REPUTATIONS FOR TOUGHNESS IN PATENT ENFORCEMENT: IMPLICATIONS FOR KNOWLEDGE SPILLOVERS VIA INVENTOR MOBILITY

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Reputations for Toughness in Patent Enforcement: Implications for Knowledge Spillovers via Inventor Mobility

Abstract

"Job hopping" by scientists and engineers is an important channel for knowledge diffusion. Little is known, however, about the effectiveness of actions firms take to reduce the outward flow of know-how and talent from their own organizations. Building on theories of reputation-building and strategic deterrence, this study investigates the moderating effects of corporate reputations for "toughness" in the enforcement of patents. Drawing on a unique database of enforcement activity, inter-firm inventor mobility events, and patent citations in the U.S. semiconductor industry, we find that a firm's litigiousness significantly curtails the dissemination of knowledge anticipated from employee departures, particularly to firms that are relatively disadvantaged to fund or withstand a legal dispute (i.e., that are small, young, or private). The overall effects are similar in magnitude for California-based firms relative to firms headquartered in other states. The study sheds new light on the strategic levers firms use to capture value from investments in human capital and R&D.

"The best way to send information is to wrap it up in a person."

-- J. Robert Oppenheimer[1]

The mobility of scientists and engineers in labor markets provides a vibrant channel for knowledge dissemination within industries, both among established firms and between incumbents and entrepreneurial ventures (Arrow, 1962; Stephan, 1996; Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003; Agarwal, *et al.*, 2004; Klepper and Sleeper, 2005). In a survey of 100 fast-growing private companies, for example, Bhide (1994) finds that 71% of the entrepreneurial founders commercialized ideas they had encountered or discovered while working at other companies. In an earlier survey of R&D managers, Levin *et al.* (1987) similarly report that hiring employees from rivals enabled established firms to learn about external technologies more efficiently and, in turn, hastened the speed of imitation. Kerstetter (2000) further documents celebrated employee raids designed to gain access to competitors' technologies, claiming that technology companies often live by the adage: "If you have trouble with the competition, simply raid its talent."

For firms competing in knowledge-intensive industries, however, departures of key talent can deliver a double blow—not only do they lose valuable human capital but rivals also stand to gain technological know-how at their expense. This study investigates the efficacy of a potential strategic lever available to firms seeking to *reduce* the outward flow of know-how and talent from their own organizations—building a reputation for being "tough" in the enforcement of intellectual property (IP). The past few decades have witnessed an explosion of IP-related lawsuits in the United States, particularly over patent-protected technologies (Landes and Posner, 2003; Bessen and Meurer, 2006).[2] The surge in case filings is simultaneously attributed to institutional reforms in the mid-1980s that strengthened the bargaining power of U.S. patent owners (Jaffe, 2000; Gallini, 2002) and intensified efforts by firms to capture more value from their innovation-related investments (Somaya, 2003). Are there potential reputational effects of these litigious acts, and what are the

[1] As quoted in Stephan (2006).

[2] The main forms of IP protection include patents (for novel, useful, and non-obvious inventions of commercial relevance), trade secrets (for business-sensitive information), copyrights (for creative expressions such as songs, films, books, or computer programs), and trademarks (for distinctive brands or logos).

implications for spillovers through employee departures? Extant literature is silent on this issue, a gap that we propose to fill in this study.

Anecdotal evidence suggests that some firms are indeed willing to take an aggressive stance toward protecting their exclusionary rights to technological discoveries and know-how, often in direct response to unanticipated employee exits. Consider, for example, National Semiconductor's retaliation in 1984 against Linear Technology, a startup founded by former employees to commercialize improved chip technologies they discovered while working at National. In justifying the decision to file an IP lawsuit against the individuals and the startup they had founded, National's CEO at the time noted that "it might easily cost $60 million to develop a new semiconductor technology…With investments of such magnitude at stake today, you do get sensitive" (Larson, 1984). To stem a similar tide of employee defections to startups in the 1980s, Intel's CEO reportedly issued a blanket order to his General Counsel to file two IP lawsuits per quarter to dissuade engineers from "walking out the door" with proprietary technologies (Jackson, 1994: p. 214). More recently, Intel sued Broadcom in a tug-of-war over engineering talent, voicing concerns about a "systematic effort to recruit [Intel] employees" (AP Newswire, 2000).[3] As part of the dispute, Intel accused Broadcom—and a company Broadcom was in the process of acquiring—of infringing five Intel patents, threatening to halt the manufacture and sale of core products at both companies. The case settled quickly on terms favorable to Intel (AP Newswire, 2000).

