at 1304–07.

64. The concept of entry barrier is much debated and sometimes borders on the metaphysical. The formulation used in the text above adopts the narrowest "Chicago school" definition of entry barrier as any differentially higher cost of new firms, as compared to incumbents in the relevant market. GEORGE J. STIGLER, THE ORGANIZATION OF INDUSTRY 67 (1968) ("A barrier to entry may be defined as a cost of producing . . . which must be borne by a firm which seeks to enter an industry but is not borne by firms already in the industry."). Consistent with that definition, it is not absolute commercialization costs per se that constitute a barrier to entry; rather, it is the differential cost of capital borne by nonintegrated relative to integrated firms that explains why absolute cost increases can have socially relevant entry-deterrent effects.

65. 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, 673–88 (1998), which states that excessively fragmented property rights can generate net social losses by impeding, rather than facilitating, innovation (or, in a broader real property context, other) investments; and Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998), *available at* http://www.sciencemag.org/content/280/5364/698.full.pdf, which advances the same thesis with respect to gene patents, and concludes that "[p]olicy-makers should seek to ensure coherent boundaries of upstream patents and to minimize restrictive licensing practices that interfere with downstream product development."

the short term, improves incentives.[66] Even the contrary outcome can result: weak patents can make it harder to enter a market. The rationale is straightforward but largely overlooked.[67] Weak patents restore expropriation risk and therefore induce firms to adopt consolidated structures that can control that risk. Those structures in turn raise entry costs, cultivating concentrated markets consisting of highly integrated entities that can independently fund and implement the commercialization process. Conversely, strong patents mitigate expropriation risk and therefore enable firms to negotiate contractual relationships in order to capture specialization gains. Transactional flexibility lowers entry costs, cultivating substantially disintegrated markets consisting of weakly integrated providers of technology and production inputs.

2. Disintegration Effects

This line of argument is not intended to imply that strong patents necessarily trigger vertical disintegration; rather, strong patents are one of a set of legal and nonlegal conditions that must be satisfied in order to enable firms to accrue specialization gains through disintegrated structures. Where these nonlegal conditions are satisfied, patents act as the catalyst that can set off a typically observed sequence of progressive disintegration: patents (1) facilitate entry by specialized suppliers of research functions located in upstream portions of the supply chain, which entry in turn (2) facilitates entry by specialized suppliers of production functions located in downstream portions of the supply chain. Some of the leading nonlegal conditions for facilitating vertical disintegration are as follows:

- *Downstream Economies of Scale*. Downstream production and distribution functions 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 by economies of scale and low levels of firm differentiation.
- *Upstream Diseconomies of Scale*. Upstream R&D functions require

66. This result is a subset of a more general set of circumstances in which firms' ability to migrate to alternative appropriability instruments (including but not limited to organizational form) renders ambiguous any effect of changes in intellectual property protection on incentives and access. For further discussion, see Jonathan M. Barnett, *Is Intellectual Property Trivial?*, 157 U. PA. L. REV. 1691, 1692–97 (2009).

67. For an important exception, see Adelman, *supra* note 10, at 458, 463, 466 (observing that patents substitute for the entry barriers that allow for recoupment of R&D costs in concentrated markets and, conversely, the absence of patents requires market concentration to restrain imitative entry).

lower resource allocations, rely on highly differentiated human and intellectual resources, and are characterized by diseconomies of scale. The last assumption reflects evidence that smaller firms often exhibit superior R&D performance as reflected by a number of factors.[68]

- *Technological Interface*. No technological constraint bars segregation of R&D and production functions as a practical matter. This assumption will be most clearly satisfied in markets that have developed interfaces that enable firms to work independently on modular components or to work on design of a component without being involved in its production.[69]
- *Rich or Immature Market*. No incumbent has a patent portfolio that covers all technological entry points into a given market and would rationally refuse to license it to entrants.[70] This assumption will be most clearly (but not exclusively) satisfied in technologically immature markets that have not yet settled on a dominant design or technologically rich markets that offer abundant R&D opportunities.[71]

Together with a background set of secure intellectual property rights, these

68. Small firms outperform larger firms in R&D performance on several measures. First, small firms obtain, on average, more highly cited patents and more patents per employee. *See* CHI RESEARCH, INC., SMALL SERIAL INNOVATORS: THE SMALL FIRM CONTRIBUTION TO TECHNICAL CHANGE 3 (2003), *available at* http://archive.sba.gov/advo/research/rs225tot.pdf. Second, small firms produce more innovations per employee. Zoltan J. Acs & David B. Audretsch, *Innovation in Large and Small Firms: An Empirical Analysis*, 78 AM. ECON. REV. 678, 680–82 (1988). Third, small firms otherwise exhibit higher measures of innovative output relative to R&D dollars. *See* F.M. SCHERER & DAVID ROSS, INDUSTRIAL MARKET STRUCTURE AND ECONOMIC PERFORMANCE 654–56 (1990).

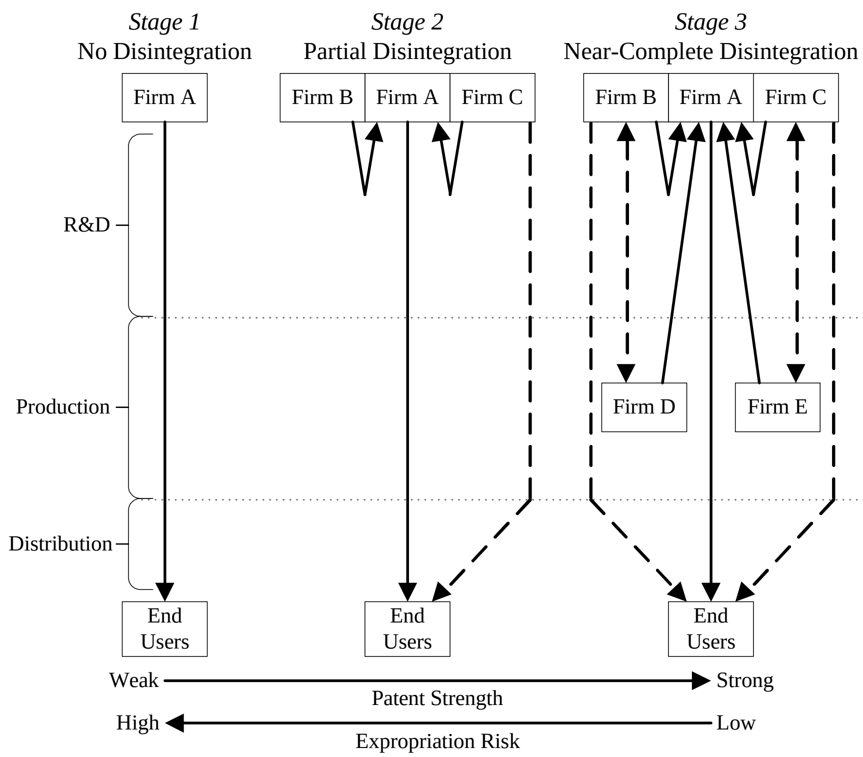
69. For extensive discussion, see 1 CARLISS Y. BALDWIN & KIM B. CLARK, DESIGN RULES: THE POWER OF MODULARITY (2000) (describing the growing role of modular design in the evolution of integrated systems industry structure).

70. The "rationality" qualifier substantially narrows the set of circumstances under which a patent forecloses entry into a technology market. Even in mature markets in which a patent position controls a dominant design or basic process or product technology, the patent holder may have a rational incentive to license the patent widely. First, the holder may recoup some licensing revenue. Second, it may protect its position in a market for platform goods that derive value from third-party suppliers of complementary goods and services. As I have shown elsewhere with respect to markets for operating systems and other platform technologies, even the most dominant firms often give away access at a zero or even negative fee. *See* Jonathan M. Barnett, *The Host's Dilemma: Strategic Forfeiture in Platform Markets for Informational Goods*, 124 HARV. L. REV. (forthcoming 2011) (manuscript at 16–17) (on file with author).

71. David Adelman emphasizes this point with respect to the biotechnology market, which he notes is rich in opportunities and therefore not easily susceptible to preclusion by patented positions. *See* David E. Adelman, *A Fallacy of the Commons in Biotech Patent Policy*, 20 BERKELEY TECH. L.J. 985, 1018–23 (2005).

characteristics will tend to ensure that (1) there exist specialization gains that firms can extract through supply chain disaggregation and (2) there does not exist any technological or contracting constraint that bars extraction of those specialization gains. The figure below (which assumes a simplified supply chain consisting of R&D, production, and distribution functions) depicts the resulting disintegration sequence in graphic form; I will refer to it in the discussion that follows.

FIGURE 4. Disintegration Stages



a. Partial Disintegration

As shown in *Stage 1*, in which patents are weak or absent, incumbent *Firm A* must (at least in the extreme case) 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 (*Firm B* and *Firm C*) (or, equivalently, allow *Firms B* and *C* to interact with providers of downstream supply chain functions). As shown in *Stage 2*, precontractual negotiation secured by patent rights enables *Firm A* to adopt a disaggregated structure that allocates the upstream portion of the supply chain to lower-cost providers. The 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 4, shows partial disaggregation of the supply chain into an upstream cluster of stand-alone R&D enterprises, *Firms B* and *C*, that provide technological inputs to *Firm A*, which continues to perform independently all other downstream product-delivery functions. By assumption, *Firm A* also retains some R&D functions so that it can "backward integrate," or credibly threaten to do so, in some cases.[72] Relative to *Stage 1*, a competitive supply of upstream design functions lowers total innovation and commercialization costs, thereby increasing expected profits and encouraging innovation consistent with the conventional rationale.

b. Nearly Complete Disintegration

Disaggregation of the R&D-intensive upstream portion of the supply chain precipitates disaggregation of the capital-intensive downstream portion of the supply chain. Accordingly, stand-alone upstream firms, *Firms B* and *C*, may be viewed not only as suppliers of R&D services to downstream firms, but also as purchasers of production and distribution services required to bring an innovation to market. 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 and take the lion's share of user revenues. 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 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

72. As indicated by the dashed line in figure 4 running from *Firm C* to end users in *Stage 2*, 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).

capacities of the existing incumbent. Conversely, upstream suppliers of technological inputs enable downstream suppliers of production functions to enter the market without acquiring the specialized expertise required to backward integrate into R&D functions.[73] As shown by the dashed lines, *Firms B* and *C* generate technological inputs that can then be embodied in 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.[74] If we assume a substantially homogenous goods market, vertical disintegration by upstream technology suppliers in turn compels the integrated incumbent, *Firm A*, to pursue the same outsourcing relationship with *Firms D* and *E* in order to replicate its competitors' cost structure. To the extent 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 that supply chain function in order to replicate the same cost structure.

C. MAKING MARKETS

So far I have proposed a targeted reformulation of the incentive thesis. Patents enable firms to calibrate organizational structures in order to maximize specialization gains, inducing innovative entry consistent with the standard thesis as applied in mediated form. In this section, I identify social gains that derive from these organizational effects but cannot be

73. This result is precisely what occurred in the oil and gas industry, in which specialized engineering firms ("SEFs") have historically licensed patented process technologies to downstream manufacturers (principally, petrochemical refiners). The downstream firms serviced by these process-technology specialists included a large number of smaller refiners, which fact implies that upstream disaggregation of the research function facilitated entry into the downstream portions of the supply chain. New firms that could cost-effectively construct and operate manufacturing facilities but lacked design competencies saved the cost of integrating backward into the upstream portion of the supply chain by contracting with lower-cost providers of technological inputs. *See* ARORA, FOSFURI & GAMBARDELLA, *supra* note 10, at 46–47, 151–52 (discussing economies of specialization brought about by SEFs, allowing design engineers to think about chemical processes in general rather than about specific chemicals); Ashish Arora & Alfonso Gambardella, *Evolution of Industry Structure in the Chemical Industry*, *in* CHEMICALS AND LONG-TERM ECONOMIC GROWTH: INSIGHTS FROM THE CHEMICAL INDUSTRY 379, 392–97 (Ashish Arora et al. eds., 1998) (discussing the role of SEFs and illustrating their increasing market share); Nathan Rosenberg, *Chemical Engineering as a General Purpose Technology*, *in* GENERAL PURPOSE TECHNOLOGIES AND ECONOMIC GROWTH 167, 188 (Elhanan Helpman ed., 1998) (describing SEFs as an "important niche" market that contributed to rapidly diffusing the new technologies of the oil industry).

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

captured by the conventional relationship in which "more IP" equals "more innovation." In particular, the segregation of research, production, and other functions to match providers' comparative advantages along the supply chain supports the emergence of secondary markets for trading, licensing, and valuing intellectual resources. Patents not only organize markets but also make new markets. It is now possible to describe the full sequence of organizational effects that can flow from property rights that mitigate expropriation risk in the commercialization process. Where intellectual property enables innovators to select organizational forms that would not be feasible under higher levels of expropriation risk, it enables the extraction of specialization gains through transactions between holders of complementary technology and production inputs. Transactional flexibility expands entry opportunities into capital-intensive technology markets, which, as will now be discussed, promotes the formation of secondary markets that trade in disembodied supply chain functions and inputs.

