

Intellectual Property Regimes and Firm Strategy: Putting Hall and Ziedonis (2001) in Perspective¹

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1. Introduction

Scholars in the fields of business, economics, and law have long recognized that rights to intellectual property (IP) intimately shape innovative activity and the pursuit of profits. More than sixty years ago, for example, Michal Polanyi voiced the following concerns about awarding property rights to creations of the “intellect”:

“The law...aims at a purpose which cannot be rationally achieved. It tries to parcel up a stream of creative thought into a series of distinct claims, each of which is to constitute the basis of a separately owned monopoly. But the growth of human knowledge cannot be divided into such sharply circumscribed phases. Ideas usually develop gradually by shades of emphasis, and even when, from time to time, sparks of discovery flare up and suddenly reveal a new understanding, it usually appears that the new idea has been at least partly foreshadowed in previous speculations” (Polanyi, 1944: pp. 70-71).

¹ The author thanks Kathryn Clark, Georg von Graevenitz, Jackson Nickerson, Joanne Oxley, and Brian Silverman for helpful comments and suggestions on this paper. Excerpts are drawn from Hall and Ziedonis (2001) and Ziedonis (2008). For reviews of the larger literature on IP rights and innovation, see Landes and Posner (2003), Scotchmer (2004), and Harhoff et al. (2008).

While better known in the field of strategy for his writings on the “tacit” dimension of knowledge (Polanyi, 1966), Polanyi aptly describes a source of friction in markets for ideas that continues to thwart modern IP systems.²

Edith Penrose, whose writings on competitive advantage and the growth of firms are foundational in strategy (Polanyi, 1959), shared Polanyi’s interest in the relationship between IP rights and innovative activity. In her article with Fritz Machlup (Penrose and Machlup, 1950), Penrose reviews attempts by nineteenth century scholars to wrestle, unsuccessfully, with several fundamental questions: Where should governments “draw the line” between one innovation and another? Are there conditions under which alternative mechanisms, such as prizes or R&D subsidies, would promote progress in the arts and sciences more effectively? More generally, how can individuals and the organizations that employ them build upon the discoveries of others while simultaneously justifying the time and expense of their own endeavors? In the decades that followed, these questions stimulated pioneering works by Nelson (1959), Arrow (1962), Nordhaus (1967), and others on the sources of market failure in the production of knowledge and the moderating effects of IP protection. Linking “appropriability regimes” to effective paths for commercialization, Teece (1986) built on this work and contributed a seminal framework to the field of strategy.

Within this rich tradition of research, my “patent paradox” paper with Bronwyn Hall (Hall and Ziedonis, 2001) contributed new insights on how strengthening IP regimes—in our case, U.S. patent policies—can affect innovative activity in ways sometimes unintended. This article provides broader perspective on our study and its implications for research on IP

² Interestingly, Polanyi’s 1944 article, titled *Patent Reform*, recommends the abolishment of the British patent system in favor of an alternative scheme whereby individuals or firms contributing worthwhile inventions would be paid “reasonable royalties” from government purses. This ill-fated policy prescription could explain why, unlike his other work, Polanyi’s patent reform article is rarely cited.

regimes and the strategic behavior of firms. Below, I first discuss some of the factors that led to the study and facilitated its completion. I then identify three questions left unresolved by our 2001 study and review recent attempts to address them. To conclude, I highlight a series of questions on IP and firm strategy that remain ripe areas for continued research.

2. The Patent Paradox Study

Our “patent paradox” paper was motivated by contradictions among several stylized facts. The first fact emerged from surveys asking U.S. R&D lab managers to rate the relative importance of mechanisms used to capture returns from R&D investments, thus yielding useful proxies for “appropriability regime” strength (Teece, 1986). As is now well known, the 1983 Yale survey revealed that firms in most industries (with notable exceptions like chemicals and pharmaceuticals) rely more heavily on mechanisms *other* than patents to recoup returns to R&D spending (Levin et al., 1987). Alternative appropriability mechanisms deemed more vital by R&D managers included other forms of legal IP protection, such as trade secrets, as well as market-oriented strategies, such as relying on lead-time or manufacturing superiority.

Many scholars anticipated that patents would figure more prominently among these rankings in a follow-on survey conducted in 1994 by Wes Cohen, Richard Nelson, and John Walsh. As discussed in our article (Hall and Ziedonis, 2001; pp. 105-106), the decades of the 1980s witnessed a marked “pro-patent” shift in the U.S. institutional environment. No other event signaled the movement toward stronger legal protection of patents than the 1982 creation of a centralized appellate court for patent disputes, the Court of Appeals for the Federal Circuit (CAFC). Although the driving force behind the legal reform was a need to unify U.S. patent doctrine, the CAFC put in place a number of procedural and substantive

rules that collectively favored patent owners (Jaffe, 2000; Gallini, 2002). Since the CAFC was established shortly before the Yale survey was administered, it was unclear whether survey respondents would have had sufficient time to recognize (much less respond to) this shift in the legal regime affecting patents.

Surprisingly, however, the 1994 Carnegie Mellon Survey (Cohen et al., 2000) essentially corroborated the earlier Yale findings! Except in a handful of industries, R&D managers continued to report greater reliance on *non-patent* mechanisms such as lead-time and secrecy to recoup investments from R&D spending. This lackluster opinion ignited new interest in an old question: Are patents an effective tool for encouraging innovation?

A second curious fact was that, despite these survey findings, the number of patents filed for and awarded in the United States had grown dramatically since the CAFC's formation. From the turn of the century through the mid-1980s, applications for U.S. patents ranged between 40,000 and 80,000 per year. By 1995, however, the number had climbed to over 120,000 U.S. patents filed for new inventions. An influential article by Kortum and Lerner (1999), released around the same time as preliminary findings from the Carnegie Mellon Survey, documented this unprecedented surge in U.S. patenting and provided the first systematic analysis of its possible origins. Using aggregate data on industry-level R&D spending and U.S. patent filings, the authors rejected the view that the growth in patent filings was causally influenced by the CAFC and its pro-patent rulings. Instead, they suggested that the escalation in patenting was explained by gradual improvements in the productivity of industrial R&D, thus yielding more patented output per R&D dollar. Put differently, the pro-patent shift and the upsurge in U.S. patenting were seen as correlated in time but causally unrelated events.