To investigate the broader implications of such litigiousness for mobility-driven spillovers, we draw insights from a longstanding body of work in strategy and economics on how corporate reputations cast shadows that alter the behavior of others (Kreps and Wilson, 1982; Milgrom and Roberts, 1982; Weigelt and Camerer, 1988; Shamsie, 2003). Viewing IP enforcement as a general "reputation-building" strategy (rather than a particular tactic employed against a particular litigant or involving a particular patent), we develop three hypotheses. First, we predict that a firm's reputation for toughness will significantly reduce the spillovers otherwise anticipated from employee departures

[3] This dispute is particularly interesting since Intel and Broadcom sell complementary products. Indeed, Intel provided venture financing and technical assistance to Broadcom prior to its initial public offering (IPO) in hopes that the startup's networking products, if successful, would pull demand for Intel chips (AP Newswire, 2000).

to rivals. Put differently, we expect these reputations to moderate the effects of mobility events on inter-firm knowledge flows. Second, we predict that tough reputations will be particularly powerful in curbing spillovers to firms that are at a relative disadvantage to fund and withstand an IP-related dispute (i.e., hiring firms that are small, young, or private). Finally, we predict that IP toughness will be less effectual as a spillover-reduction mechanism for California-based companies (relative to firms headquartered in other states) due to the unusually strong norms of informal knowledge-trading and reciprocity believed to characterize innovative activity within the state (Saxenian, 1994).

We test these predictions in the context of the U.S. semiconductor industry—a canonical setting used in prior studies to illustrate the importance to firms of "learning by hiring" employees from other companies (Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003). The setting therefore provides a context in which firms face challenges appropriating the returns to investments in human capital and R&D. Empirically, we integrate hand-collected data on patent litigation histories of 136 public semiconductor firms between 1973 and 2001 (first assembled in Ziedonis 2003) and merge these data with broader patterns of inventor mobility and patent citation behavior within the industry. Our estimation sample comprises 447 potential hiring organizations and includes both entrepreneurial ventures and established firms.

The study contributes to three literature streams. In the context of the literature on knowledge spillovers through employee mobility, Agarwal *et al.* (2007) emphasize the need for research to understand the boundary conditions and constraints on inter-organizational transfers of knowledge. This study theorizes and provides evidence that firms can and do undertake reputation-building strategies to hinder inter-organizational knowledge flows. Second, our study also builds on and extends the literature on reputation effects in corporate strategy. Just as firms can enhance performance by developing reputations for being "good" (see Roberts and Dowling, 2002), so can they garner strategic advantages by developing reputations for being "tough" in IP enforcement. Finally, within the literature on IP litigation (Somaya, 2003; Lanjouw and Schankerman, 2004), our study highlights the fact that in addition to the potential immediate benefits of protecting intellectual property, firms may also gain longer term benefits due to added reputation effects of patent enforcement that deter future potential infringers. In this context, our study also highlights the differential effects of toughness in IP enforcement on private, small, and young firms, which is relevant for policy considerations aimed at creating institutions that foster entrepreneurship.

THEORETICAL FRAMEWORK

Knowledge Spillovers through Employee Mobility and Entrepreneurship

According to the knowledge-based view of the firm, privately held knowledge is an important source of competitive heterogeneity (Grant, 1996; Spender, 1996; Teece *et al.*, 1997). A rich body of literature has focused on firms existing for the acquisition and creation of organizational knowledge (Griliches, 1979; Cohen and Levinthal, 1990). Organizational procedures, norms, rules, and forms serve as repositories of such information (Nelson and Winter, 1982; Levitt and March, 1988; March, 1991), and potentially provide a competitive advantage given difficulty encountered by other firms in the replication and imitation of such "tacit" knowledge.