1. The Disintegration Problem

The classical integrated enterprise can be construed as an intermediary that 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.[75] It may, therefore, be expected that vertical disintegration implies disintermediation. Suppliers can interact directly with buyers and avoid paying the premium assessed by the now-redundant intermediary. Hence, in *Stage 3* in figure 4, I indicated the possibility that *Firms B* and *C* may bypass *Firm A* to reach the target user market.

Fuller consideration, however, shows that roughly the contrary is the case: the monolithic superintermediary that occupies a single node of the supply chain is replaced by smaller-scale intermediaries that operate at multiple nodes of the supply chain. Disaggregated supply chains must be reintermediated 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*). This increase in complexity can be illustrated by

75. *See* DANIEL F. SPULBER, MARKET MICROSTRUCTURE: INTERMEDIARIES AND THE THEORY OF THE FIRM, at xiii–xvi (1999) (introducing the intermediation theory of the firm).

comparing the fully integrated supply chain set forth in *Stage 1* of figure 4 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 three subsets: (1) the existing interactions between *Firm A* and the end-user population; (2) the additional interactions between *Firms B* and *C* and the end-user population; and (3) the 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*). As this example illustrates, end users, intermediate users, and suppliers in disaggregated supply chain structures 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.[76] Reintermediation, therefore, is the final and necessary step in the disaggregation process that is enabled by secure patents. Without it, the transaction costs of decentralized exchange would deplete the specialization gains from disaggregated design, production, and distribution functions.

76. Under the rubric of transaction costs, we may include the costs entailed in reaching agreement among multiple suppliers of complementary inputs so as to avoid a collectively harmful "royalty stacking" outcome (equivalent to the more general problem of double marginalization), in which each input holder demands excessive licensing fees, resulting in input costs that prevent or impede commercialization by depleting total profits. Market intermediaries and other participants can reduce these costs through several mechanisms that substantially preserve the transactional flexibility of vertically disintegrated organizational structures. One mechanism is the use of patent pools and cross-licensing mechanisms that enable blanket licensing of large packages of patented technologies across large pools of patentees and licensees. This is a common phenomenon in the electronics industry. *See* Barnett, *supra* note 40, at 1789 & n.71; Peter C. Grindley & David J. Teece, *Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics*, 39 CAL. MGMT. REV. 8, 8–10 (1997). Another mechanism available to intermediaries is to assemble packages of complementary patented inputs that are sold as a single bundle, an emergent tendency in the fabless industry examined later in this Article. *See infra* Part IV.C. Last, dominant upstream patent holders may unilaterally adopt self-imposed restraints on pricing. There is anecdotal evidence of these restraints in the mobile handset industry. *See* QUALCOMM, LICENSING/IPR OVERVIEW 20 (2006), *available at* http://www.qualcomm.com/common/documents/financial/QCOMIPR0621.pdf. On royalty stacking, and the paucity of evidence for its existence, see Damien Geradin, Anne Layne-Farrar & A. Jorge Padilla, *The Complements Problem Within Standard Setting: Assessing the Evidence on Royalty Stacking*, 14 B.U. J. SCI. & TECH. L. 144, 145–50 (2008). For the most well-known theoretical argument identifying the possibility of royalty stacking, see Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 1992–95 (2007). Where these mechanisms do not sufficiently address these pricing inefficiencies, then market participants would have an incentive to revert to more integrated organizational structures.

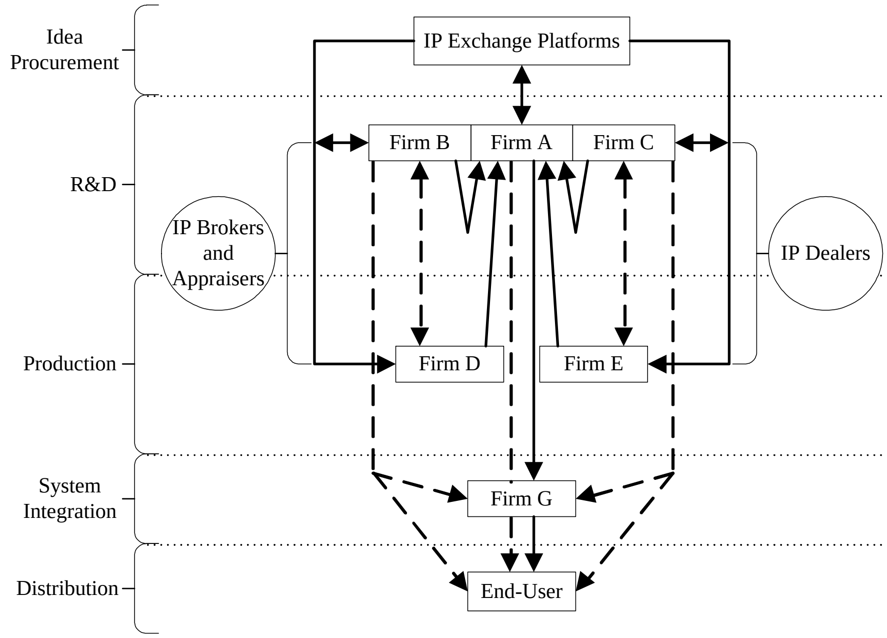
2. The Reintermediation Solution

The increased complexity inherent to supply chain disaggregation necessitates transactional structures that facilitate exchanges among buyers and sellers of supply chain functions and inputs. Just as competitive pressures drive firms to locate the least-cost external provider of any supply chain function, in turn inducing 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, in turn inducing entry by specialized suppliers of transactional solutions.

This reintermediation process is illustrated graphically in figure 5, which expands on *Stage 3* of figure 4 to reflect the new "market in ideas" that results from reintermediation of a disaggregated supply chain. In particular, several new market segments and populations have emerged. First to appear are systems integrators (*Firm G*). These firms assemble 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.[77] Second are "IP dealers," which purchase and warehouse intellectual assets for resale to other entities, thereby relieving search costs for producers and intermediate users. Third are "IP brokers," which facilitate exchanges of intellectual resources between producers and intermediate users, thereby relieving search, evaluation, and negotiation costs. And fourth are "IP exchange platforms," which offer venues or technologies for exchanging intellectual assets, thereby relieving search and evaluation costs for producers and intermediate users.

77. Note that the figure contemplates that *Firms A*, *B*, and *C* may also distribute component bundles to end users directly through in-house assembly services.

FIGURE 5. The Reintermediated Supply Chain



Some of these entity types may appear to be somewhat unusual fixtures in intangible goods markets, but should sound familiar in any developed market for tangible goods. Subject to the unique definitional costs of intellectual property rights, these entities have the potential to yield pricing and liquidity efficiencies that lower firms' innovation and commercialization costs. By a positive feedback effect, secondary trading and valuation entities expand the market into which firms can expect to sell their innovations. This expansion in turn induces further innovative entry.

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[78] or the normative claim that markets will always maximize innovation investment under

78. As a positive matter, an important countervailing factor that may push firms toward integration even under strong forms of patent protection are the double-marginalization inefficiencies that can arise as a result of uncoordinated pricing by holders of patents on nonsubstitutable components of a single technological bundle. As I note in the previous section, however, market participants often display strong capacities to anticipate and address this risk through contracting mechanisms that preserve the transactional flexibility of disintegrated organizational structures. *See supra* note 76.

disintegrated structures. 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 that transact through various intermediaries.[79] Several decades of indeterminate research on the optimal firm size and market structure for R&D activity counsel against adopting any broad generalizations.[80] But it is precisely the impossibility that any outside observer, court, regulator, or legislature could determine optimal firm and market structure that supplies the strongest efficiency case for secure patents, at least as a matter of gross social cost-benefit analysis.[81] Without secure property rights by which to guard against expropriation risk, the market has no opportunity to learn through bargaining the supply chain configuration that minimizes innovation and commercialization costs.

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79. A prominent stream of economic thought once promoted this view. *See* JEWKES, SAWERS & STILLERMAN, *supra* note 21, at 185 (noting, as of 1969, 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. 1962).

80. For reviews of the literature, see ZOLTAN J. ACS & DAVID B. AUDRETSCH, INNOVATION AND SMALL FIRMS 38–45 (1990) (reviewing literature and finding it mostly ambiguous, but claiming some support for Schumpeter's hypothesis with regard to R&D activity, which increases more than proportionally to firm size, while patenting activity increases less than proportionally); MORTON I. KAMIEN & NANCY L. SCHWARTZ, MARKET STRUCTURE AND INNOVATION 75–104 (1982) (reviewing literature and empirical studies and finding some evidence of linear correlation between an increase in firm size and either inventive or R&D activity, subject to decreasing returns after a threshold point).

81. Note that this Article's framework does not address (at least) two social costs of patent protection that would be reflected in a net welfare analysis: (1) transaction costs that impede subsequent innovation (provided that any subsequent innovation still would have taken place under weaker levels of intellectual property) and (2) deadweight losses incurred by consumers as a result of supracompetitive pricing. On transaction costs, it must be noted that decreases in patent protection generate another set of transaction costs captured by the disclosure paradox, which, as discussed at length, can also reduce negative effects on innovation incentives. For further discussion, see *infra* Part IV.D and, in particular, note 160. Deadweight losses 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, those costs must be reflected in higher prices, constraining output relative to an environment in which 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 29, 31 (Thomas M. Jorde & David J. Teece eds., 1992) (citation omitted) (noting the 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").

This process of learning through bargaining, and the resulting optimization of the supply chain to reflect comparative firm advantage, provides the fundamental link between organizational effects and innovation effects. Weak patent coverage predetermines a market structure that compels highly integrated organizational forms, which may depress innovation relative to more weakly integrated organizational forms that innovators would have selected at some lower level of expropriation risk. Where it is not the first-best organizational option, the integration solution for controlling expropriation risk becomes an "integration problem" that inflates commercialization costs. This effect can depress upstream R&D investment and distort downstream product output. In the case of moderate- to large-sized firms with established production and distribution infrastructures, weak patent coverage may still yield partial disincentive effects. Innovation proceeds at some positive level, but the firm is unable to accrue specialization gains by contracting with lower-cost providers of technological and other inputs. Thus, moderate- to large-sized firms may make some positive level of innovation investment, but at a reduced rate compared to an environment with stronger property rights. In the case of small or weakly integrated innovators that have limited ability to finance integrated structures, the disincentive effects of weak patents are catastrophic: the firms must exit and underinnovation ensues.

IV. ORGANIZATIONAL TRANSFORMATIONS

To gain greater understanding of the proposed relationships among patent strength, firm scope, and market structure, it will be necessary to test those relationships by application to specific markets and periods. This challenge offers a rich vein of inquiry for future research, with complex policy implications.

As a preliminary matter, however, these relationships are broadly consistent with organizational developments in capital-intensive technology markets characterized by intensive adoption and enforcement of patents. In particular, patents appear to play a vital role in the organizational development of capital. In other words, innovative activity from large, integrated firms funded by internal cash flow—the classic integrated enterprise of the twentieth-century U.S. industrial landscape[82]—has been reallocated on a large scale to smaller, weakly integrated firms funded by venture capital ("VC") and other external sources of capital.

82. For the classic account, see ALFRED D. CHANDLER, JR., THE VISIBLE HAND: THE MANAGERIAL REVOLUTION IN AMERICAN BUSINESS 1–11 (1977).

Since the increased adoption and enforcement of patent rights in the early 1980s and continuing through the present, leading technology markets have undergone substantial transformations in industrial organization, moving from vertically integrated to substantially disaggregated structures populated by specialized suppliers of technology and production inputs.[83]

This reallocation of innovative activity and capital has coincided with the growth of secondary markets in trading and licensing intellectual assets.[84] A variety of nonpatent factors certainly drive this organizational transformation in any particular industry or period; however, patent strength appears to act as an important input in the reconfiguration of integrated supply chains and the resulting expanded trade in intellectual assets. In this part, I review some of these developments generally and then look in particular at patents' organizational effects in the fabless semiconductor market.