Early in our patent paradox study we re-examined the trends reported in Kortum and Lerner (1999) by computing “patent propensities” with annual firm-level data on patent counts and R&D spending. Figure 1 reproduces what we discovered. Unlike Kortum and Lerner, we saw no evidence of an overall climb in patent rates across U.S. manufacturing sectors during the 1980s. Instead, as shown by the solid line in the figure, the average firm-level patent rate (awards normalized by R&D spending) was essentially flat across all manufacturing sectors and, in pharmaceuticals, had declined. These trends were difficult to reconcile with gradual, economy-wide improvements in R&D productivity.

[Insert Figure 1 here]

Looking more closely at Figure 1, we also were struck by the visible climb in the propensities of firms in the computing and electronics-related sectors to patent in ways unaccounted for by R&D spending. The escalation in patent propensities was especially striking in the semiconductor industry (sic3674), coinciding more closely with the CAFC’s formation than revealed in Kortum and Lerner’s (1999) statistics.

This combination of stylized facts provided a useful “hook” for our study. In the influential Yale and Carnegie Mellon Surveys, R&D managers from the semiconductor industry consistently ranked patents among the *least* effective mechanisms for appropriating returns to R&D investments. Yet Figure 1 revealed that semiconductor firms were devoting an increasing share of R&D resources toward the filing of patents. If semiconductor firms do not rely heavily on patents to appropriate returns to innovation, then why are they patenting so aggressively?

Recognizing this apparent paradox in firm behavior, Bronwyn and I proposed to investigate the matter further in response to a call for research on the patent system and innovation by the National Bureau of Economic Research (NBER).³ At the time, Bronwyn was a professor in UC Berkeley's economics department and I was a doctoral student in business and public policy at Berkeley's Haas School of Business in search of a dissertation topic. Needless to say, I jumped at the opportunity to collaborate with Bronwyn and was thrilled when our proposal received funding.

Our initial plan was to study both the semiconductor and computer sectors given similarities in the trend-lines reported in Figure 1. As the study evolved, we decided to “focus, focus, focus” by restricting attention to semiconductors, where the contrast between survey responses and patent practices was most striking. This narrowing of scope enabled us to explore interesting sources of variation within the industry that otherwise may not have been feasible and made it easier to obtain and integrate industry-specific data sources. Archival reports from Integrated Circuit Engineering (ICE), for example, helped us understand the timing of technological shifts within the industry and expand the number of design firms represented in the sample.

As part of the NBER/Sloan project, we were encouraged to meet with practitioners from industry. The number of formal interviews we conducted was quite small, involving twenty-one managers of varying roles from four manufacturers and three design firms. To obtain additional insights about patent practices and legal issues, I attended lectures on IP strategy and patent law at UC Berkeley's Boalt Law School and participated in an internal

³ The patent project was part of a larger initiative of the NBER Project on Industrial Technology and Productivity, sponsored by the Alfred P. Sloan Foundation. As Jaffe et al. (2001) explain, the goal of the project was to generate a deeper understanding of the sources of productivity in the economy, specifically pertaining to IP regimes and their effects on commercial innovation.

training course on IP management at a local semiconductor manufacturer. Being located in Berkeley, California, within driving distance of Silicon Valley, we also benefited from informal interactions with industry representatives.

Our conversations with patent attorneys, R&D managers, and semiconductor executives contributed several important insights. First, it was clear that perceptions regarding the value and strategic use of patents varied markedly within the industry. Managers from integrated manufacturers seemed preoccupied with ramping up patent portfolios, primarily to reduce litigation risks and gain leverage in license negotiations. To boost inventive productivity, some firms had created internal “patent advocacy” committees, designed rewards for invention disclosures and successful patent filings, and set explicit organizational goals for patent volume (e.g., “file 1,000 patents in the year 2000”).

In contrast, representatives from design firms, which specialize in the design of integrated circuits but contract out manufacturing to foundries, focused more narrowly on the “traditional” role of patents—as primarily a means of securing some degree of exclusivity in product markets and, in turn, attracting capital from investors. While being fast to market was often viewed as a make-or-break-it for profitability and survival, design firms in our interview sample simultaneously devoted considerable managerial and financial resources toward securing “bullet proof” patents that would withstand legal scrutiny. For these firms, far greater attention seemed to be placed on patent *quality* rather than portfolio size.

These interviews also breathed life into a theoretical concept prominent in the transactions cost and economics literatures—holdup. By the late 1990s, over \$3 billion was needed to build and operate a state-of-the-art semiconductor fabrication facility. Not surprisingly, firms owning these technologically complex facilities were concerned about

outside patent owners threatening to shut down production and sales through an injunction. Millions could be lost from even a temporary halt in activity.

Finally, it was interesting to observe an apparent lag between the actual reforms to U.S. patent policies, which legal scholars and economists tend to peg to the 1982 formation of the CAFC, and managerial response. As discussed in our article, we heard repeated references to high profile cases from the mid-1980s that seemed to demonstrate the increased bargaining power of patent owners. As one manager from a manufacturing firm stated, “our CEO didn’t care about patents until Polaroid shut down Kodak’s facility” (as an outcome of a patent infringement lawsuit). Corroborating this view, a flurry of media articles in 1985 and 1986 proclaimed the “surprising new power of patents.” As noted in our 2001 article (p. 118), these proclamations typically referenced the mid-1980s Polaroid-Kodak verdict and the coinciding triumph of Texas Instruments (TI) in enforcing patents against Japanese and Korean DRAM producers, thus enabling TI to strike lucrative licensing agreements within the industry.