Importantly, organizational investment in R&D—a primary method of new knowledge creation—occurs through the process of imparting human capital to employees. Simon (1991) emphasized that all learning occurs in the minds of individuals, and organizations learn either due to enhanced learning of their employees or by hiring new employees who bring in new types of knowledge or expertise. The symbiotic relationship between organizational and individual knowledge implies that firms that invest in knowledge creating activities by their employees also run the risk that they may lose this value creating asset. Unlike other value-generating resources, knowledge embedded in employees is a precarious possession—individuals can quit at any time (Coff, 1997). Indeed, as suggested earlier, employee mobility has been identified as a key conduit of knowledge spillovers, defined as the external benefits from knowledge creation that accrue to parties other than the creator (Griliches, 1992).

Consistent with Simon's (1991) identification of learning through hiring, scholars have found strong support for knowledge spillovers or transfer through employee mobility (Bhide, 1994; Almeida and Kogut, 1999; Burton *et al.*, 2002; Phillips, 2002; Rosenkopf and Almeida, 2003; Agarwal *et al.*, 2004; Klepper and Sleeper, 2005; Klepper, 2006). While the early literature on agglomeration and regional economics focused on localization as a primary mechanism that fosters knowledge spillovers, recent work has drawn attention to the role of employee mobility in overcoming local search (Rosenkopf and Almeida, 2003). Saxenian (1994) and Klepper (2001) attribute the development of regional economies to high levels of knowledge spillovers through employee mobility/entrepreneurship. In particular, Gilson (1999) argues that the Silicon Valley phenomenon is largely attributable to the reluctance of California courts to enforce non-compete clauses, which amplified the effects of employee mobility on knowledge diffusion.

The above literature, in general, has focused on the benefits for the *recipient* firm of acquiring knowledge through employee mobility.[4] Almeida and Kogut (1999), Rosenkopf and Almeida (2003), and Song *et al.* (2003), for instance, provide empirical evidence of the benefits for innovation (as measured by patenting activity) to firms that acquire employees from their rivals. Taking such knowledge transfer for granted, scholars have also examined whether employee mobility engenders explorative or exploitative search, and how firms should organize themselves to maximize the benefits of such knowledge transfer (Madsen *et al.*, 2003; Tzabbar *et al.* 2007). The related literature on employee entrepreneurship—where employee mobility results in spinouts or founding of new ventures—also extols the benefits of inherited knowledge. Agarwal *et al.* (2004) and Klepper and Sleeper (2005) show how various types of knowledge transferred to spinouts aids their performance, in addition to benefits of affiliation to high status parents (Burton *et al.*, 2002).

Less attention, however, has been given to the adverse effects on the *source* firm, which not only stands to lose valuable resources when employees leave but also faces the risk that such departures will heighten the capabilities of rivals. Extant work that specifically examines the strategic levers used to safeguard against mobility-induced spillovers focuses on contractual solutions, such as the inclusion of non-compete clauses in employment contracts (Pakes and Nitzan, 1983; Fallick *et al.*, 2006; Marx *et al.*, 2007). As suggested earlier, however, non-compete agreements are difficult to enforce in several states, including California where many technology-intensive companies are based.

[4] Consistent with prior studies (e.g., Rosenkopf and Almeida, 2003), we refer to a *recipient* firm as a potential receiver of technological know-how and human talent from another firm. Similarly, a *source* firm is a potential supplier of such know-how and talent to others. Firms can, of course, assume both roles.

The only work, to our knowledge, that examines how firms adapt their IP strategies in light of leakage concerns associated with employee departures is by Kim and Marschke (2005). The authors raise the intriguing possibility that, when confronted with high turnover rates among skilled employees, firms seek to protect a larger share of their inventions with patents, which are easier to enforce than trade secrets and non-compete agreements.[5] Left unanswered by their study, however, is whether firms gain added reputation benefits through patent enforcement.