83. For relevant discussion in economic and management literatures, see, for example, Naomi R. Lamoreaux, Daniel M.G. Raff & Peter Temin, *Beyond Markets and Hierarchies: Toward a New Synthesis of American Business History*, 108 AM. HIST. REV. 404 (2003) (describing, through historical surveys, progression toward vertical hierarchies until the 1980s, and then away from these hierarchies in the computer era, toward coordination by long-term relationships), and Richard N. Langlois, *The Vanishing Hand: The Changing Dynamics of Industrial Capitalism*, 12 INDUS. & CORP. CHANGE 351, 376 (2003) (describing the disintegration trend of the knowledge economy, in which firms specialize and have "soft" assets and "technical standards . . . permit external mechanisms of coordination and reduce the need for rich information transfer" (footnote omitted)). In legal literature, see generally Ronald Gilson, Charles F. Sabel & Robert E. Scott, *Contracting for Innovation: Vertical Disintegration and Interfirm Collaboration*, 109 COLUM. L. REV. 431, 432 (2009) (describing how vertical disintegration and changes in the boundaries of firms have given rise to a new form of implicit and explicit "contracting" in which the parties deter opportunism by acquiring "transaction-specific investments in knowledge about their collaborators' capacities"); Erica Gorga & Michael Halberstam, *Knowledge Inputs, Legal Institutions and Firm Structure: Towards a Knowledge-Based Theory of the Firm*, 101 NW. U. L. REV. 1123 (2007) (discussing how knowledge-management requirements and relevant legal regimes affect firm structure); Merges, *Transactional View*, *supra* note 10, at 1487–88 (framing the role of property rights in a transaction-intensive economy as providing for precontractual liability and enforcement flexibility); and Merges, Input Markets, *supra* note 10 (discussing the theoretical framework for the role of intellectual property rights in increased licensing activity and, ultimately, industry structure and firm specialization).

84. *See* Feng Gu & Baruch Lev, *Markets in Intangibles: Patent Licensing* 3–7 (N.Y. Univ. Stern Sch. of Bus., Working Paper No. 2451/27465, 2001), *available at* http://ssrn.com/abstract=1280686 (noting that growing offline and online markets trading in intangibles creates complex accounting issues relating to valuation and disclosure); Merges, Input Markets, *supra* note 10, at 3. Estimates of the value of the market for patent licensing, patent sale, and trading of patent technology vary substantially. *See, e.g.*, ARORA, FOSFURI & GAMBARDELLA, *supra* note 10, at 40 (estimating a 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, 472 (2009) (citing estimates of $500 million in 2006 in the United States but noting that precise estimates are not available); Gu & Lev, *supra*, at 4 (noting data showing that revenues from patent licensing rose from $15 billion in 1990 to more than $110 billion in 1999).

A. OLD IDEA MARKETS

The vertical disintegration of technology markets and the emergence of secondary markets in patented assets recall a historical precedent that occurred roughly a century earlier. As documented in great detail by economic historians,[85] the widespread adoption of patents in the middle to late nineteenth-century United States supported a network of "patent dealers" and other intermediaries that facilitated trading in patented inventions. This market operated to the mutual benefit of individual inventors who could not otherwise support independent commercialization, and large firms that did not have strong R&D competencies. This secondary market nurtured professional inventors who could rely on revenues from licenses and assignments to large corporations.[86]

The role of patents in supporting independent invention, and the associated trade in technological knowledge, is strongly suggested by changes in market structure that occurred once patent strength was relaxed. As courts increased the rates at which patents were invalidated[87] (and increased the use of compulsory licensing remedies),[88] the individual inventor was eclipsed by the corporate R&D department. Patenting rates per capita then initiated a long decline that persisted from the 1930s until the early 1980s.[89]

85. *See* Naomi R. 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 19 (Naomi R. Lamoreaux et al. eds., 1999) [hereinafter Lamoreaux & Sokoloff, *Inventors*] (describing how U.S. intellectual property rights allowed inventors to assign their inventions to intermediaries in various arrangements and facilitated the diffusion of technical knowledge and the development of markets for technology); Naomi R. 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, *supra* note 20, at 213, 223–28 [hereinafter Lamoreaux & Sokoloff, *The Market for Technology*] (describing the emergence of patent intermediaries in the late nineteenth century).

86. *See* Lamoreaux & Sokoloff, *Inventors*, *supra* note 85, at 29–30.

87. Invalidation rates of patents involved in infringement suits in federal appeals courts were 33% in 1925–1929, as compared to 51% in 1935–1939 and 65% in 1945–1949. SCHMOOKLER, *supra* note 21, at 31. Invalidation rates in excess of 60% continued through 1956. *See* SCHERER ET AL., *supra* note 21, at 83–85.

88. *See* SCHERER ET AL., *supra* note 21, at 75 (citing SUBCOMM. ON PATENTS, TRADEMARKS, & COPYRIGHTS, S. COMM. ON THE JUDICIARY, 85TH CONG., REP. ON PATENTS, TRADEMARKS AND COPYRIGHTS 14 (Comm. Print 1957)) (noting that, from 1941–1957, more than one hundred court decrees were issued ordering compulsory licensing to all applicants).

89. *See id.* at 130–35 (showing the decline in U.S. patent applications from 1930 through 1955 in absolute values, showing a sharper decline per capita since 1914, and suggesting that the decline may be due to increased judicial invalidation rates); *id.* at 137–46 (finding a disproportionate decline in patenting during the period from 1939–1956 among large corporations subjected to compulsory licensing remedies, especially if those remedies required licensing of future patents); SCHMOOKLER,

These trends may be the ironic result of New Deal patent policy (in 1938, President Franklin D. Roosevelt proposed subjecting all patents to compulsory licensing).[90] Weakening patent protection may have fostered concentrated markets dominated by a handful of large firms sheltered from innovative entry.

It is telling that the prevailing organizational form for much of the post–World War II period was the integrated, and often overextended, conglomerate.[91] Without secure patents, managers may have been compelled to expand firm scope in order to control expropriation risk during the commercialization process. This expansion in firm size raised capital requirements for entry, which requirements may have fostered increased concentration and discouraged entry by unintegrated innovators. As late as the 1970s, some of the nation's "leading industrial sponsors of fundamental research, for example, AT&T, DuPont, IBM, Kodak, and Xerox, earned substantial portions of their revenues in markets in which they had shares of 80 percent and more."[92]

B. NEW IDEA MARKETS

The establishment of the Court of Appeals for the Federal Circuit in 1982 is widely associated with increased security of patent coverage and increased adoption and enforcement of patents.[93] These changes have coincided with a reversal in the organizational tendencies that prevailed

supra note 21, at 30–31 (observing that, starting in the 1930s, corporations reduced patenting rates, which fact may be attributed to the increased rates at which courts invalidated patents, the increased exposure to antitrust liability for alleged patent misuse, and a general political animus toward patents at the time); Lamoreaux & Sokoloff, *The Market for Technology*, *supra* note 85, at 236 (noting how the rise of the corporate R&D department may have contributed to the decline in patenting rates and the decline of the individual inventor).

90. *See* SCHERER ET AL., *supra* note 21, at 72 (quoting President Roosevelt as saying that "future patents might be made available for use by anyone upon payment of appropriate royalties" (quoting GEORGE E. FOLK, PATENTS AND INDUSTRIAL PROGRESS 260 (1942))). President Roosevelt's proposal was never enacted but was adopted in the final report of the Temporary National Economic Committee. *See* TEMPORARY NAT'L ECON. COMM., FINAL REPORT AND RECOMMENDATIONS, S. DOC. NO. 77-35, at 36–37 (1941).

91. *See supra* note 83.

92. *See* Richard S. Rosenbloom & William J. Spencer, *Introduction: Technology's Vanishing Wellspring*, *in* ENGINES OF INNOVATION: U.S. INDUSTRIAL RESEARCH AT THE END OF AN ERA 1, 4 (Richard S. Rosenbloom & William J. Spencer eds., 1996).

93. During the period 1983–2002, the number of patents issued tripled, representing an annual rate of increase of about 5.7 percent per year, which compares to an annual rate of increase of 1 percent per year from 1930 until 1982 (the year in which the Federal Circuit was established). *See* ADAM B. JAFFE & JOSH LERNER, INNOVATION AND ITS DISCONTENTS: HOW OUR BROKEN PATENT SYSTEM IS ENDANGERING INNOVATION AND PROGRESS, AND WHAT TO DO ABOUT IT 11–12 (2004).

during the long period of weak patents from the 1930s through the early 1980s. In 1981, immediately prior to the establishment of the Federal Circuit, small firms performed less than 5 percent of industrial R&D in the United States; in 2003, small firms performed 25 percent of industrial R&D.[94] That same period witnessed the rise of VC financing: between 1980 and 2007, VCs invested $550 billion in U.S.-based start-ups,[95] thereby fulfilling the financing function that is satisfied by internal capital in integrated firms. The combination of patent-shielded commercialization and VC or other external financing has proliferated throughout technology markets. The most widely discussed example is the biopharmaceutical industry. Since the extension of patent rights to genetically engineered life forms by the Supreme Court in 1980,[96] the industry has adopted a substantially disintegrated structure that largely allocates research-incentive functions to specialized R&D suppliers and the remaining set of downstream functions to integrated pharmaceutical companies.[97]

Information technology ("IT") markets have pursued even more advanced levels of vertical disaggregation. Not only have VC-backed firms entered the upstream R&D segment, but also large, established firms have moved up the supply chain by diverting resources from production activities to design and research activities. As of the early 1980s, the U.S.

94. *See* Rosemarie H. Ziedonis, *On the Apparent Failure of Patents: A Response to Bessen and Meurer*, 22 ACAD. MGMT. PERSP. 21, 25 & fig.1 (2008) (citing *Business and Industrial R&D*, NAT'L SCI. FOUND., http://www.nsf.gov/statistics/industry/ (last visited Apr. 25, 2011)) (compiling data from surveys of industrial R&D available on the National Science Foundation Web site).

95. *See id.* (citing data from Venture Economics). It might be thought that technology start-ups funded by VC do not always, or do not even usually, own patents. Evidence suggests otherwise. In industries in which patents are clearly available, VC-backed firms widely patent and, as is widely reported, VCs generally insist that firms' technology assets are protected by patents. On the former point, see Graham et al., *supra* note 57, at 1280 (noting VC-backed firms' tendency to increase patenting activity, in part because of investors' preference, based on survey evidence for start-ups in the medical device, biotechnology, IT hardware, and software markets).

96. *See* Diamond v. Chakrabarty, 447 U.S. 303, 309–10 (1980) (affirming that microorganisms are patentable subject matter).

97. This description is a simplification. Some biotechnology start-ups have integrated forward to some extent, and all large pharmaceutical firms maintain some upstream R&D capacities in biotechnology. These structures are consistent with strategically anticipating that bargaining leverage would be lost without being able credibly to threaten independently to undertake R&D (in the case of a downstream incumbent) or production and distribution functions (in the case of an upstream R&D firm). For further discussion of these structures, see ARORA, FOSFURI & GAMBARDELLA, *supra* note 10, at 63–76 (discussing the growing role of dedicated biotechnology firms and analyzing the nature of the alliances and the uses of IT that have arisen in their aftermath), and Gary P. Pisano, Weijian Shan & David J. Teece, *Joint Ventures and Collaboration in the Biotechnology Industry*, *in* INTERNATIONAL COLLABORATIVE VENTURES IN U.S. MANUFACTURING 183 (David Mowery ed., 1988) (analyzing empirical evidence on collaborative relationships between established firms and dedicated research firms, and on characteristics, motivating factors, and transactional difficulties peculiar to the market).

computer industry was dominated by four companies: IBM, DEC, Sperry Univac, and Wang. Each maintained vertically integrated structures covering sales and distribution, application software, operating systems, computer hardware, and semiconductor chips. By the late 1980s, these structures were being displaced by a radical process of vertical disintegration. Most integrated incumbents disappeared and were replaced by multiple firms that competed at each level of the supply chain, or "IT stack" in industry jargon.[98]

Even surviving IT companies that once manufactured most of their own inputs—IBM and AT&T being classic examples—now contract out most production and other non-R&D functions to a network of outside suppliers in order to reach market at the lowest possible cost.[99] At the same time, these firms rely on licensing and acquisition transactions in order to obtain externally developed R&D inputs at the top of the supply chain.

Consider the following examples:

- Starting in the early 1990s, IBM, the leading patentee since 1993,[100] has converted much of its business into an outsourcing operation that licenses out internally developed technologies. IBM's patent and technology licensing agreements earned cash revenues of $345 million in 1993, $640 million in 1994, and exceeded $1 billion by 2000.[101] At the same time, IBM regularly uses outside suppliers to manufacture products that it continues to distribute independently.[102]

98. A pithy description of this turn of events can be found in an account by a founder of Intel. *See* ANDREW S. GROVE, ONLY THE PARANOID SURVIVE: HOW TO EXPLOIT THE CRISIS POINTS THAT CHALLENGE EVERY COMPANY AND CAREER 39–47 (1996).