In combination, these qualitative insights directly informed the front-end framing of our paper and helped guide our econometric analysis. Perhaps most obvious, we better understood how the pro-patent shift in U.S. policies could yield heterogeneous effects on firms within the industry, thus encouraging us to differentiate between integrated manufacturers and design specialists. Equally important, the interviews suggested that capital-intensity could be used to capture (at least to some degree of approximation) a firm’s vulnerability to patent holdup. In traditional models of patent production functions (e.g., Hausman, Hall, and Griliches, 1984), capital-intensity was employed as an alternative proxy for firm size—not as a theoretically relevant determinant of patenting behavior. Finally, the

interviews guided how we analyzed the regime shift in the environment. When did the “before” period end? How long of an adjustment period should we allow? When did the “after” regime begin? References to demonstration events in 1985 and 1986 informed our response to these tricky questions (see Table 2 on p. 119).⁴

Key Findings and Implications

To summarize briefly, our study made several contributions to the literature on patent regimes and innovation. The first contribution pertains to what we *failed* to observe. When investigating the effects of strengthened patent protection, the most obvious place to look is for a boost in R&D spending. Among the 95 U.S. semiconductor firms in our sample, however, we found no evidence that the changed institutional environment stimulated greater R&D investments than otherwise would be predicted. While others report similar findings (e.g., Kortum and Lerner, 1999), it was important to document this “first order” effect within the context of our study.

We did, however, observe more subtle effects of the pro-patent shift on behavior within the industry. On one hand, our qualitative and econometric evidence suggested that the shift spawned “portfolio races” by capital-intensive firms. Instead of being driven by a desire to win monopolistic control over a technological prize, these firms seemed propelled by strategic motives aimed at reducing risks of holdup and gaining leverage in license negotiations. On the other hand, our analysis also revealed greater entry following the pro-patent shift in entry by “technology specialists” (in the context of our study, semiconductor

⁴ An alternative approach is to let the data speak for themselves. In more formal tests, Hall (2005) later shows a structural break in the patent propensities of U.S. semiconductor firms around 1983, which coincides more closely with the CAFC’s formation. This discrepancy begs the question of whether managers from the incumbents we interviewed were from a sub-set of late responders, thus revealing a potential (and unintended) selection bias in our interview sample.

design firms). This latter finding is consistent with the view that stronger patent rights facilitate vertical specialization within industries—a compelling argument discussed at greater length below and by Cassiman and Gambardella (2009) in this volume.

Do these results surpass the “so what” test of academic research? In my view, the answer is yes. From a policy perspective, patent portfolio races are troublesome. Collectively, firms engaged in these races may be better off devoting fewer resources toward patent-related activities. Individually, however, private incentives could pull them toward amassing greater stockpiles of patents. This prisoner’s dilemma-type dynamic has garnered considerable attention in the media (e.g., *The Economist*, 2001; Harmon, 2001), theories of patent holdup and settlement (e.g., Parchomovsky and Wagner, 2005; Lemley and Shapiro, 2005, 2007; Farrell and Shapiro, 2008), and debate over reforms to the U.S. patent system (FTC, 2003; Jaffe and Lerner, 2004; Bessen and Meurer, 2008). Top executives from the IT industry have been leading the reform initiatives, primarily due to concerns of rent expropriation and a proliferation of low-quality patents (see FTC, 2003).

Interestingly, our more sanguine result—that the pro-patent shift simultaneously appeared to facilitate entry by technology specialists—has received far less media and policy attention. Within the literature on markets for technology (e.g., Arora and Merges, 2004), this finding primarily is used to corroborate the view that stronger patent rights reduce hazards in technology trading, thus facilitating entry by firms specializing in those activities.⁵ While our interviews and quantitative evidence were consistent with this view, we could not definitively rule out the possibility that identical patterns of design firm entry would have

⁵ Agrawal (2009) provides useful context on this point, emphasizing the importance of means other than patents (such as human interaction and co-location) for reducing hazards in technology trading. See also Oxley (2009) on research linking patent strength to the governance of inter-organizational alliances.

occurred *without* the pro-patent shift in the U.S. institutional environment, thus adding an important caveat to this aspect of our study. As we acknowledged in the paper (Hall and Ziedonis, 2001; p. 120), a trend toward vertical specialization was already underway in the early-1980s due to advances in complementary metal oxide semiconductor (CMOS) technologies. Since the adoption of CMOS technologies coincided with the emergence of the pro-patent era, we faced an identification problem: The pro-patent era *seemed* to facilitate design firm entry and their financing activities, but we lacked a clean way of disentangling the “patent effect” from simultaneous but unrelated technological factors.

A second complicating factor (for purposes of identification) was the co-evolution of industry structure with licensing practices within the industry. While the 1980s witnessed a shift away from second-source agreements (Grindley and Teece, 1997), suppliers of manufacturing services (“foundries”) nonetheless played an active role as bundlers of IP rights on the behalf of buyers. Unless explicitly prohibited from doing so through bilateral contracts, foundries could resell rights to third-party patents via purchase agreements for manufacturing services.⁶ These contracts, and the judicial rulings that allowed them, helped alleviate the need for design-firm buyers to negotiate access to myriad process-related patents—thus paving an express route through patent thickets. Absent this market-mediated response and structural characteristic of the industry, it is unclear that the pro-patent shift would have facilitated entry by specialists to the degree documented in our study.

Laudably, recent studies have devised cleaner tests with which to identify linkages between patent protection and vertical specialization within industries. In a careful analysis using Carnegie Mellon Survey data, Arora and Ceccagnoli (2006) find that increases in patent

⁶ See *Intel v. ULSI Technology Inc* (995 F. 2d 1566, 1567; Fed Cir. 1993) and discussion in Ziedonis (2003).

strength (or “effectiveness”) stimulate the propensity of firms to license, but only among firms lacking complementary assets required for commercialization—a finding that resonates nicely with Teece’s (1986) appropriability framework.