Thus, there is a need to pay more attention to the issue on whether firms adopt specific strategies to combat knowledge spillovers through employee mobility, and their efficacy in doing so. We are interested in particular in whether variation in firms' propensity to seek legal recourse in protecting their intellectual property rights (through patent litigation) and their resultant reputations for "toughness" affect the spillovers anticipated from employee departures.

Literature Review on Reputations and Firm Performance

Corporate reputations have long been cast as strategic assets. Many scholars across the fields of economics, sociology, and strategy have documented the beneficial effects of building a positive reputation or "brand capital" on performance (Shapiro, 1983; Podolny, 1993; Rao, 1994; Roberts and Dowling, 2002; Shamsie, 2003). Being known as a high quality producer yields a premium (Shapiro, 1983), particularly in conditions of uncertainty where past reputation and "high status" can serve as a signal for continued excellence (Spence, 1974; Podolny, 1993).[6] Similarly, corporations admired by peers out-perform less reputable firms (Roberts and Dowling, 2002). The literature has also shown that reputation-building is a strategic variable shaped by firm actions and reactions to moves of its competitors (Basdeo *et al.*, 2006; Nicholls-Nixon and Woo, 2003; Rao, 1994).

[5] While trade secrets help protect against leakage of business-proprietary information (Cohen et al., 2000; Hannah, 2005), proving theft can be difficult and poses a disclosure paradox for potential plaintiffs: to establish theft, firms must reveal valuable private information, thus making them reluctant to file suit. In contrast, information about patent-protected inventions is already public as part of the granting process. Patents also confer an added strategic advantage over trade secrets in industries where new technologies can be reverse engineered: while independent invention (through reverse engineering or other means) is a legal defense against allegations of trade secret theft, a firm can reverse engineer and improve upon patented technologies of another firm and still be held liable for patent infringement (Moore et al., 1999).

[6] These performance benefits can also accrue to affiliates of high status firm; researchers have shown that network ties to high status firms can enhance the legitimacy of the related firms (Stuart *et al.*, 1999; Podolny, 2001) and improve performance of entrepreneurial startups created by former employees (Burton *et al.*, 2002).

While this recent literature focuses on the returns from being "good," an older literature in industrial economics highlights the strategic advantages of being "tough," particularly in the context of entry deterrence and predatory pricing (Kreps and Wilson, 1982; Milgrom and Roberts, 1982; Weigelt and Camerer, 1988). In reviewing this literature, Carlton and Perloff (2005) discuss the two conditions under which reputation-building investments can yield strategic benefit. First, the investing organization must have an advantage over its rivals. Second, they must demonstrate a credible commitment to following through with their strategy, regardless of rival actions.

Asymmetry between firms helps ensure that these two conditions are met. For instance, Milgrom and Roberts (1982) discuss the case where imperfect information results in existing organizations successfully engaging in predation or entry deterrence if there is uncertainty in the minds of rivals or potential entrants regarding its options, motivation or behavior. Given imperfect information, rival firms are likely to infer current and future behavior of the focal firm based on past behavior. The focal firm, in such a situation, can credibly commit by investing in building a reputation for "toughness" even when the cost of doing so in one particular strategic interaction exceeds the benefits in that instance, since the expected benefits of developing a tough reputation include the competition-inhibiting effects by deterring other firms (Scherer, 1980; Kreps and Wilson, 1982; Milgrom and Roberts, 1982).

By engaging in costly actions such as establishing a history of predatory pricing or raising rival costs through advertising campaigns, firms can build a reputation for toughness that deters competitors, thus permitting them to earn superior rents (Carlton and Perloff, 2005). The costliness of the action helps ensure a separating equilibrium. If "passive" types could easily mimic the behavior of "tough" types in the search for performance enhancements, outsiders would find it difficult to predict future action based on past behavior; in turn, the signaling function of strategic action would unravel (Spence, 1974; Weigelt and Camerer, 1988). Finally, to shape the expectations of third parties, the action must also be observable (like pricing, marketing campaigns, or, in the context of our study, the filing of a patent lawsuit).