99. *See* Timothy J. Sturgeon, *Modular Production Networks: A New American Model of Industrial Organization*, 11 INDUS. & CORP. CHANGE 451, 458–59 (2002) (noting the outsourcing trend). For a description of the same phenomenon in a broader range of industries, see Giovanni Dosi et al., *The Economics of Systems Integration: Towards an Evolutionary Interpretation*, *in* THE BUSINESS OF SYSTEMS INTEGRATION 95, 109 (Andrea Prencipe et al. eds., 2003) (noting this process in "many industries"); Keith Pavitt, *Specialization and Systems Integration: Where Manufacture and Services Still Meet*, *in* THE BUSINESS OF SYSTEMS INTEGRATION, *supra*, at 78, 82–83 (describing how technological breakthroughs in various industries have been related to processes of technological convergence and vertical disintegration).

100. Press Release, IBM, IBM Shatters U.S. Patent Record; Tops Patent List for 18th Consecutive Year (Jan. 10, 2011), *available at* http://www-03.ibm.com/press/us/en/pressrelease/33341.wss#release.

101. Deepak Somaya & David J. Teece, *Patents, Licensing, and Entrepreneurship: Effectuating Innovation in Multi-invention Contexts*, *in* ENTREPRENEURSHIP, INNOVATION, AND THE GROWTH MECHANISM OF THE FREE-ENTERPRISE ECONOMIES, *supra* note 20, at 185, 198 (citing IBM ANNUAL REPORT 91 (2001); IBM ANNUAL REPORT 7 (2000); IBM ANNUAL REPORT 5 (1994)).

102. *See* R. Gene Richter, *Foreword* to DAVE NELSON, PATRICIA E. MOODY & JONATHAN STEGNER, THE PURCHASING MACHINE: HOW THE TOP TEN COMPANIES USE BEST PRACTICES TO

- In 1999, Qualcomm—which began its life as a scientist-founded start-up, and is also the world's originator of the "CDMA" standard for wireless telecommunications, the leading standard in the U.S. market—sold its manufacturing operations and converted its business into what is largely a licensing and chipset design operation.[103] This operation is founded on a portfolio of over 11,000 granted and pending U.S. patents and over 54,000 granted and pending foreign patents.[104]
- Large U.S. technology firms, such as Apple, Philips, AT&T, Hewlett-Packard, Sun Microsystems (acquired by Oracle), Sony, and Cisco Systems, contract out production, testing, and even support services to third-party contract manufacturers.[105] Hon Hai Precision Industry, the world leader in contract manufacturing in the electronics industry, based in Taiwan, reported annual revenues of over $60.8 billion for fiscal year 2009, and in 2008 employed 486,000 workers.[106] At the same time, even the most technologically advanced firms, such as Intel, Cisco, and Microsoft, purchase R&D inputs from, or acquire in whole, smaller firms that have specialized expertise.[107]

The organizational transformation of technology markets, which relies on patent-mediated technology in-licensing and out-licensing transactions, has yielded a rough convergence of organizational form. The special case

MANAGE THEIR SUPPLY CHAINS, at xi (2001) (remarking on IBM's increased reliance on outside suppliers).

103. *See* QUALCOMM INC., QUALCOMM BUSINESS MODEL: A FORMULA FOR INNOVATION & CHOICE 3–4 (2008), *available at* http://www.qualcomm.com/documents/files/qualcomm-business-model-formula-innovation-choice.pdf.

104. The number of patents is as reported in Qualcomm's annual report for fiscal year 2009. Qualcomm, Inc., Annual Report (Form 10-K), at 13 (Nov. 5, 2009).

105. *See* Sturgeon, *supra* note 99, at 459; Timothy J. Sturgeon, *Turnkey Production Networks: The Organizational Delinking of Production from Innovation*, *in* NEW PRODUCT DEVELOPMENT AND PRODUCTION NETWORKS: GLOBAL INDUSTRIAL EXPERIENCE 67, 76 (Ulrich Jürgens ed., 2000).

106. This company is sometimes better known by its subsidiary Foxconn International Holdings Ltd. On revenues, see *Financial Statements for Hon Hai Precision Industry*, BUS. WK., http://investing.businessweek.com/research/stocks/financials/financials.asp?ticker=2317:TT (last visited Apr. 25, 2011) (citing revenues of nearly 2 trillion new Taiwanese dollars). The revenues figure in the text is calculated using the exchange rate to United States dollars at the end of fiscal year 2009. On the number of employees, see *Fortune Global 500 2009: The World's Biggest Companies—Hon Hai Precision Industry*, CNNMONEY.COM, http://money.cnn.com/magazines/fortune/global500/2009/snapshots/11204.html (last visited Apr. 25, 2011).

107. *See* Robert K. Perrons, *The Open Kimono: How Intel Balances Trust and Power to Maintain Platform Leadership*, 38 RES. POL'Y 1300, 1300–01 (2009) (analyzing and characterizing Intel's supplier relationships as a platform leader).

of the dedicated R&D firm—for which patents almost certainly provide an incentive function—has in fact become the general case. Even the largest technology firms are often substantially disintegrated research and design entities that rely on the ability to contract over intellectual resources with lower-cost suppliers of production and other supply chain inputs.

This organizational metamorphosis follows the logic of specialization. Economies of scale drive rivals to outsource production and other downstream functions to a limited set of least-cost providers, thereby driving down commercialization costs throughout the supply chain. Following "size of the market" effects, outsourcing opportunities induce further upstream entry. Outsourcing transactions are promoted by intellectual property rights, contractual instruments, technological protections, and reputation effects that guard against expropriation risk. Once the enabling set of technological and legal conditions has been satisfied, firms actually have little choice in this matter: failure to match the cost efficiencies made available by outsourcing supply chain functions to least-cost outside providers inherently results in a competitive disadvantage. Paradoxically, propertization of the upstream pool of intellectual resources both enables and compels collectivization of the downstream functions required to embody those resources into consumption goods.

To be sure, vertical disintegration is often in large part a function of an abundance of nonpatent factors—labor costs, tariff barriers, product complexity, communications, and transportation costs in any particular case.[108] But the strengthening of patent rights starting in the early 1980s, and the consequent rise in patenting rates, as well as the worldwide extension of patent rights through implementation of the 1994 Agreement on Trade-Related Aspects of Intellectual Property Rights,[109] appear to have played a role in reducing the expropriation risk that otherwise distorts interfirm exchanges of knowledge assets and prevents reducing commercialization costs to the extant technological minimum. Empirical evidence is consistent with this view. In industries or jurisdictions in which intellectual property rights are weak, firms reduce technology transfer in general, bias technology transfer away from the most novel technologies,

108. For a review of the variety of factors at play, see Sturgeon, *supra* note 99, at 462–64.

109. The Agreement on Trade-Related Aspects of Intellectual Property Rights is formally Annex 1C of the Marrakesh Agreement of the World Trade Organization, signed on April 15, 1994, and binds all 144 members of the World Trade Organization. *See* Agreement on Trade-Related Aspects of Intellectual Property Rights, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, 1869 U.N.T.S. 331.

and implement technology transfer through joint ventures, subsidiaries, or other firm-like arrangements.[110]

It is telling that economists and management scholars once commonly argued that the high risk of interfirm technology transfer necessitated conducting innovation by integrated firms in concentrated markets,[111] which conduct often promoted the conclusion that patents had little role to play in supporting innovation.[112] A 1985 U.S. Department of Commerce report lamented that the U.S. biotechnology industry would be unable to compete with the commercialization capacities of Japan's large congolomerates.[113] With the benefit of hindsight, that view is myopic in the extreme. The United States enjoys a thriving biotechnology industry, propelled in substantial part by smaller R&D-intensive firms that contract with larger pharmaceutical companies for production and distribution functions. The type of position expressed in the Department of Commerce report appears to be an artifact of a weak patent regime that may have

110. *See* Bharat N. Anand & Tarun Khanna, *The Structure of Licensing Contracts*, 48 J. INDUS. ECON. 103, 106, 125, 128–30 (2000) (analyzing a sample set of 1612 technology licensing agreements and 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); Ashish Arora, Marco Ceccagnoli & Wesley M. Cohen, *Trading Knowledge: An Exploration of Patent Protection and Other Determinants of Market Transactions in Technology and R&D*, *in* FINANCING INNOVATION IN THE UNITED STATES, 1870 TO THE PRESENT 365, 376–81 (Naomi Lamoreaux & Kenneth L. Sokoloff eds., 2007) (finding, based on survey of 1478 manufacturing units, that, in industries in which patents are stronger, there is greater licensing of new technological knowledge by smaller firms, or firms that specialize in R&D, but that no such effect is observed in the case of larger firms); 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). For further discussion of this point and supporting evidence, see Mikhaelle Schiappacasse, *Intellectual Property Rights in China: Technology Transfers and Economic Development*, 2 BUFF. INTELL. PROP. L.J. 164, 172–75 (2004) (discussing the role of the relative strength of intellectual property rights in encouraging foreign direct investment, technology transfer, and hence also in bringing about technological advances).

111. *See, e.g.*, Stephen P. Magee, *The Appropriability Theory of the Multinational Corporation*, 458 ANNALS AM. ACAD. POL. & SOC. SCI. 123, 129 (1981) (stating that innovating firms must expand to solve appropriability problems). On these older views, see Langlois, *supra* note 83, at 361–62 & n.16 (recounting the view that integration is necessary to avoid expropriation risk); Gary P. Pisano & Paul Y. Mang, *Collaborative Product Development and the Market for Know How: Strategies and Structures in the Biotechnology Industry*, *in* 5 RESEARCH ON TECHNOLOGICAL INNOVATION, MANAGEMENT, AND POLICY 112 (Richard S. Rosenbloom & Robert A. Burgelman eds., 1993).

112. *See* Naomi R. Lamoreaux & Kenneth L. Sokoloff, *Afterword* to FINANCING INNOVATION IN THE UNITED STATES, 1870 TO THE PRESENT, *supra* note 110, at 469, 471 ("Not so long ago . . . it was common for many in industry and academe to question how useful patents were as a means of encouraging private parties to invest in inventive activity.").

113. *See* Martin Fransman, *Biotechnology: Generation, Diffusion, and Policy*, *in* TECHNOLOGY AND INNOVATION IN THE INTERNATIONAL ECONOMY 41, 66 (Charles Cooper ed., 1994).

compelled firms to conduct innovation under integrated structures, which therefore appeared to be the only viable environment for conducting capital-intensive innovation.

The market's organizational detour around weak patents had obscured an alternative scenario. If firms could rely on patents to contract safely over intellectual assets with third parties in order to minimize commercialization costs, then transfer risk could be mitigated and integrated structures would not be necessary in order to capture innovation returns. The forgotten invention markets of the nineteenth century had already suggested such a possibility, albeit in settings characterized by substantially lower capital requirements. Thriving innovation by weakly integrated and patent-dependent firms—both large and small—in the late twentieth and early twenty-first centuries' most capital-intensive technology markets has now confirmed that possibility with far greater force.

C. CASE STUDY: "FABLESS" SEMICONDUCTOR MARKET

To illustrate in greater detail the interaction between patents and organizational form, I will now examine patents' organizational effects over roughly the past two decades in a selected segment of the semiconductor market. Consistent with theoretical expectations, patents, together with favorable technological developments, appear to have facilitated a transformation of firm and market structure that challenges the industry's historical model of integrated research, production, and distribution.[114] In particular, entry by patent-intensive R&D firms has been accompanied by the disintegration and multiplication of markets. Several of the elements discussed above have been realized: (1) downstream disaggregation of capital-intensive production functions to stand-alone

114. For prior commentary on this segment by management scholars, see CLAIR BROWN & GREG LINDEN, CHIPS AND CHANGE: HOW CRISIS RESHAPES THE SEMICONDUCTOR INDUSTRY 61–75 (2009) (describing rising design costs); Ludovic Dibiaggio, *Design Complexity, Vertical Disintegration and Knowledge Organization in the Semiconductor Industry*, 16 INDUS. & CORP. CHANGE 239 (2007) (examining the impact of knowledge integration versus collaborative outsourcing on firm boundaries and organizational capabilities); Greg Linden & Deepak Somaya, *System-on-a-Chip Integration in the Semiconductor Industry: Industry Structure and Firm Strategies*, 12 INDUS. & CORP. CHANGE 545 (2003) (analyzing the role of design trading in semiconductor industry organizational structures); Jeffrey T. Macher & David C. Mowery, *Vertical Specialization and Industry Structure in High Technology Industries*, 21 ADVANCES STRATEGIC MGMT. 317, 330–37 (2004) (describing the progression toward fabless firms and vertical specialization); and Jeffrey T. Macher, David C. Mowery & Timothy S. Simcoe, *E-Business and the Semiconductor Industry Value Chain: Implications for Vertical Specialization and Integrated Semiconductor Manufacturers* (East-West Ctr. Working Papers, Econ. Series, Paper No. 47, 2002), *available at* http://www.eastwestcenter.org/fileadmin/stored/pdfs/ECONwp047.pdf (describing the progression and implications for policy).

manufacturing firms; (2) creation of secondary markets in the provision of design tools and other services to facilitate upstream R&D; and, at an emergent level, (3) creation of tertiary markets in the trading of supply chain functions and inputs. This is a remarkably close, if still imperfectly developed, realization of a market for ideas in an industry that stands at the heart of our information-based economy.