Using a different methodology and dataset, Gans, Hsu, and Stern (2009) provide more targeted evidence that patent rights facilitate trading in markets for technology, thus reducing the costs associated with specialization. Exploiting lags in the patent application process, the authors show that patent grants stimulate the formation of inter-firm alliances to commercialize new technologies. Interestingly, the estimated impact of patent awards on the hazard of licensing is greater in electronics than in the biotechnology sector, despite considerable evidence that patents “matter most” in the life sciences (e.g., see Cohen et al., 2000; Mann and Sager, 2007). Also intriguing, the effect of patent awards on license formation appears to be “noisiest” in the software sector. This result could reflect a true result in which formal patent rights play a negligible role in commercializing software-related products, perhaps due to lower entry costs relative to other sectors. Alternatively, since the authors’ estimates are averaged across the decade of the 1990s (a period of landmark legal rulings targeted toward software-related inventions), they could obscure marked shifts in the value and use of software patents documented in other studies (Hall and MacGarvie, 2006; Lerner and Zhu, 2007).

As this discussion makes clear, there are opportunities to probe more deeply into how patent rights affect the extent and mode of technology trading, ideally through the use of panel data for multiple sectors. Similarly, despite heated debate (e.g., see Harhoff et al., 2008), it is unclear how fundamental differences among countries in the legal protection of

patents for software-related inventions affect investment incentives, patterns of entry, or trade in technology markets, thus naturally inviting further study.

Finally, a related body of recent work focuses more explicitly on the relationship between patents and the supply of capital for entrepreneurial ventures. If patents facilitate entrepreneurial-firm financing, or improve the terms with which entrepreneurs are able to secure capital for the development of early-stage projects, they may stimulate greater entry than otherwise would occur. Consistent with this view, recent working papers by Cockburn and MacGarvie (2007) and Haeussler, Harhoff, and Müller (2008) find that the number of patent filings—particularly of high quality—speeds the rate at which private firms receive venture capital (VC) financing. From a strategic perspective, acceleration in financing should be particularly valuable in settings where lead-time and speed-to-market are critical. In related work, David Hsu and I investigate the extent to which patent filings boost the valuations of private companies in the semiconductor industry (Hsu and Ziedonis, 2008). For 370 US venture-backed firms, we find that doubling the patent application stock of a new semiconductor venture increases the average valuation by 28% across rounds of financing, thus improving the terms with which entrepreneurs secure funds. These findings again suggest that patents may play a far more important role for entrepreneurial firms in the IT sector than is commonly suggested in the literature (e.g., see Mann, 2005; Mann and Sager, 2007). For example, Heeley et al. (2007) argue that, within the IT sector, patents fail to reduce information asymmetries in capital markets, while Dushnitsky and Lenox (2005) suggest that IT start-ups are particularly vulnerable to misappropriation by corporate venture capitalists due to weaknesses in patent rights within the sector. Future research could strive to resolve these apparent discrepancies in linkages between patent strength and entrepreneurial activity.

For scholars interested in innovation more broadly, several implications arise from this discussion. First, caution is needed when making inferences about the “strength” or value of patents as appropriability mechanisms based on rankings from the Yale or Carnegie Mellon surveys. Few would dispute the claim that the average patent is more valuable in pharmaceuticals than in semiconductors. It is also likely, however, that few semiconductor entrepreneurs or investors view patents to be “weak” or “ineffectual” within their industry: If true, then why would entrepreneurial ventures devote scarce resources toward securing patents? When using rankings from the Yale and Carnegie Mellon surveys, it is important to recognize that managers from small and young companies are under-represented among these surveys’ respondents.⁷

On a related point, researchers investigating linkages between patent rights and firm behavior should also question whether aggregate industry statistics mask fundamental sources of heterogeneity among firms. As our patent paradox study illustrates, the value and strategic use of patents can vary widely among firms even within an industry. More recently, Hall and MacGarvie (2006) and Lerner and Zhu (2007) reveal systematic sources of variation among firms in the value they capture from owning software patents.

Finally, as Cohen et al. (2000) point out, even if patents rank relatively low among mechanisms for appropriating the returns to R&D investment, it is erroneous to conclude that patents are (in an absolute sense) weak or ineffectual determinants of firm performance.

⁷ Noting this limitation of the Yale Survey, Levin et al. (1987) note that: “[f]or small, start-up ventures, patents may be a relatively effective means of appropriating R&D returns, in part because some other means, such as investment in complementary sales and service efforts, may not be feasible. The patents held by a small, technologically oriented firm may be its most marketable asset” (p. 797). While the Carnegie Mellon Survey captured a broader size distribution of firms, the survey was administered to manufacturing firms only and oversampled Fortune 500 companies (see Cohen et al., 2000). Hall (2009) reviews recent European surveys of patent value and their sampling methodologies, which tend to be more representative of small firms and service sectors.

Within the IT sector, for example, profits often hinge on the release of new-generation products sooner than the competition. Nonetheless, the successful acquisition and enforcement of patents can reinforce competitive advantage, both by deterring acts of imitation and by helping safeguard against rent expropriation. In the longer-term quest to secure profits from innovation investments, patents often work in tandem with, rather than as substitutes for, other means of IP protection.

3. Unanswered Questions

Like many studies, our patent paradox paper leaves numerous questions unresolved. Since we narrowed scope to a single industry, it is unclear whether our findings generalize to other sectors. More broadly, the laws and institutions influencing IP protection are complex, wide-ranging, and continuously changing. This inherent “messiness” of IP systems and their evolving nature makes it difficult to offer unqualified policy guidance based on the results of our analysis. Even with an identical sample of firms, an identical pro-patent shift may not spawn portfolio races in less litigious societies or in regimes with more rigorous standards for awarding patents.⁸ Similarly, an identical regime-shift could fail to stimulate entry by technology specialists if implemented in an economic climate ill positioned for expansion or in an industrial context where suppliers do not provide an “IP bundling” service. This specificity in context and our inability to observe the true counterfactual (of portfolio races or entry levels *absent* the pro-patent shift) are inherent limitations of our study that set the stage for further investigation.

⁸ A recent study Deng (2007) shows that the creation of the European Patent Office (EPO) simultaneously unified patent standards among signatory European nations and expanded the scope of protection. There is little evidence, however, that the European reforms fueled the aggressive stockpiling of patents in electronics industries like that documented in the U.S. and Japan (e.g., Cohen et al., 2000, 2002).