Reputation for IP Toughness and Knowledge Spillovers through Employee Mobility

Insights from the above models extend to the context where firms take strategic actions to reduce the risk that technological know-how is expropriated through employee departures. When an individual scientist or engineer discovers a novel, non-obvious, and useful invention while working under an employment contract, legal rights to any patents based on those discoveries are assigned (with rare exception) to the employer (Merges, 1997) [7]. Employees that leave to join or establish another company may not have legal rights to make, use, or build upon patented technologies owned by the former employer unless explicit permission to do so has been granted through a license agreement. Even if the ex-employee (and his or her new employer) tries to "invent around" prior patents, the success of such design-around solutions can be costly to ascertain. As legal scholars note, it is difficult to determine a priori whether the extent of changes and designs around a patented device are sufficient to prove/disprove infringement unless a case has been adjudicated (Moore *et al.*, 1999). In the face of these ownership rights and legal ambiguities, patents may help firms not only in safeguarding against unauthorized use of protected technologies by imitators and product rivals, but also in protecting against insider misappropriations (Kim and Marschke, 2005).

While firms that engage in costly R&D investments often patent their innovations to secure intellectual property rights on the product of these investments (Levin *et al.*, 1987; Cohen *et al.*, 2000), such rights confer the right (but not the obligation) to sue others for alleged acts of infringement.[8] Though estimates vary, it is reasonable to conclude that the costs required to enforce patents are several orders of magnitude larger than those required to acquire the exclusionary rights. Lemley (2004), for example, estimates that the cost of obtaining a typical U.S. patent, inclusive of

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[7] Fisk (1998) describes the shift in early 20th century from a "shop rights" regime (employees had patent ownership rights, which were licensed back to their employers) toward a pre-invention assignment regime (employees agreed ex ante to sign over inventions rights as an employment contract condition). According to Fisk, "once employer lawyers disabused judges of the inventor-hero image in favor of the modern vision of inventive employees working in a big, employer-financed laboratory, the law began to change" (p. 1198). Fisk reports that modern U.S. courts continue to uphold an employer's interest in "protecting confidential information, trade secrets, and more generally, its time and expenditure in training and imparting skills and knowledge to its paid work force" (p. 1196).

[8] We refer readers to Moore *et al.*, (1999) and Lanjouw and Schankerman (2004) for detailed discussions regarding patent rights and their enforcement procedures. It is important to recognize, however, that patent rights are exclusionary, not affirmative: a patent, (if valid) grants a patentee a limited period right to <u>exclude</u> others from use of the patented invention; it does not grant the patentee the right to <u>use</u> the patented invention if such use infringes upon others' rights.

filing and attorney fees, is approximately $20,000. Meanwhile, the AIPLA (2003) estimates that the costs of a patent litigation suit of average complexity are between $3 and $5 million.

For the purposes of our study, patent enforcement is therefore a particularly useful lever to firms seeking to build reputations for "toughness" against the unauthorized use of proprietary technologies. The activity is costly, thus providing a sorting function. Moreover, once filed, patent lawsuits are frequently monitored by the press, which spreads news about a firm's prior litigious actions. In turn, employees and their potential hirers are better able to gauge which firms are likely to adopt a protective stance against unauthorized uses of proprietary technologies.

Thus, corporate reputations for patent litigiousness can moderate the extent to which proprietary technologies disseminate through employee departures. Consistent with the first condition of reputation-building strategy (Carlton and Perloff, 2005), the source firm has an advantage over its rival given its ownership of patents on the innovation—with the ownership of IP being analogous to cost advantage in the predation/entry deterrence models. If the source firm has additionally invested in the costly activity of engaging in IP litigation, the employee and the recipient firm will perceive a credible threat, the second condition for the strategy to be successful (Carlton and Perloff, 2005). Absent full information on the source firm's actions, ex-employees and the hiring organization will use the source firm's past behavior to make inferences about its future actions toward curbing unauthorized use proprietary know-how and technologies. In turn, incentives to misappropriate technologies from firms perceived as "tough" will be diminished.