1. Industry Background

The semiconductor industry is of paramount importance. The market is economically significant by any measure, with estimated worldwide revenues of more than $300 billion in 2010.[115] It provides the backbone for a broad set of information and communications technology industries, with semiconductor chips currently used in all manner of communications, computing, and electronics products.

Described simply, a semiconductor chip consists of an integrated circuit engraved on a silicon wafer using photolithographic technology. Integrated circuits are categorized by function: memory chips, logic chips, and microprocessor chips, with the last characterized by being programmed to perform a set of instructions.[116] Advances in miniaturization technology—increases in 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. These advances have enabled the development of application-specific integrated circuits ("ASICs," often known as "system on a chip" or "SoC" devices), which are widely used in multimedia mobile phones, netbooks, flat-screen televisions, digital cameras, and a variety of multimedia, video, and graphics applications.[117] This market segment had worldwide revenues of approximately $59.6 billion in 2010[118] and will be the focus of the discussion below.

115. Press Release, Gartner, Inc., Gartner Says Worldwide Semiconductor Revenue Increased 31.5 Percent in 2010 to Exceed $300 Billion (Dec. 8, 2010), http://www.gartner.com/it/page.jsp?id=1487916.

116. *See Semiconductors and Related Devices Market Report*, HIGHBEAM BUS., http://business.highbeam.com/industry-reports/equipment/semiconductors-related-devices (last visited Apr. 26, 2011).

117. Note that ASIC devices can be divided into two categories: (1) off-the-shelf devices that can be programmed by the user to implement certain functions as desired and (2) customized devices supplied by an integrated circuit manufacturer. *See* RAKESH KUMAR, FABLESS SEMICONDUCTOR IMPLEMENTATION 67 (2008).

118. *See 13 Fabless IC Suppliers Forecast to Top $1.0 Billion in Sales in 2010!*, RES. BULL. 1 (Dec. 21, 2009), http://www.icinsights.com/data/articles/documents/204.pdf [hereinafter *Fabless IC Suppliers*].

2. Organizational Evolution

Recalling the core framework, property rights mitigate the expropriation risk inherent to precontractual and infracontractual interaction, creating opportunities to extract specialization gains that will induce disaggregation of the supply chain, in turn inducing entry by providers of supply chain functions and inputs, in turn inducing entry by intermediaries that facilitate trading in those functions and inputs. This theoretical sequence closely tracks the actual reconfiguration of supply chains in the fabless market.

a. Integration

For several decades, the semiconductor industry largely operated on a vertical integration model in which each firm independently carried out research, product development, production, distribution, and support functions.[119] During this postwar period, patents were generally weakly enforced by the courts, and semiconductor firms tended to follow an industry norm against aggressive enforcement of patents.[120] 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; stronger enforcement of patents since the establishment of the Federal Circuit; passage of sui generis legislation to protect chip designs;[121] substantially increased rates of patenting by all firms;[122] and aggressive patent litigation by some firms.[123] Figure 6 shows the

119. *See* Macher, Mowery & Simcoe, *supra* note 114, at 3. Distribution was sometimes outsourced with the manufacturer retaining some "captive" distribution capacities. Some distributors also provided basic support services. For an extensive history of the industry, see generally BO LOJEK, HISTORY OF SEMICONDUCTOR ENGINEERING (2007).

120. *See* DAVID P. ANGEL, RESTRUCTURING FOR INNOVATION: THE REMAKING OF THE U.S. SEMICONDUCTOR INDUSTRY 37–43 & n.4 (1994) (describing how in postwar years most firms made no attempt to enforce patents and instead cross-licensing became the norm, thus contributing to the openness of the U.S. technological environment); CHRISTOPHE LÉCUYER, MAKING SILICON VALLEY: INNOVATION AND THE GROWTH OF HIGH TECH, 1930–1970, at 253–94 (2006) (recounting the growth and structure of the semiconductor industry in the Silicon Valley in the 1960s and 1970s).

121. Semiconductor Chip Protection Act of 1984, Pub. L. No. 98-620, 98 Stat. 3347 (codified as amended at 17 U.S.C. §§ 901–914 (2006)).

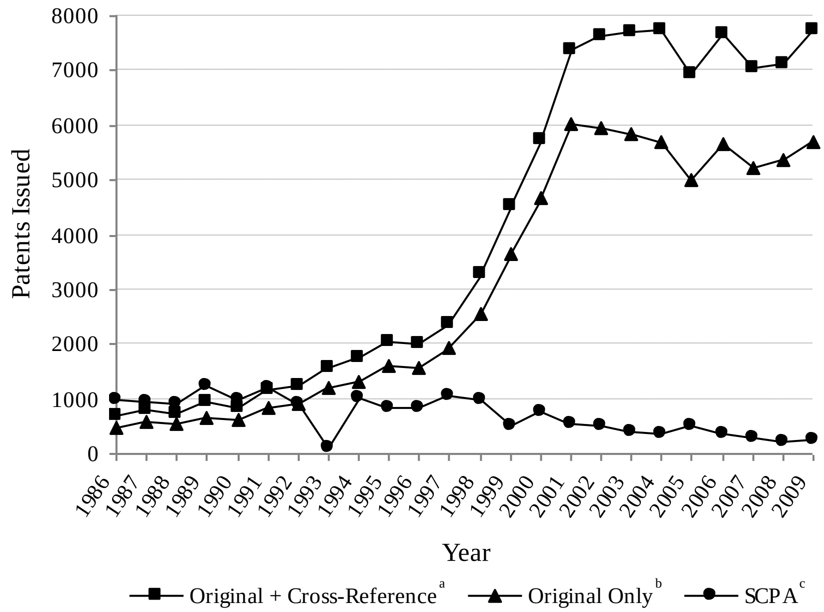
122. Adjusted relative to R&D dollars, this rate (that is, the propensity to patent) doubled during 1982–1992. *See* Rosemarie Ham Ziedonis & Bronwyn H. Hall, *The Effects of Strengthening Patents on Firms Engaged in Cumulative Innovation: Insights from the Semiconductor Industry*, *in* 13 ENTREPRENEURIAL INPUTS AND OUTCOMES 133 (2001) (analyzing the patenting behavior of ninety-five U.S. semiconductor firms during 1979–1995).

123. In particular, Texas Instruments is infamous for having broken from the industry norm of underenforcement of patents. *See* Bronwyn H. Hall, *Exploring the Patent Explosion*, *in* ESSAYS IN HONOR OF EDWIN MANSFIELD: THE ECONOMICS OF R&D, INNOVATION, AND TECHNOLOGICAL CHANGE 195, 201–02 (Albert N. Link & F.M. Scherer eds., 2005).

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.[124] Following standard views, these developments might be depicted as a case in which an industry that once thrived without strong patents has been saddled with an unnecessarily aggressive patent regime. As we shall see, several factors challenge this interpretation.

124. *See* Ziedonis & Hall, *supra* note 122. Note that figure 6 also depicts registration rates for "mask works" covered under the Semiconductor Chip Protection Act. As is evident, the Act has been underused. This underuse is generally attributed to technological developments that have frustrated third-party imitation that relies solely on reverse engineering layout designs. *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, 1077–80 (2000).

FIGURE 6. Semiconductor Patenting Rates (1986–2009)



[a] The higher curve for patent rates ("Original + Cross-Reference") 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. *Patent Counts by Class by Year*, U.S. PATENT & TRADEMARK OFFICE, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/data/cbcby.htm#PartA1-2 (last modified Apr. 1, 2011) [hereinafter *Patent Counts*] (providing data from 1990 to 2009); U.S. PATENT & TRADEMARK OFFICE, PATENT COUNTS BY CLASS BY YEAR: JANUARY 1977–DECEMBER 2005, pt. II, at 7, 9 (2006) (providing data from 1986 to 2005).

[b] The lower curve ("Original Only") includes only patents so classified based on the original classification. *Patent Counts*, *supra* fig.6, note a (providing data from 1990 to 2009); U.S. PATENT & TRADEMARK OFFICE, *supra* fig.6, note a, pt. II, at 7, 9 (providing data from 1985 to 2005).

[c] Total figures for "mask work" registrations under the Semiconductor Chip Protection Act ("SCPA") are based on the annual reports of the Copyright Office. U.S. COPYRIGHT OFFICE, ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FISCAL YEAR ENDING SEPTEMBER 30, 2009, at 49 (2010); U.S. COPYRIGHT OFFICE, ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FISCAL YEAR ENDING SEPTEMBER 30, 2008, at 3 (2009); U.S. COPYRIGHT OFFICE, ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FISCAL YEAR ENDING SEPTEMBER 30, 2007, at 3 (2008); U.S. COPYRIGHT OFFICE, ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FISCAL YEAR ENDING SEPTEMBER 30, 2006, at 10 (2007); U.S. COPYRIGHT OFFICE, ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FISCAL YEAR ENDING SEPTEMBER 30, 2005, at 12 (2006); U.S. COPYRIGHT OFFICE, ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FISCAL YEAR ENDING SEPTEMBER 30, 2004, at 6 (2005); U.S. COPYRIGHT OFFICE, 106TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 2003, at 8 (2004); U.S. COPYRIGHT OFFICE, 105TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 2002, at 8 (2003); U.S. COPYRIGHT OFFICE, PROMOTING CREATIVITY THROUGH AN EFFECTIVE NATIONAL COPYRIGHT SYSTEM: 104TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 2001, app. at 55 (2002); U.S. COPYRIGHT OFFICE, PROMOTING CREATIVITY THROUGH AN EFFECTIVE NATIONAL COPYRIGHT SYSTEM: 103RD ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 2000, at 9 (2001); LIBRARY OF CONG., ANNUAL REPORT OF THE LIBRARIAN OF CONGRESS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 1999, app. j at 157 (2000); LIBRARY OF CONG., ANNUAL REPORT OF THE LIBRARIAN OF CONGRESS: FOR THE FISCAL YEAR ENDING 30 SEPTEMBER 1998, app. j at 169 (1999); LIBRARY OF CONG., ANNUAL REPORT OF THE LIBRARIAN OF CONGRESS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 1997, app. k at 161 (1998); LIBRARY OF CONG., ANNUAL REPORT OF THE LIBRARIAN OF CONGRESS: FOR THE FISCAL YEAR ENDING 30 SEPTEMBER 1996, app. m at 161 (1997); U.S. COPYRIGHT OFFICE, 98TH ANNUAL REPORT

OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1995, at 20 (1996); U.S. COPYRIGHT OFFICE, 97TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1994, at 29 (1995); LIBRARY OF CONG., ANNUAL REPORT OF THE LIBRARIAN OF CONGRESS: FOR THE FISCAL YEAR ENDING 30 SEPTEMBER 1993, at 45 (1994); LIBRARY OF CONG., 95TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1992, at 35 (1993); LIBRARY OF CONG., 94TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1991, at 34 (1992); LIBRARY OF CONG., 93RD ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1990, at 38 (1991); LIBRARY OF CONG., 92ND ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1989, at 37 (1990); LIBRARY OF CONG., 91ST ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1988, at 25 (1989); LIBRARY OF CONG., 90TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1987, at 25 (1988); LIBRARY OF CONG., 89TH ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS: FOR THE FISCAL YEAR ENDING SEPTEMBER 30 1986, at 23 (1987). Annual reports are available on the U.S. Copyright Office's Web site. *Annual Reports*, U.S. COPYRIGHT OFFICE, http://www.copyright.gov/history/annual_reports.html (last visited Apr. 28, 2011).

b. Disintegration

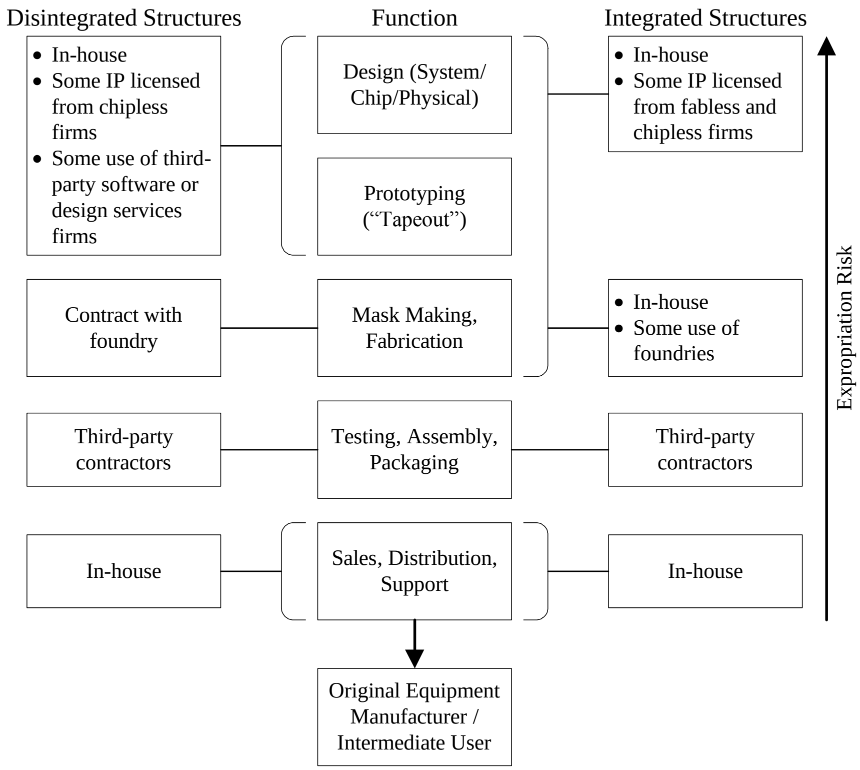
The onset of vigorous patent adoption and enforcement in the semiconductor industry has been followed by organizational changes. Some firms have migrated away from the uniform practice of vertical integration toward an increased diversity of organizational forms. The largest firms that still conform to the integrated model in this segment now compete in the most design-intensive segments with fabless companies, which enjoyed expected revenues of $59.6 billion in 2010,[125] representing about 25 percent of the worldwide semiconductor market. Design firms license proprietary chip designs to production-only foundries that specialize in wafer fabrication.[126] A fabless firm then recovers the wafers for testing, assembly, and packaging (technical functions that are outsourced to third parties), and, finally, handles distribution and marketing to intermediate users who are usually component manufacturers or system integrators.[127] As shown below, the result of these contractual relationships is a substantially disaggregated supply chain that departs sharply from incumbents' substantially integrated supply chains.