From a methodological perspective, recent work by Lerner (2005) and Qian (2007) illustrate the analytical traction to be gained from analyses of patent regime shifts in multiple countries and/or industries. Exploiting differences in non-compete regimes across U.S. states, Stuart and Sorenson (2003) use a similar identification strategy when estimating the effects of state-level institutional environments on entrepreneurial activity. More recently, Marx et al. (2009) fruitfully employ a reasonably exogenous change in Michigan laws to discern how a pro-IP shift in non-compete enforcement altered spillover patterns in labor markets. Students of transactions cost economics will appreciate the advantages of this comparative approach to institutional analysis (Williamson, 1991).

The remainder of my comments focus more narrowly on three questions that flow directly from our 2001 study: (1) Do patent holdup problems ignite portfolio races in sectors other than semiconductors?; (2) Why don't firms solve these holdup problems through means other than portfolio racing? (Or do they?); and (3) If the U.S. patent system is imposing an implicit "tax" on innovation, shouldn't we reform the system? If so, how? Below, I discuss recent developments that pertain to these three questions and propose avenues for further study.

Question 1: Do patent holdup problems ignite portfolio races in sectors other than semiconductors?

In Hall and Ziedonis (2001), we argued that patent portfolio racing was a strategic response to holdup problems. As per Michael Polanyi's quote from the introduction, it is easy to imagine that the potential for conflict ex post is greater in areas where the "stream of creative thought" eludes subdivision into distinct, well-marked claims. If firms face zero transaction costs when assembling rights to external patents, patent conflicts should be straightforward to resolve: firms could engage in efficiency-enhancing trades regardless of

how the initial entitlements of exclusionary rights are allocated among owners (Coase, 1960). Assuming instead that frictions exist in the bargaining process, we argued (but did not establish empirically) that patent portfolio races should be observed in other contexts where the legal rights to technologies embedded in commercialized goods and services overlap and are costly to disentangle.

Here, it is important to recall that patents do *not* necessarily grant monopoly power in markets for protected goods and services, as commonly asserted in the popular press. Instead, as Farrell (2009, p. 39) puts it: “[p]roperty rights, including intellectual property rights (IPR), are typically best seen as a basis for negotiation, not a prescription for who actually uses what assets or ideas.” Put differently, patents are “rights to sue” others for infringement. Illustrating the importance of this point, a former Intel executive once estimated that more than 90,000 U.S. patents related to central processing technologies had been awarded to over 10,000 firms, research institutions, and individuals by 2002 (FTC, 2003; see testimony of Peter Detkin). Outside a zero transaction cost environment, these external “rights to sue” naturally introduce hazards and opportunities for rent extraction. In turn, patents hold strategic value for use in reciprocal threat, exchange in the trading of patents and technologies via license and cross-license agreements, and competitive blocking.

In an influential working paper, Cohen et al. (2000) make a useful distinction between “complex” and “discrete” product industries, thus providing a broader conceptualization of contexts in which the strategic value of patents is likely to differ. According to the authors’ definition, “the key difference between a complex and a discrete technology is whether a new, commercializable product or process is comprised of

numerous separately patentable elements versus few” (p. 19).⁹ Electronic and computer products, including but not limited to semiconductor devices, tend to comprise numerous patentable components as suggested above, and thus are characterized as complex. In contrast, new drugs or chemical compounds typically are comprised of relatively few patentable elements and are characterized as discrete. Bessen and Meurer (2008) make a similar contrast between the IT and life science/chemical sectors but emphasize differences in the clarity (or “fuzziness”) of patent boundaries as the key source of distinction.

As asserted but not shown in our 2001 study, growing evidence suggests that the accumulation of patent portfolios is a response to holdup problems in complex product industries other than semiconductors. Based on responses to the Carnegie Mellon Survey in the US and Japan, Cohen et al. (2000, 2002) report that firms in complex product industries are more likely to file patents to safeguard against risks of litigation than are firms in industries characterized as discrete. Consistent with our interviews, respondents from complex product industries further noted the value of holding rivals hostage through controlling technologies embedded in their products, thus enabling them to strike more favorable terms in license agreements (Cohen et al., 2000). In effect, building a larger portfolio of patents creates a Williamsonian-type “exchange of hostage” (Williamson, 1983): by credibly threatening to impose reciprocal harm through litigation, firms may be able to reach a truce and reduce bilateral risks of expropriation. Unlike hostage taking in alliance contexts, however, the identities of parties involved in patent license agreements are not necessarily known in advance of investment decisions, thus rendering holdup problems more difficult to solve through ex ante contracting.

⁹ See Cohen et al. (2000, p. 19) for discussion of prior studies that use similar typologies.

Approaching the issue from a different angle, Lanjouw and Schankerman (2004) report that the *lack* of portfolios for use in trading places small firms at a relative disadvantage in the settlement of patent lawsuits. Similarly, others find that, vis-à-vis incumbents, entrepreneurial firms are at a disadvantage in funding or withstanding lawsuits (Lerner, 1995; Lanjouw and Lerner, 2001). By examining the patent filings of new biotechnology firms with various levels of litigation costs, Lerner (1995) shows that firms with high litigation costs (firms with fewer financial resources and low litigation experience) are more likely to avoid patenting in crowded areas, particularly when low-litigation-cost firms have secured ownership stakes in those areas. More recently, Rajshree Agarwal, Martin Ganco and I similarly show within semiconductors that corporate reputations for “IP toughness” deter spillovers in markets for skilled labor, particularly when employee-inventors leave to join or form entrepreneurial ventures (Agarwal et al., 2009). These findings call into question whether the high costs of patent acquisition and enforcement tilt competitive advantage toward established firms with deeper pockets and/or larger portfolios of patents.

In combination, these studies provide credence to the view that patents hold strategic value to firms when navigating through patent thickets (Shapiro, 2001). Looking forward, they also invite more systematic research on how asymmetries between firms (in size or resource endowments) alter how firms respond to expropriation risks posed by outside patent owners and the consequences of those decisions.