Note that it is not necessary for the source firm to actively pursue IP litigation against all, or even many, of its employees. Similar to the entry deterrence models when firms operate in multiple markets (Scherer, 1980), the critical issue is not which patents the firm chooses to defend, or whom the firm targets, but whether it builds a reputation more generally for being "tough" in IP enforcement. From the source firm's perspective, then, even if the costs outweigh the benefits of being litigious in a particular dispute, the deterrence of future knowledge spillovers can justify the investment. Accordingly, we make the following prediction:

H1: A firm's reputation for IP toughness will have a negative effect on knowledge spillovers due to inventor mobility.

We now turn to whether the effects of reputations for IP toughness differ based on recipient firm characteristics. As noted above, investments in reputation building can lead to success if the source firm has an advantage over rivals—in terms of the initial ownership of IP, and rival firms perceive a credible threat of retaliation (Kreps and Wilson, 1982; Milgrom and Roberts, 1982). If recipient firms are differentially affected by the potential disruptions and costs due to IP litigation (with some being more negatively affected than others), however, we should expect heterogeneous responses to the reputations for IP toughness. Lerner (1995) finds evidence supportive of this prediction by examining the patent filings of new biotechnology firms with various levels of litigation costs. Specifically, he shows that firms with high litigation costs (i.e. firms at a relative disadvantage to fund/withstand an IP lawsuit) are more likely to avoid patenting in subclasses with other awards, particularly when low-litigation-cost firms have secured prior ownership stakes in those areas.[9] Consistent with arguments in the law and economics literature (Lerner 1995; Lanjouw and Lerner, 2001), we anticipate that high litigation cost firms will take greater precautions to avoid conflict when hiring employees from firms with reputations for IP toughness.

We identify three related, yet conceptually distinctive, firm-level characteristics that could differentially affect the organizational and financial burdens associated with IP litigation, thus altering firm behavior in anticipation of potential conflict: (a) lack of access to public equity markets (i.e., private ownership status), (b) firm size, and (c) firm age. Prior studies suggest that imperfections in capital markets can disproportionately affect the ability of firms to finance costly litigation (Lanjouw and Lerner, 1999). Compared with their publicly-traded counterparts, we argue that privately-held firms are at a relative disadvantage when raising funds required to defend against potential claims of infringement, either by issuing additional equity to investors or by securing

[9] Lerner's 1995 study builds on a larger body of work in law and economics that examines how costly regulations (or legal expenses) differentially affect firms. In an influential earlier study, for example, Bartel and Thomas (1987) argue that "if the cost burden of certain regulations falls heavily on one group of firms and lightly on a second group, then an indirect effect of these regulations is to provide cost advantage to the second group of firms" (p. 239). Consistent with this argument, the authors find that "compliance asymmetries" among firms in the costs of meeting occupational safety and environmental regulations tilt advantage in favor of large firms, enabling them to earn greater profits at the expense of smaller firms within an industry. While this literature is not commonly cited in the strategy literature, the intuition that emerges from this research directly informs how costly activities (including but not limited to legal disputes over IP) may have heterogeneous effects on firm behavior and therefore shape sources of competitive advantage.

loans.[10] As Nesheim (2000) notes, "venture capitalists hate investing in a start-up that gets bogged down in lawsuits that drain precious time and cash resources" (p. 43).

Further, legal disputes over IP rights would be particularly deleterious for small and/or young firms. In a 1990 survey, Koen (1991) found that the time and expense of IP litigation was a significantly more important factor in small firms' decisions to not pursue an innovation stream than for large firms, who were less likely to view the disruption and cost of legal IP disputes as a significant impediment to forgoing research opportunities. More recently, Lanjouw and Schankerman (2004) suggest that small firms are disproportionately handicapped when settling IP-related disputes: small firms tend to lack the larger patent portfolios of larger firms, thus putting them at a bargaining disadvantage when "trading" IP rights in the settlement of a dispute. Small firms also are less likely than larger firms to have in-house legal counsel (Lerner, 1995; Lanjouw and Schankerman, 2004), which puts them at a cost disadvantage in managing IP disputes.