125. *See Fabless IC Suppliers*, *supra* note 118, at 1.

126. To provide somewhat greater detail, a design firm typically provides a foundry with a "specification" (an electronically deliverable prototype) for purposes of testing conformity to fabrication process parameters, after which the foundry can undertake "mask making" (equivalent to producing a mold in traditional manufacturing) and a full-scale production run.

127. *See* Rajà Attia, Isabelle Davy & Roland Rizoulières, *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 137, 145–46 (Bernard Guilhon ed., 2001) (describing the maturation of the fabless model); Ziedonis & Hall, *supra* note 122, at 136.

FIGURE 7. Supply Chain Structures in the ASIC/SoC Market



Note: System design, chip design (“spec”), and physical design (“layout”) constitute distinct stages in the chip development process, each covering multiple technical steps that require specialized expertise. Note further that the figure does not reflect the fact that foundries sometimes backward integrate by providing fabless firms with layout services or intellectual property modules or design libraries. For further discussion, see KUMAR, *supra* note 117, at 76–77, 177, 188, 206 (illustrating the distinct stages and backward integration possibilities); Linden & Somaya, *supra* note 114, at 569–70.

Together with fundamental technological and standardization advances that facilitate segregation of the design and production functions along the supply chain,[128] the opportunity to contract with foundries

128. Two developments were of particular importance. First, in 1979, a technical achievement in semiconductor design methodology, known as very large scale integration (“VLSI”), enabled the assembly of 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 69, at 77–88 (describing Carver Mead and Lynn Conway’s breakthrough to dimensionless, scalable design rules and their impact on chip designs); Nathan Rosenberg & W. Edward Steinmueller, *The Economic Implications of the VLSI Revolution*, *in* INSIDE THE BLACK BOX: TECHNOLOGY AND ECONOMICS, *supra* note 19, at 178 (projecting the impact of VLSI as depending on economic factors). Second, in the 1980s, the industry converged on silicon-based complementary metal oxide semiconductors as the dominant design in semiconductor process technology. This convergence facilitated standardization of the interfaces that allow design modules to be designed independently by multiple providers. *See* Linden &

enables design firms to contest incumbents' market share by avoiding the exorbitant investment required to set up a fabrication plant. The math is simple: "fab" construction costs can run into several billions of dollars;[129] design costs run into the tens of millions of dollars.[130]

The cost savings from vertical disaggregation inherently come at the price of expropriation risk, which is highest in the design stages of the supply chain.[131] Design firms, therefore, must rely on a combination of technology, contract, and intellectual property rights in order to control knowledge leakage at each point of technology transfer. Expropriation risk explains why fabless firms tend to adopt aggressive patent acquisition and enforcement strategies,[132] which contrast with the cooperative practices of vertically integrated incumbents, which engage in limited enforcement as a

Somaya, *supra* note 114, at 555.

129. As of 2007, a new plant required a $3.5 billion investment, as illustrated by Intel's newest plant in Israel. *See* ILKKA TUOMI, JOINT RESEARCH CTR. SCIENTIFIC & TECHNOLOGICAL REPORTS, THE FUTURE OF SEMICONDUCTOR INTELLECTUAL PROPERTY ARCHITECTURAL BLOCKS IN EUROPE 74 n.109 (Marc Bogdanowicz ed., 2009), *available at* http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/6946/1/jrc52422.pdf. These costs are compounded by the fact that plant technology is usually obsolete within a few years due to technological advances. *See* G. Dan Hutcheson, *Economics of Semiconductor Manufacturing*, *in* HANDBOOK OF SEMICONDUCTOR MANUFACTURING TECHNOLOGY 35-1, 35-14 (Robert Doering & Yoshio Nishi eds., 2d ed. 2008).

130. In total, design costs of an ASIC device have been estimated as high as $45 million. *See* KUMAR, *supra* note 117, at 235. Other sources give estimates of up to $80 million for a highly customized design. *See* Dieter Ernst, *Internationalisation of Innovation: Why Is Chip Design Moving to Asia?* 8 n.21 (East-West Ctr. Working Papers, Econ. Series, Paper No. 64, 2004), *available at* http://www.eastwestcenter.org/fileadmin/stored/pdfs/ECONwp064.pdf. Higher estimates rise to $100 million for the latest-generation chip designs. *See* TUOMI, *supra* note 129, at 75 fig.23.

131. 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 (that is, 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 114, at 559–61.

132. *See* Ziedonis & Hall, *supra* note 122, 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 patents based on creation of Federal Circuit, and, 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); Adam B. Jaffe, *The U.S. Patent System in Transition: Policy Innovation and the Innovation Process*, 29 RES. POL'Y 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 Acquisition 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).

general matter[133] and have widely entered into cross-licensing and even cooperative R&D arrangements with peer competitors.[134]

Incumbents' cooperative behavior, and entrants' aggressive behavior, reduces to a simple function of marginal integration costs. Larger firms are inherently protected against expropriation risk through integrated structures and therefore have a reduced need to expend resources on patent enforcement to achieve that objective. Precisely the opposite state of affairs applies to more weakly integrated firms.

Historically, the "fab/foundry" model arose in response to the interest of design-specialist firms in bypassing the incumbent bottleneck on wafer fabrication facilities.[135] The symbiosis between knowledge-intensive fabless firms and production-intensive foundries[136] has resulted in a flowering of design firms that challenge incumbents that would otherwise have been protected by the capital costs required to fund a fully integrated supply chain. According to the fabless trade association, there are approximately 1300 fabless firms worldwide,[137] located predominately in

133. Controlling for increases in the number of patents held and amount of R&D spending, large firms have not initiated more patent litigation since the early 1980s. *See* Hall, *supra* note 123, at 203–04 (comparing entrants to incumbents for market value of patents).

134. *See* DAVID J. TEECE, MANAGING INTELLECTUAL CAPITAL: ORGANIZATIONAL, STRATEGIC, AND POLICY DIMENSIONS, app. A at 193–94, 203–07 (2000). Some of the leading integrated firms are members in the SEMATECH research consortium, which pools member resources to develop manufacturing technologies. *See* SEMATECH, 2005 ANNUAL REPORT: ACCELERATING THE NEXT TECHNOLOGY REVOLUTION 3–5 (2006), *available at* http://www.sematech.org/corporate/annual/annual05.pdf.

135. The precise historical sequence is somewhat more complex. The leading foundry, Taiwan Semiconductor Manufacturing Company, Ltd. ("TSMC"), was founded as a combination of existing Taiwanese government initiatives to promote local technology industries and demands by integrated circuit design start-up firms, some of which had codeveloped technology with a Taiwanese government R&D institute, which required a local specialized chip foundry in order to avoid sending production overseas to Korean firms. In 1988 TSMC was founded through an investment and transfer of intellectual property by Philips, as well as investments by local investors and the Taiwanese government. *See* ALICE H. AMSDEN & WAN-WEN CHU, BEYOND LATE DEVELOPMENT: TAIWAN'S UPGRADING POLICIES 166–67 (2003) (discussing the Taiwanese government's role in the establishment of foundries, the integrated circuit mask industry, and the training of human resources in integrated circuit design); WILLY SHIH & JYUN-CHENG WANG, UPGRADING THE ECONOMY: INDUSTRIAL POLICY AND TAIWAN'S SEMICONDUCTOR INDUSTRY 8 (Harvard Bus. Sch. Case Study No. 9-609-089, 2010).

136. More precisely, foundries are "production mostly." To secure manufacturing contracts, some foundries have integrated backward to a partial extent, offering brokering services, module libraries, and limited design services to facilitate development of SoC designs by upstream suppliers.

137. *Industry Data: Semiconductor & Fabless Facts*, GLOBAL SEMICONDUCTOR ALLIANCE, http://www.gsaglobal.org/resources/industrydata/facts.asp (last visited Apr. 27, 2011) [hereinafter *Industry Data*]. Based on forecasted 2010 results, thirteen fabless firms are expected to have in excess of $1 billion in sales in 2010 and together account for about 70 percent of total fabless company sales. *Fabless IC Suppliers*, *supra* note 118, at 1. Those firms are Qualcomm, Broadcom, Advanced Micro Devices Inc. ("AMD"), MediaTek, Marvell Semiconductor, Nvidia, Xilinx, Altera, LSI Corp., Avago,

the United States, with clusters of smaller firms in Canada, Israel, the United Kingdom, Taiwan, and South Korea.[138] These firms outsource manufacturing functions to a concentrated group of wafer foundries, located principally in Taiwan and Singapore,[139] of which the top five firms hold an 82 percent market share.[140] The largest design firms, often backed by VC investors, pose a competitive threat to large integrated firms in the ASIC market.[141] Integrated firms themselves obtain some design inputs

Novatek, ST-Ericsson, and MStar. *Id.* at 2 fig.1.

138. *See* Jeffery T. Macher, David C. Mowery & Alberto Di Minin, *The "Non-Globalization" of Innovation in the Semiconductor Industry*, 50 CAL. MGMT. REV. 217, 223 (2007).

139. On the geographic distribution of semiconductor design firms and foundries, see Macher & Mowery, *supra* note 114, at 334–35. Some readers have expressed surprise that design houses would transfer technology to Asian jurisdictions in which patent protections are generally thought to be insecure. Two observations largely moot this concern. First, even if patent protections are insecure, expropriation opportunities are limited by the fact that the target markets for the ultimate consumption goods would bar entry of any products made using unlicensed patented components. Second, contrary to common belief, Asian jurisdictions do not uniformly have insecure patent rights. Taiwan, the chief location of the largest foundries, explicitly adopted a policy of strongly enforced patents in 1986, consisting principally of increased infringement awards and creation of a specialized court to hear patent disputes. That change 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, thus also enabling mutually efficient technology-transfer transactions with Western (mostly U.S.-based) design houses. This reform process is extensively detailed by Shih-tse Lo, *Strengthening Intellectual Property Rights: Experience from the 1986 Taiwanese Patent Reforms* (Concordia Univ., Dep't of Econ., Working Paper No. 04004, 2004), *available at* http://economics.concordia.ca/documents/working_papers/04004sl.pdf. Shih-tse Lo describes the reforms and documents the positive effects both on domestic innovation by R&D-intensive Taiwanese firms (as measured by R&D investment and patenting in the United States) and on foreign direct investment into Taiwan. These legal reforms have translated into concrete enforcement effects, as reflected by dramatically lower software piracy rates in Taiwan (43 percent) relative to China (86 percent). *See* Chun-Hsien Chen, *Explaining Different Enforcement Rates of Intellectual Property Protection in the United States, Taiwan, and People's Republic of China*, 10 TUL. J. TECH. & INTELL. PROP. 211, 213 (2007). As further confirmation, it appears that weaker, but far from nonexistent, protections of intellectual property in China are impeding further outsourcing of wafer fabrication to China, despite lower costs relative to Taiwan and other East Asian jurisdictions. *See* SHIRI SHNEORSON, TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY: THE SEMICONDUCTOR SERVICES COMPANY 18 (Stanford Graduate Sch. of Bus., Case Study No. GS-40, 2006), *available at* http://www.gsb.stanford.edu/scforum/login/pdfs/Taiwan_Semiconductor_2006.pdf ("[F]oreign fabless companies were worried about the country's lack of respect to intellectual property.").