Finally, in a direct extension of our 2001 paper, Bronwyn Hall explicitly documents that the 1980s pro-patent shift stimulated portfolio racing in a broader set of complex products industries (Hall, 2005). Mirroring patterns in the semiconductor sector, her analysis reveals significant trend-breaks in the patent propensities of firms in computing and

electronics-related sectors more generally following the CAFC's formation. As expected, she also *fails* to observe a similar stimulus to patenting post-CAFC in discrete industries like pharmaceutical. Interestingly, as noted earlier, her estimates suggest that managers responded more quickly to the pro-patent shift than asserted in our 2001 study: Significant escalations in patenting occurred soon after the new court's formation.

While Hall (2005) establishes that the pro-patent shift in U.S. policies fueled portfolio racing in complex product industries other than semiconductors, other questions remain open. First, it is unclear *why* the acceleration in patenting is more pronounced post-CAFC in semiconductors relative to other complex product industries. Were semiconductor firms disproportionately shielded from patent assertions pre-CAFC due to the liberal technology licensing programs of AT&T and IBM that followed antitrust-related settlements? If so, this could impose a downward bias in their pre-CAFC propensities to patent relative to firms in industries like chemicals or pharmaceuticals that were less shielded by these open licensing practices.

Alternatively, are there specific conditions in the semiconductor industry that heighten the risks of patent holdup? As noted in our patent paradox article, the state-of-the-art advances notoriously quickly in this industry. From the perspective of contractual hazards, this rapid pace ironically could amplify holdup problems by creating a lag between the deployment of new technologies in design or manufacturing and the emergence of new patents from the two-to-three year examination process: Technologies could be embedded and built upon in multiple generations of products before managers *realize* that they are covered by outside patents. This observation highlights an important assumption underpinning formal models of bargaining over rights to cumulative innovation: for ex ante

agreement to be reached, entities involved in the negotiations are assumed to be identifiable and known (e.g., Scotchmer, 1991). Presumably there is considerably heterogeneity in the degree to which this assumption depicts the actual bargaining environment in which firms operate and make investment decisions—a point that warrants explicit consideration in future studies.

Making matters worse from the perspective of expropriation, semiconductor manufacturing also tends to be a capital-intensive and technologically sophisticated activity. As made famous by Intel’s “copy exact” policies—where identical equipment, processes, and layouts are employed in similar cohorts of Intel fabrication facilities—even minor changes in production can have costly and unpredictable effects on production yields and product quality. In theory, technological sophistication (affecting the costs of inventing around patents *ex post*) and sunk costs in capital equipment impose conceptually distinctive influences on the bargaining power of outside patent owners. As illustrated by our study, it nonetheless can be difficult to disentangle these factors empirically. The more complex and interdependent the manufacturing process, the more likely it is to require costly capital investment. Future studies could tease apart these dimensions by identifying contexts in which technological sophistication and capital expenditures are less co-determined.

Looking forward, more also could be done to identify fundamental sources of holdup problems in markets for patented technologies—both in terms of industrial/technological contexts and incentives of patent owners. Laudable advances in this direction include recent economic models by Farrell and Shapiro (2007), Reitzig et al. (2007), and Bessen and Maskin (2009). Within the field of strategy, future research could help unravel how heterogeneity among firms or the environments in which they operate informs

the strategic response to patent holdup problems and the resulting consequences of those decisions. Examples of recent empirical research that moves in this direction are discussed below.

Question 2: Why don't firms solve patent holdup problems through ex ante licenses or patent-sharing agreements?

A second, more Coasian question was unaddressed in our patent paradox study: If firms face holdup problems in markets for technology, why don't they solve those problems through ex ante mechanisms like patent pools or license agreements?

To be clear, some patent holdup problems are indeed resolved through means other than portfolio racing. von Hippel (1988) and Grindley and Teece (1997), for example, document the widespread use of bilateral licenses and cross-licenses that grant rights to use patented inventions. More recently, Lemley (2002), Chiao et al. (2007), and Rysman and Simcoe (2009) report efficiencies gained through multilateral patent-sharing agreements in standards organizations. Like our patent paradox paper, however, these studies tend to investigate one mechanism in isolation rather; they do not analyze trade-offs among alternative strategic responses. Adding useful perspective, Shapiro (2001) casts “defensive patenting,” licensing, standards-setting, and patent pooling as alternative means through which firms navigate patent thickets. Shapiro (2001) does not, however, analyze why or when firms use one mechanism over others or investigate the effects of those decisions.

An emerging strand of research pursues a more comparative agenda by exploiting (as an analytical lever) the distribution of exclusionary rights embedded in a firm's goods and services. Are those rights concentrated in a handful of owners? If so, firms should find it more straightforward to reach agreement (or invent around) prior to commercialization—

whether bilaterally or multilaterally in pools or standards organizations. Are the rights distributed among a fragmented array of outside parties instead as alluded to by the Intel executive noted earlier? In this event, ex ante solutions could be rendered infeasible simply due to the costs and delays associated with identifying and negotiating with myriad outside patent owners. In turn, firms may opt to move forward with commercialization without a license and focus on ways to improve their negotiating positions in the event of conflict ex post, a point developed more fully in Ziedonis (2004) discussed below. A subtle but important insight arises from this discussion: how firms respond to patent holdup may be shaped not only by the overall strength of protection afforded by patents but also by the *distribution* of rights among outside owners.

Legal scholars Michael Heller and Rebecca Eisenberg provided building blocks for this transactions-cost logic in an influential article on gene patenting (Heller and Eisenberg, 1998). Voicing concerns about a proliferation in gene-related patents, the authors cautioned early-on that awarding too many exclusionary rights on too small a scale “upstream” paradoxically could stifle downstream drug development. Instead of a tragedy of the commons, where common ownership leads to the overuse of shared resources, the authors forewarn a “tragedy of the anticommons,” where fragmented ownership leads to the underuse of economic resources. Michael Heller develops this argument more fully in his recent book, *The Gridlock Economy*, and provides fascinating examples of the contracting problems posed by fragmented rights to both intellectual property (like patents and copyrighted materials) and “real” property like land (Heller, 2008).