Finally, the opportunity costs of becoming embroiled in an IP-related lawsuit should loom particularly large for nascent organizations relative to more established ones. While there is little prior research and quantitative evidence supporting this claim, the conjecture resonates with qualitative accounts of IP attorneys and entrepreneurs. Following an IP lawsuit filed by IBM, the vice president of a startup founded by ex-IBM employees (Cybernex Corp) reported that the lawsuit "scare[d] off new recruits, customers, suppliers, and, most important, investors" (Larson, 1984). In interviews with Silicon Valley attorneys, Larson (1984) cites heightened concerns that entrepreneurs "will be absorbed at the most crucial time in the start-up's history"—the early stages of the firm's development—and concludes that the "founders' time is one of the clearest and most costly victims of [IP] suits" (p 2). Further, younger firms may lack the organizational experience and capabilities to deal with IP litigation, given their lack of tenure in the industry.

[10] When enforcing IP rights against others, law firms are sometimes willing to accept cases on a contingency-fee basis, thus reducing the ex ante costs of filing suit for plaintiffs. The up-side potential of defending against claims of infringement is much lower since the goal is to invalidate the other party's patent or to be found not guilty of infringement. With that in mind, it would presumably be more difficult or costly for resource-poor firms to secure legal counsel when defending against assertions brought by others.

In combination, these arguments suggest that firms that are private, small, or young will be disadvantaged to fund and withstand an IP-related dispute relative to publicly-traded, larger, and more established firms. Assuming that such firms take added precautions to avoid legal conflict when hiring employees from litigious firms, we offer the following empirical predictions:

H2: The negative effect of a firm's reputation for IP toughness on knowledge spillovers due to inventor mobility will be amplified for (a) private (vs. public) firms, (b) small (vs. large) firms, and (c) young (vs. old) firms.

The nature of the business environment may also influence the effects of "tough" IP reputations on rival firm behavior. Saxenian (1994) attributes the continuing success of the Silicon Valley firms, relative to firms within the Route 128 region in Massachusetts, to a unique configuration of West Coast culture, detachment from the traditional hierarchical business practices, and norms established by some of the first major players like Hewlett-Packard. Saxenian (1994) argues that firms like HP encouraged its employees to pursue outside entrepreneurial activities as opposed to the defensive approach taken by its East Coast counterparts like Digital Equipment. Additionally, institutional factors within California also encourage knowledge spillovers due to employee mobility, given that California's state laws typically do not enforce non-compete covenants in employment (Gilson, 1999). These factors led to an environment with extensive job hopping, dense communication and social networks of inventors across firm boundaries (von Hippel, 1987; Appleyard, 1996; Rogers and Larsen, 1984; Saxenian, 1994). The agglomeration effects due to knowledge spillovers and collaborative networks resulted in a dynamic environment with pervasive mobility and high start-up rates (Stuart and Sorenson, 2003), which was reinforced by a relative abundance of venture capital in California (Saxenian, 1994).

A stylized fact emerging from these studies is that firms in computer-related industries based in Silicon Valley and in California (since the institutional and cultural factors extend beyond the Silicon Valley) tend to simultaneously face a rapid "absorption" by other firms within the region of information and know-how pertaining to their inventions and unusually high turnover rates among skilled employees (Almeida and Kogut, 1999; Kim and Marschke, 2005; Fallick *et al.*, 2006).[11] In a job-hopping culture with dense inter-firm communication channels that encourages knowledge spillovers (Saxenian, 1994), the effect of firm-level strategies regarding reputation building is likely to be weaker. Consequently, firms in California may find signaling toughness through reputation building more difficult. Thus, we predict that California firms that invest in tough reputation building will be worse off in reducing knowledge spillovers through employee mobility than their counterparts in other states, since strategic levers at the firm level will be less effective. Accordingly,

H3: The negative effect of a firm's reputation for IP toughness on knowledge spillovers due to inventor mobility will be less pronounced for California-based source firms than it is for source firms not based in California.

EMPIRICAL CONTEXT AND METHODOLOGY

Industry Context and Data Description

The context of our study is the U.S. semiconductor industry. As discussed above, the industry exhibits a high degree of employee mobility and prior studies document that such mobility facilitates inter-firm transfers of technological knowledge (Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003). We use these prior empirical studies, which trace patterns of citations revealed on patent documents, to construct a baseline model and to benchmark our results. Firms in this industry also have high propensities to file patents (Hall and Ziedonis, 2001) and appear to have grown more active in enforcing those exclusionary rights of protection (Ziedonis, 2003; Bessen and Meurer, 2006). The extent to which (if at all) these latter developments influence knowledge spillovers due to employee departures remains an open question.