140. *See TSMC Holds More Than 50% Share of Top Ten Semiconductor Foundries*, EE HERALD (Jan. 31, 2010), http://www.eeherald.com/section/news/nw100010277.html (summarizing IC Insights' 2010 report, and listing figures for 2009). The leading firms and market share are TSMC (based in Taiwan; 47% share); UMC (based in Taiwan; 14.7% share); Chartered (based in Singapore; 8% share); Globalfoundries (based in the United States; 5.8% share); and SMIC (based in China, 5.6% share). *Id.* (calculating market shares based on revenue figures). In the fourth quarter of 2009, Globalfoundries acquired Chartered. *See Foundries Play Semiconductor Survivor in 2010*, ISUPPLI (Sept. 21, 2009), http://www.isuppli.com/Semiconductor-Value-Chain/MarketWatch/Pages/Foundries-Play-Semiconductor-Survivor-in-2010.aspx.

141. *See* Linden & Somaya, *supra* note 114, at 555 n.14.

from upstream fabless firms and contract some production to outside foundries.[142] Intel, the leading integrated firm, retains a dominant share in the microprocessor market for desktop computers, but fabless firms such as Broadcom and Qualcomm are leaders in emerging markets for netbooks, mobile handsets, and smartphone devices.[143] Unburdened by the overhead of a production and distribution infrastructure, fabless firms can devote a disproportionate share of revenues to R&D. In 2007, leading publicly traded fabless firms substantially exceeded the semiconductor industry average ratio of R&D expenditures to sales (approximately 15%): Qualcomm devoted 21% of its revenues to R&D, Broadcom devoted 36%, and LSI Corporation devoted 25%.[144] As shown below, the fab/foundry business model has experienced rapid success, reaching almost $60 billion in worldwide revenues for publicly traded fabless firms in 2009, compared with $235 billion in worldwide revenues for the semiconductor industry as a whole in 2009.[145]

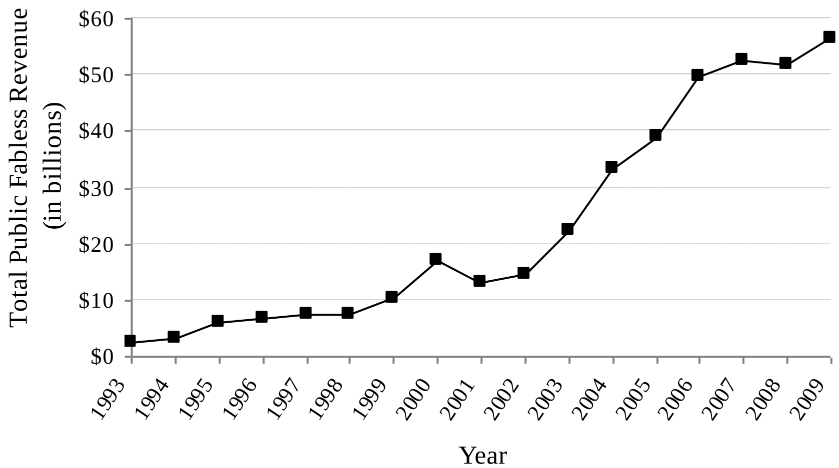
142. *See* JEORGE S. HURTARTE, EVERT A. WOLSHEIMER & LISA M. TAFOYA, UNDERSTANDING FABLESS IC TECHNOLOGY, at xvii–xviii (2007) (noting that most major integrated manufacturers today have adopted outsourcing to some extent).

143. BANK OF AM. MERRILL LYNCH, TECHNOLOGY: FINDING VALUE IN SMARTPHONES 2–4 (2009), *available at* http://thebln.com/wp-content/uploads/2009/12/Smartphone-market-2010.pdf.

144. ORG. FOR ECON. CO-OPERATION & DEV., OECD INFORMATION TECHNOLOGY OUTLOOK 2008, at 161, 162 tbls.3 & 4 (2008), *available at* http://www.oecd-ilibrary.org/docserver/download/fulltext/9308041e.pdf?expires=1303976079&id=id&accname=ocid177219&checksum=75D22929C1F0A9419ECEF6D390E1DBBA.

145. *See Industry Data*, *supra* note 137.

FIGURE 8. Growth of Fabless Semiconductor Firms



Note: This table is taken from *Industry Data*, *supra* note 137.

The fabless threat has induced dramatic organizational responses from integrated firms, which must match the specialization advantages achieved through contractual outsourcing. Consistent with general tendencies in IT markets, these responses have resulted in a rough convergence of organizational form: even the largest firms have adopted some elements of the fabless model. In 2007, IBM established the Common Platform Alliance, a joint project with Samsung (another integrated manufacturer) and Chartered Semiconductor (a foundry), that is intended to provide a package of services for designing and producing SoC chips for systems integrators and other intermediate users.[146] In 2009, Advanced Micro Devices Inc. ("AMD"), the world's second-largest microprocessor chip firm, spun off its manufacturing arm into an independent foundry entity, Globalfoundries (which acquired Chartered Semiconductor in early 2010), thereby converting the remainder of the company into what is now the world's third-largest fabless firm.[147]

These "top-down" organizational movements toward vertical disintegration imply some cost or quality advantage of specialized design-only and production-only firms relative to the integrated model. The market

146. For further information, see *Manufacturing Alliance Partners*, COMMON PLATFORM, http://www.commonplatform.com/about/manufacturing_partners.asp (last visited Apr. 28, 2011).

147. *See* Mark LaPedus, *AMD Foundry Spinoff Open for Business*, EE TIMES (Mar. 4, 2009, 12:01 AM), http://www.eetimes.com/electronics-news/4081523/AMD-foundry-spinoff-open-for-business.

is apparently rewarding firms that select disintegrated forms of implementing commercialization. Absent countervailing advantages or transactional frictions, this disintegration process ultimately must result in a universal outsourcing outcome that compels all firms to pursue similar organizational strategies.[148]

c. Reintermediation

The reorganization of firm and market structure 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 increases the number of sources and variety of supply chain functions and inputs. The resulting informational complexities induce entry by intermediaries that offer transactional technologies that lower search and evaluation costs for buyers and sellers of functions and inputs. This reintermediation process forms the basis for an emerging market in licensing and trading design modules and design tools that support disaggregated processes for the design and production of ASIC devices.

Three principal firm types promote the development of this market: software tool providers, standardization consortia, and intellectual property aggregators. These types can be described briefly as follows.

- *Software Tool Providers*. Software tool providers are indispensable in permitting disaggregation of design and production functions in the supply chain. These firms provide electronic design automation ("EDA") software that allows design firms to simulate the function of the circuit being designed,[149] facilitating the transmission of design information from fabless firms to foundries.[150] Those capacities facilitate vertical disintegration by limiting interdependency between design and production functions.
- *Standardization Initiatives*. Fabless firms, EDA software providers,

148. Certainly not all market segments will pursue this trend. The integrated model is still the predominant business structure in the microprocessor and memory chip markets and often 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 114, at 571–72; Macher, Mowery & Simcoe, *supra* note 114, at 4 & nn.6–7.

149. *See* Linden & Somaya, *supra* note 114, at 568–69. 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.

150. For more detailed discussion, see ARORA, FOSFURI & GAMBARDELLA, *supra* note 10, at 79 (discussing the example of Rambus), and Linden & Somaya, *supra* note 114, at 568–69 (elaborating this concept).

design services firms, systems integrators, and other participants have formed industry consortia to promote standardized design, trading, or licensing protocols. Standardization alleviates informational asymmetries relating to buyer concerns over the performance of modules consistently with the buyer's chip architecture, which asymmetries can frustrate trading in design modules. While substantial obstacles remain, these consortia have achieved some progress in achieving this objective.[151]

- *IP Suppliers*. Since the early 1990s, the fabless market has witnessed the emergence of a tertiary market segment consisting of "IP suppliers" or aggregators, also known as "chipless" firms. These firms, which accrued estimated revenues of over $2 billion in 2008,[152] accumulate libraries of performance-tested "IP blocs" or "IP modules"[153] for licensing to chip design firms, foundries, and integrated manufacturers.[154]

151. Almost concurrently with the emergence of the SoC market, software companies, fabless chip companies, and other entities established the Virtual Socket Interface ("VSI") Alliance (disbanded in 2008) in order to establish standardized interfaces for the transmission of design modules from fabless firms to foundries and the circulation of design modules among chipless and fabless firms. *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 1, 4–6 (Grant Martin & Henry Chang eds., 2003). Other leading standardization initiatives are as follows: (1) OCP International Partnership, which provides an openly licensed socket ("IP core interface") (OCP 2.2), OCP-IP, http://www.ocpip.org/ (last visited May 4, 2011); (2) Accellera (merged with SPIRIT in 2010), which provides design and verification standards, including hardware design language (System Verilog), ACCELLERA, www.accellera.org (last visited May 4, 2011); (3) Open System Initiative, which provides an open industry standard for system-level modeling, design, and verification (SystemC 2.2), and an interface standard enabling interoperability of models at the transaction level (TLM Standard 2.0), OPEN SYSTEMC INITIATIVE (OSCI), www.systemc.org (last visited May 4, 2011); and (4) Silicon Integration Initiative, which provides open interface standards for producing integrated silicon systems, SI2 (SILICON INTEGRATION INITIATIVE), www.systemc.org (last visited May 4, 2011). On obstacles to achieving greater standardization in the semiconductor market, see Macher, Mowery & Simcoe, *supra* note 114, at 11–16 (describing the development of Web-enabled software to connect fabs and foundries, and describing the founding of the VSI Alliance).

152. *See* TUOMI, *supra* note 129, at 14 (citing preliminary data from Gartner Inc. reporting $1.486 billion in design intellectual property licensing revenues and $586 million in semiconductor intellectual property technology licensing).

153. 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. But, the "IP" is always licensed subject to contractual or technological restrictions or both.

154. *See* ARORA, FOSFURI & GAMBARDELLA, *supra* note 10, at 76–77 (describing the development of "chipless" firms); Attia, Davy & Rizoulières, *supra* note 127, at 146, 165–67 (discussing industry structure and economic implications); Linden & Somaya, *supra* note 114, at 568–69 (discussing the role of EDA). By licensing design modules from third-party suppliers, foundries can offer clients both production and design input functions (as in the case of the market leader, TSMC).

ARM Holdings provides a good example of trends in the semiconductor market. ARM is the market leader in the emerging intellectual property supplier market, with 2010 revenues of $631.3 million,[155] and May 2011 market capitalization of approximately $12.84 billion.[156] ARM derives royalty revenues from licenses of its patented "RISC" processor designs to integrated and fabless semiconductor firms, as well as systems integrator firms in the computing and telecommunication industries. These firms then create SoC devices based on the licensed designs. This model has resulted in impressive levels of market penetration: as of year-end 2010, ARM reported that ARM-based processors were used in 90% of all "smartphones," 90% of "feature phones," 70% of protable media players, 80% of digital cameras, 65% of printers, and 85% of hard disk and solid state drives.[157]

As do other intellectual property suppliers, ARM maintains an inventory of design modules that can be reused across a variety of applications and, through planning and estimation tools, alleviate valuation obstacles to licensing transactions. Design reuse reduces substantially the costs of designing a new chip, in turn lowering licensees' development costs and facilitating entry by fabless entrants as well as sophisticated systems integrators.[158] Apple, for example, effectively entered the fabless market by licensing an ARM design and contracting with foundries to develop and manufacture a customized chip for the iPad device.[159]

See MARCO IANSITI & ROY LEVIEN, THE KEYSTONE ADVANTAGE: WHAT THE NEW DYNAMICS OF BUSINESS ECOSYSTEMS MEAN FOR STRATEGY, INNOVATION, AND SUSTAINABILITY 132–33 (2004) (discussing the NVIDIA example of using third-party design tools and building blocks, as well as testing standards).

155. ARM HOLDINGS PLC, 20/20 VISION: 20 YEARS OF GROWTH DELIVERING FUTURE OPPORTUNITIES: ANNUAL REPORT AND ACCOUNTS 2010 31 (2010) [hereinafter ARM ANNUAL REPORT], *available at* http://media.corporate-ir.net/media_files/IROL/19/197211/626-1_ARM_AR_040311.pdf (using average dollar exchange rate for 2010 of $1.55 to £1).

156. Market capitalization is based on the company's NASDAQ share price as of May 3, 2011. *ARM Holdings plc (ARMH)*, YAHOO! FINANCE, http://finance.yahoo.com/q?s=ARMH (last visited May 4, 2011).