Not surprisingly, Heller and Eisenberg’s (1998) “anticommons” prediction caused great alarm within the scientific and policy communities and has motivated close scrutiny by

a number of scholars. To date, however, empirical evidence causally linking dispersed rights to bargaining inefficiencies and resource underutilization remains limited. Murray and Stern (2006) offer some cause for concern, showing that patenting of biomedical inventions reduces levels of follow-on research than otherwise would be predicted. In reviewing the empirical evidence, Caulfield et al. (2006) nonetheless conclude that a combination of market and regulatory responses—including the formation of consortia that donate upstream patents and procedural reforms at the U.S. patent office—have prevented the under-use prediction from coming to fruition.

Whether and how fragmented ownership affects firm behavior more broadly remains an area of considerable debate within the field, thus inviting continued research. Extending our patent paradox paper, I used insights from anticommons theory to investigate the conditions under which firms may find it particularly useful to respond to patent holdup problems by amassing large quantities of patents (Ziedonis, 2004). In line with Heller and Eisenberg (1998), I assumed that ex ante solutions are more difficult and costly to reach when rights required for commercialization are widely distributed among outside owners. Given these potential drawbacks of ex ante contracting, I argue that firms will file patents more aggressively ex post when rights to patents embedded in their products are allocated among a more fragmented (versus concentrated) pool of outside parties as suggested above.

To test this prediction, I devised a time-varying “fragmentation index” based on the distribution of assignees owning patents cited by a firm in a given year. The index is far from perfect: Firms cite many patents that pose zero risk of infringement, either because the cited patents are non-infringed, invalid, or no longer in force. Nonetheless, the index provides an analytically tractable means by which to capture (unobservable) frictions in markets for

technology introduced by dispersion among rights holders. Consistent with the view that ex ante solutions are less viable when ownership rights are more fragmented among owners, I find that greater fragmentation induces higher levels of patenting among semiconductor firms than would otherwise be predicted (Ziedonis, 2004). Similar to Hall and Ziedonis (2001), I show further that the effect is amplified for capital-intensive firms and is greater in magnitude following the pro-patent shift in US policies associated with the CAFC's formation.

More recently, a series of working papers explore the effects of fragmented ownership rights—not only on incentives to patent, but also on R&D investment and entry decisions. Using “X” and “Y” references reported in European patent data, von Graevenitz, Wagner, and Harhoff (2008) report that greater fragmentation among patent owners spawns higher levels of patenting in complex product industries, particularly when firms are large.¹⁰ Interestingly, the authors fail to observe this effect in discrete product industries such as pharmaceuticals or chemicals, lending further credence to the view that the strategic use of patents fundamentally differ between these contexts. Noel and Schankerman (2006) report a similar effect among software firms. Consistent with a recent model by Clark and Konrad (2006), Noel and Schankerman (2006) further demonstrate a feedback effect whereby fragmentation boosts patent levels and simultaneously reduces R&D investment. Exploring implications for entry, Cockburn and MacGarvie (2007) further document that software start-ups entering areas with large numbers of patents or assignees have longer delays in receipt of financing than start-ups entering less crowded areas.

¹⁰ Interestingly, von Graevenitz et al. (2008) find that the patenting decision of small firms is far more responsive to shifts in technological opportunities than it is to changes in the “crowdedness” of external patent thickets.

In related work, others explore the extent to which markets for technology enable firms to “reassemble” access to technological inputs owned by outsiders—or solve holdup problems through means other than aggressive patenting. Preliminary evidence on this point remains mixed. Using technology licenses reported for semiconductor firms, Siebert and von Graevenitz (2008) find that licensing helps resolve holdup but is not a “cure all” solution: the propensity of firms to license decreases as the fragmentation of property rights increases and arises mainly between large firms with similar market shares. Based on a survey of licensing activities of German firms, Cockburn, MacGarvie, and Mueller (2008) report that firms facing fragmented IP landscapes are *more* likely to engage in in-licensing to bring together requisite pieces of upstream technologies. Importantly, the authors also explore the implications of in-licensing and fragmentation on the innovative performance of German firms, as measured by the introduction of new products. While preliminary results from the study are somewhat complicated to interpret, fragmented IP rights appear to reduce the innovative performance for firms with few patents while positively affecting the innovative output of firms with large portfolios of patents.

These studies raise a number of questions that warrant further investigation. First, what factors shape a firm’s choice between these alternative mechanisms? Are some approaches (e.g., in-licensing) more effective in the presence of others (e.g., aggressive patenting)? If so, what are the performance implications for firms of different sizes and/or resource endowments? Second, to what extent do results from the working papers noted above generalize to other contexts? The Cockburn et al. (2008) findings, based on a survey of German firms, are particularly intriguing. It would be interesting to see whether an identical survey administered to U.S. or Japanese firms would yield divergent or similar findings. Relative to the U.S. and Japan, the standard of obviousness required for

patentability is generally higher in Germany and the European Patent Office and the examination process is more rigorous. This regulatory environment may help shield German firms—at least partially—from patent holdup problems relative to firms in the U.S. or Japan. These are open questions in need of further study.

Finally, the policy implications of various solutions to patent holdup problems are ambiguous yet important to consider. In a recent working paper, Mossoff (2009), for example, shows that the sewing machine patent pool from the nineteenth century reduced transactions costs and helped mitigate bargaining breakdowns over patents. Lampe and Moser (2009) provide similar evidence yet show further that the pool had a deleterious effect on the rate of innovation within the industry—a finding of clear concern both from an innovation policy and anti-trust perspective.

Question 3: If the U.S. patent system is imposing an implicit “tax” on innovation, should it be fixed? If so, how?

A final set of questions unresolved in our patent paradox paper relates to policy solutions. Are reforms needed? If so, which ones? And how are they best implemented—through legislation, administrative action, or judicial practice? More broadly, how should the patent system be designed so that its rules and procedures promote progress in both discrete and complex products industries? Even within industries characterized as “complex,” how should the interests of those seeking to curb patent hold-up problems be weighed against those relying on strong patents to recoup investments in R&D and human capital?

The past decade has witnessed an unprecedented level of interest in these difficult questions, both within the U.S. policy community (see FTC, 2003; Harhoff et al., 2008) and academia (e.g., Jaffe, 2000; Gallini, 2002). In their recent book titled *Innovation and Its*

Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It, Adam Jaffe and Joshua Lerner call for reform and better administrative screening by the U.S. Patent and Trademark Office of low-quality patent applications (Jaffe and Lerner, 2004). More recently, legal scholars James Bessen and Michael Meurer propose ways to increase the clarity and “notice” associated with the patent right, in a book called *Patent Failure: How Judges, Bureaucrats and Lawyers Put Innovators at Risk*. Provocatively, Bessen and Meurer (2008) estimate that the average public firm in the IT sector loses more value from infringement lawsuits filed against them in the U.S. than they gain from owning U.S. patents, a result that contrasts sharply with “net benefits” from patents realized in pharmaceuticals and chemicals. This evidence provides new ammunition for ongoing reform initiatives.

For strategy scholars, this heightened interest in IP regimes and their effects on firm behavior provides valuable opportunities for research dissemination and learning. In the past few years, for example, the U.S. Federal Trade Commission has convened a series of hearings on “Patents and Innovation” and, more recently, “The Evolving Intellectual Property Marketplace.”¹¹ Participation in these hearings, whether as a panelist or audience member, reveals multiple viewpoints from academia and industry. For management scholars in search of new research topics, these venues or others like them may inspire research that “matters more” to managers and policymakers, an outcome long called for by leaders of the Academy of Management and its associated journals (Hambrick, 1994; Rynes and Shapiro, 2005).

4. Conclusion

¹¹ The FTC website contains a useful link to testimonies from executives and other representatives from industry and academia: See <http://www.ftc.gov/opa/2003/10/cpreport.shtm> and <http://www.ftc.gov/bc/workshops/ipmarketplace/> (last visited June 1, 2009).

Intellectual property regimes play a pivotal role in the innovation process, in ways sometimes unintended. In Hall and Ziedonis (2001), we combined qualitative and quantitative research methods to investigate the effects of a pro-patent shift in US policies on the behavior of firms in one complex products industry—semiconductors. While we failed to find the “first-order” effect anticipated (increased R&D investments), the pro-patent shift appeared to stimulate greater entry by technology specialists. More striking, the shift also spawned “patent portfolio races” among firms vulnerable to rent expropriation by outside patent owners. These latter results call into question whether the U.S. patent system is imposing an implicit tax on innovation in key sectors of the economy, a possibility that remains the subject of continuing debate within the economics and policy communities.

For strategy scholars, our study and related work highlights the value of viewing IP rights as “a basis for negotiation, not a prescription for who actually uses what assets or ideas” (Farrell 2009, p. 39). The profits that firms derive from new technologies or products brought to market often hinge not only on patents owned by the firm but also on “rights to sue” held by outside parties. From the perspective of capturing value from innovation, this viewpoint suggests that firms are ill-advised to turn inward and focus solely on internal IP assets and resources: instead, the key strategic dilemma is how best to build and leverage internal resources in negotiations for rights held by outsiders.

Looking forward, numerous questions remain insufficiently addressed in the theoretical and empirical literature on IP rights and innovation. In hopes of stimulating ideas for future research, below are specific questions that in my view warrant continued investigation:

- How does heterogeneity among firms or the environments in which they operate affect the strategic response to patent holdup problems? What are the resulting

consequences of those decisions on the innovative or financial performance of firms?

- Does the risk associated with patent infringement disproportionately tilt advantage toward established firms with “deeper pockets”? How does the magnitude of this effect differ, if at all, in IP regimes with varying enforcement procedures or penalties for infringement?
- To what extent, if at all, have recent U.S. judicial rulings (including the well-publicized eBay and KSR cases) altered expropriation risks posed by outside patent owners? To what extent, if at all, have these rulings altered the IP strategies of firms in complex versus discrete industries?
- The past few years have witnessed landmark patent reforms in India and China. What are the effects of these reforms on the rate and direction of innovative activity? Have firms responded differently to these changes in the legal environment? If so how, and what are the implications for performance?
- How is the emergent “market for patents” affecting technology trade and commercialization? What are the incentives of buyers in these markets? How are the profits to patents sold on these markets divided among inventors, intermediaries, and buyers?

Finally, within strategy research on patents and innovation, the lion’s share of attention has been placed on interactions among or between firms. Far less is known about how the efficacy or value of a firm’s IP is shaped by internal organizational or human resource practices. In a recent theoretical model, for example, Hellman (2007) investigates conditions affecting the optimal allocation of IP rights between firms and their employees. Are there conditions under which firms would be “better off” (i.e., more innovative or profitable) by assigning legal title to inventions to employees, rather than retaining control over such rights? Empirical research on this intriguing topic is limited, perhaps due to common practices among for-profit entities in requiring rights to IP as a condition of employment. Future research could move forward by identifying differences among non-profit organizations, such as universities, or among countries or regions in legal requirements to relinquish control of IP rights to employee-inventors. Ideally, of course, one would like to observe variation “within” organizations, either over time or in divergent institutional environments. If well implemented, such research has the potential not only to inform

managerial practice on IP ownership and control, but also to shed new light on factors that influence entrepreneurial activity.

In a similar vein, Hannah (2005) gains “within firm” access to employees and discerns that aggressive enforcement of IP rights reinforces employee respect for safeguarding a company’s trade secrets, provided that the employee has sufficient access to such secrets *ex ante*. Separately, Harhoff and Hoisel (2007) report that royalty-sharing agreements between German employees and their employees stimulate invention disclosures but nonetheless create internal frictions and discontentment due to disputes over invention value and compensation. These studies represent laudable attempts to bring the “individual” back into studies of innovation and reveal new avenues for research.

The past few decades have witnessed a resurgent interest in IP rights and innovation, both in academia and in the policy community. While much is known about the motives for patenting and the relative efficacy of mechanisms used to profit from innovation across industries, there are exciting opportunities for further study. Hopefully this chapter inspires readers to look for creative ways—whether through field interviews or through access to employee-level data within firms—to deepen our understanding of IP regimes and their effects on firm strategy and performance.

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