157. ARM, ARM HOLDINGS PLC Q1 2011 RESULTS: ROADSHOW SLIDES 10 (2011), *available at* http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9OTA4MTJ8Q2hpbGRJRD0tMXxUeXBlPTM=&t=1.

158. *See* Ernst, *supra* note 130, at 10 (citing industry sources stating that systematic design reuse can cut chip development costs in half in three years and by more than 70 percent in six years). This observation confirms an intuition advanced by Mark Lemley and Julie Cohen with respect to the software market. *See* Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 CALIF. L. REV. 1, 5–6 (2001) (arguing that patent rights over software may promote reuse of software by allowing firms to earn returns on programming concepts that would otherwise not be disclosed).

159. *See* Vance & Stone, *supra* note 56. To further this endeavor, in 2008 Apple also purchased P.A. Semi, a semiconductor design company, for $278 million. *See* Erika Brown, Elizabeth Corcoran &

ARM and other intellectual property suppliers provide an unusually well-developed illustration of a market in ideas. As discussed, this market relies on the security umbrella consisting of the property rights, technological protections, and contractual instruments that safeguard the transmission of those ideas.

D. IMPLICATIONS: THE POTENTIAL VIRTUES OF RESOURCE FRAGMENTATION

It is widely asserted, but infrequently documented, that strong patents, and the resulting fragmentation of intellectual resources, preclude entry into technology markets or engender dispute resolution, negotiation, and other transaction costs that impede innovation.[160] The fabless market provides a counterfactual to both propositions. Incidentally, it also suggests why, contrary to those repeated assertions, today's most patent-intensive technology markets show no signs of predicted slowdowns in innovative output after almost three decades of intensive patent adoption and enforcement.

Brian Caulfield, *Apple Buys Chip Designer*, FORBES.COM (Apr. 23, 2008, 12:15 AM), http://www.forbes.com/2008/04/23/apple-buys-pasemi-tech-ebiz-cz_eb_0422apple.html.

160. These transaction costs fall into two categories. In both cases, there are cogent theoretical arguments that these patent-related costs could impede innovation, but scant empirical evidence that these costs actually do impede innovation. The first category encompasses administrative and dispute-resolution costs associated with negotiating access to intellectual inputs from third parties. Empirical inquiries have had difficulties confirming the predicted adverse effects of patent-related transaction costs on innovative activity. *See* David E. Adelman & Kathryn L. DeAngelis, *Patent Metrics: The Mismeasure of Innovation in the Biotech Patent Debate*, 85 TEX. L. REV. 1677, 1680 (2007) (finding "little evidence that the recent growth in biotechnology patenting is threatening innovation," based on a dataset of 52,000 biotechnology patents from January 1990 through December 2004); John P. Walsh, Ashish Arora & Wesley M. Cohen, *Effects of Research Tool Patents and Licensing on Biomedical Innovation*, *in* PATENTS IN THE KNOWLEDGE-BASED ECONOMY 285, 286–89, 292–94 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) (finding, based on a sample of seventy interviews, that patents on inputs to drug discovery generally have not halted research projects due to potentially conflicting patent claims held by other parties, although there is evidence of some delays in negotiating access to research tools or other valuable information or methodologies). *But see* Fiona Murray & Scott Stern, *Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis*, 63 J. ECON. BEHAV. & ORG. 648, 649–51, 672–74 (2007) (hypothesizing that anticommons effects would predict a lower citation rate for papers that contained ideas that were subsequently patented, and finding evidence of a modest effect). Second, this category encompasses "double marginalization" costs that result from uncoordinated pricing by holders of patents over nonsubstitutable components of a single technological bundle. As I note elsewhere, there exists little affirmative evidence supporting this thesis as a practical matter and considerable evidence that markets anticipate this risk and often take measures to address it. *See supra* note 76. I recognize, however, that these are unsettled empirical questions; my analytical framework, therefore, is fully open to the possibility that collateral social costs may sometimes recommend incomplete levels of patent protection, notwithstanding the fact that doing so inherently constrains innovators' transactional opportunities.

While the causality is not certain,[161] there appears to be a strong connection between widespread adoption and enforcement of patents and positive effects over entry conditions in the ASIC market. Without patents, it is unlikely that R&D-intensive start-ups could have challenged integrated incumbents that were protected by the exceptional capital costs of the fabrication process. History supports this view: the fabless model was in part motivated by the unwillingness of VC firms to fund the fabrication portion of the supply chain.[162] To be clear, this view does not imply—as the conventional formulation of the incentive thesis would imply—that the semiconductor market would have failed to sustain substantial innovation without strong patents. Most likely, the industry would have sustained innovation through the integrated structures and interfirm cooperative arrangements that had captured innovation returns for several decades and that continue to be used in part by the largest firms in the industry. And the industry may have been spared the litigation costs inherent to the aggressive patent enforcement strategies of the fabless sector (see the widely publicized litigations involving fabless firms such as Rambus, Broadcom, and Qualcomm)[163] or the opportunistic litigation strategies of some patent acquisition firms.[164]

But it is important to keep in mind that the "peace and quiet" of weak patent regimes comes at a price—or, more precisely, it comes at a different price to different types of organizational forms. With occasional exceptions,[165] legal and economic scholarship tends to assume that a world

161. For an attempt to address this difficult causality question, see Jeff Thurk, Market Effects of Patent Reform in the U.S. Semiconductor Industry (Oct. 31, 2009) (unpublished manuscript), *available at* https://webspace.utexas.edu/jmt597/www/papers/patent_pro_US_semi.pdf (running a policy simulation to estimate the effects of increased patent protection and increased market size (demand shock) on R&D investment and finding the contribution of market size is greater, but also finding there are still significant effects of patent protection on licensing revenue and the number of fabless firms).

162. *See* Hutcheson, *supra* note 129, at 35-14.

163. On Qualcomm's aggressive patent litigation strategy, see Annabelle Gawer & Michael A. Cusamano, *How Companies Become Platform Leaders*, MIT SLOAN MGMT. REV., Winter 2008, at 28, 31–32.

164. This latter strategy refers to the so-called trolls phenomenon. The extent of the phenomenon remains unclear. For relevant studies, see John R. Allison, Mark A. Lemley & Joshua Walker, *Extreme Value or Trolls on Top? The Characteristics of the Most-Litigated Patents*, 158 U. PA. L. REV. 1, 32 (2009) (finding that nonpracticing entities own a large segment of the most-litigated patents and file many of the suits, but that the issue of whether there is a "flood of patent trolls" depends on the definition); Gwendolyn G. Ball & Jay P. Kesan, *Transaction Costs and Trolls: Strategic Behavior by Individual Inventors, Small Firms and Entrepreneurs in Patent Litigation* 14–15 (Ill. Law & Econ. Paper Series, Paper No. LE09-005, 2009), *available at* http://ssrn.com/abstract=1337166 (finding inconclusively that small plaintiffs sue more often than licensing firms, and that licensing firms have less propensity to go to trial or seek judgment when suing large plaintiffs).

165. As Steven Cheung once pondered, "[E]conomists tend to overlook the crucial question: What

without patents necessarily enjoys reduced transaction costs and lower access barriers. To the contrary, a patent-free world is plagued by the transaction costs that frustrate idea exchanges without property rights, which costs can then induce substitution toward integrated structures that protect the most highly integrated incumbents that can more easily bear the cost of building and maintaining those structures. The result is that transaction costs and access costs are lower for some firms but potentially much higher for others—in particular, for R&D-dedicated firms that may pose the strongest threat to sheltered incumbents.

Political economic behavior tends to support this view. Large-firm incumbents, along with dominant firms in other complex technology markets, tend to support legislative reforms[166] that would reduce patent coverage, and have tended to support judicial decisions that have reduced this coverage. Fabless firms and venture capitalists tend to resist those changes.[167]

Whether integrated firms' private interest in weaker coverage is consistent with the public interest is a net social welfare question that is extremely difficult to settle.[168] Ultimately, the policy choice between

would an inventor or innovator do if there were no patent protection?" Stephen N.S. Cheung, *Property Rights in Trade Secrets*, 20 ECON. INQUIRY 40, 40 (1982). Possible answer: not invent or invent subject to secrecy. *See id.* 40–41; Adelman, *supra* note 10, at 458, 463, 466 (observing that the absence of patents necessitates using other entry barriers in order to block imitation).

166. For the latest proposed bills, see Patent Reform Act of 2009, S. 515, 111th Cong. (2009); H.R. 1260, 111th Cong. (2009).

167. For a fuller discussion of these tendencies, see Jonathan M. Barnett, *Property as Process: How Innovation Markets Select Innovation Regimes*, 119 YALE L.J. 384 (2009). For an example of support for the proposed reforms by a technology trade association that includes larger technology firms, including leading integrated chip manufacturers such as Intel and Micron, see Letter from the Coalition for Patent Fairness to the President of the United States (Mar. 23, 2009), *available at* http://www.patentfairness.org/pdf/CEO_letter.pdf. The Innovation Alliance (which tends to represent smaller technology firms, including fabless firms Qualcomm and LSI Logic) and the National Venture Capital Association (which represents venture capitalists) had previously opposed the reform effort but are now prepared to accept the legislation after considerable modifications. The new amended proposal is now opposed as being too weak by the Coalition for Patent Fairness, which tends to represent larger technology firms. On prior opposition by smaller technology companies, see Anne Broache, *Patent Law Overhaul: Bad for Start-Ups?*, CNET NEWS (Sept. 20, 2007, 12:19 PM), http://news.cnet.com/Patent-law-overhaul-Bad-for-start-ups/2100-1028_3-6209223.html. On opposition by venture capitalists, see Anne Broache, *Tech Companies, Investors Clash over Patent Law*, CNET NEWS (Mar. 29, 2007, 3:19 PM), http://news.cnet.com/Tech-companies%2C-investors-clash-over-patent-law/2100-1028_36171866 .html. On the changes in position with respect to the modified bill, see Kim Hart, *Tech Industry Splinters over Patent Reform Proposal*, HILLICON VALLEY (Mar. 9, 2010, 7:10 AM) http://thehill.com/blogs/hillicon-valley/technology/85515-tech-industry-splinters-over-patent-reform-proposal.

168. For a brief review of the social costs of patents that would enter a full cost-benefit analysis, see *supra* note 81.

weaker and stronger patent regimes may reduce to a social choice between hierarchical and entrepreneurial innovation regimes (where, to be clear, weak patents tend to promote the former scenario). At a minimum, however, the revealed policy preferences of incumbents and entrants cast doubt as to whether relaxing patent coverage necessarily would improve access for intermediate users or expand output for end users. If the dispute resolution costs inherent to the patent system are required to facilitate entry into capital-intensive technology markets, and are a precondition for any formal market in arm's-length trading in intellectual resources, sometimes those costs may be deemed a price worth paying.

V. CONCLUSION

The incentive justification for intellectual property is challenged. Bereft of compelling empirical support outside of selected markets, the incentive thesis in its conventional form has middling force against the view that the expensive apparatus for the legal protection of intangible goods is anything other than a generalized exercise in rent seeking. This Article provides a basis for reinvigorating the incentive thesis even in the most "IP-hostile" environment in which firms have access to powerful alternative technologies by which to capture innovation returns. This thesis is remarkably robust: it assumes that patents exert no incremental exclusionary effect in the product market, and makes no assumption as to the specialized competencies of certain types of firms or certain types of market structures. A fortiori, the incentive thesis is bolstered under more realistic "IP-friendly" assumptions. The key to this approach lies in construing intellectual property as an instrument for organizing intellectual production, not inducing it. Intellectual property typically regulates innovation incentives solely to the extent that it regulates the choices of organizational forms by which to implement innovation.

This proposition gives rise to two important implications. First, as a positive matter, it means that transactions, firms, and markets "look different" under stronger or weaker levels of intellectual property. Strong patents provide firms with opportunities to disaggregate supply chains through contract-based relationships, which in turn give rise to trading markets in intellectual resources, whereas weak patents foreclose those options. Second, as a normative matter, adjusting firm scope and breaking up supply chains to extract specialization gains facilitates entry into capital-intensive markets that are otherwise sheltered against competitive threats—precisely due to the absence of patents. Subject to technological constraints, patents can generate efficiency effects by correcting for the natural selection bias against weakly integrated enterprises that cannot bear the commercialization costs required to enter capital-intensive technology markets independently. These mediated effects over innovation behavior can yield, and most likely have yielded, far-reaching effects on the organizational structures of technology markets, effects that can ultimately result in the transactional milestone constituted by a reasonably well-functioning market in ideas.

As an instrument for inducing even substantial levels of innovation investment, intellectual property may often or even typically have questionable added value outside of selected industries. As an instrument for supporting organizational choice that yields the most efficient levels of innovation investment, intellectual property may often or even typically be essential.