Empirically, we trace the innovative activities of 447 U.S. semiconductor firms over three-decade period. We distinguish between firms that are potential *sources* of knowledge spillovers (and/or inventive talent) and other firms in the industry that are potential *recipients* of such knowledge. For simplicity, we refer to these firms as "source" (or "cited") and "recipient" (or

[11] Angel (1989) traces the career paths of semiconductor production engineers and finds high rates of inter-regional mobility until engineers move to the Silicon Valley. Silicon Valley engineers are more likely to accept a position with another firm within the region in the event that they change jobs. The mobility patterns in our data strongly support this finding. 73% of inventors that originate from California firms move to a firm within the same Consolidated Statistical Area. Only 12% of inventors originating from firms outside of California stay within their CSA, with 55% moving to firms in California.

"citing") firms respectively.[12] The sample period starts in 1973 (the first year of available litigation data) and 2003 (the last year in which we observe patent and patent citation activity).

The source firm sample is drawn from a comprehensive list of publicly-traded U.S. firms that a) compete primarily in semiconductor product markets and b) are founded prior to 1995. Restricting attention to firms that are public by the mid-1990s (n=136) allows a sufficiently long window through which to view possible litigiousness and mobility events. In 2000, these firms collectively generated over $88 billion in annual revenues and spent $12 billion in R&D.

For each source firm, we observe initiations (if any) of patent infringement lawsuits in U.S. courts between 1973 through 2001 based on data compiled in Ziedonis (2003) that merge case filings reported in legal databases (Litalert by Derwent) with supplemental information reported in archival 10-K filings, news articles, and press releases. Importantly, these data enable us to determine when a firm files a patent infringement lawsuit against a third party, not just whether patents awarded to that firm are involved in litigation as is more common in the literature (e.g., Lanjouw and Schankerman, 2001; Somaya, 2003).[13] We are therefore able to construct a firm-specific indicator of patent "toughness" that is allowed to vary over time.

To assemble a larger pool of potential "recipients" of technological knowledge and/or inventive talent within the industry, we add to source firms (a) 454 additional venture-backed startups in semiconductors that were founded between 1980 and 2001, and (b) 59 additional firms in the industry (SIC3674) that went public post-1995. Recent public entrants are identified from Compustat. The additional venture-backed startups are identified using data provided by VentureOne. Including recent entrants and startups in the pool of potential recipients is particularly useful for our tests of H2 (of heterogeneous effects based on recipient-firm characteristics).

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[12] As noted earlier, it is more appropriate to think of these firms as "potential sources" or "potential recipients" of technological knowledge; our analysis does not require that a given firm supply either technological knowledge or inventive employees to another given firm.

[13] If patents assigned to a given firm are involved in a litigated dispute, it does not necessarily mean that the original assignee (firm) is taking action to enforce its legal rights. Others could be challenging the validity of those patents or the patents could have been sold to third parties. See Ziedonis (2003) for additional discussion.

As discussed below, we identify knowledge flows and mobility events using evidence drawn from patent data. We therefore require that source and recipient firms receive at least one U.S. patent. This restriction eliminates 7 source firms, 188 startups, and 7 recent public entrants.[14] The final sample therefore includes 129 source firms, 266 private startups, and 52 recent public entrants. For the combined set of 447 firms, we integrate financial data from Compustat and VentureOne, patent data from Delphion and the National University of Singapore, information on alliances and cross-licensing activities from SDC Platinum complemented by an extensive search of the LexisNexis database, and patent litigation histories (for source firms) from Ziedonis (2003). Between 1973 and 2001, sample firms collectively receive 50,491 patents, of which 38,689 are awarded to the subset of source firms for which we observe litigation behavior.

Variable Definition

Dependent Variable: Citation Count

The dependent variable is the count of citations made by patents of the recipient (citing) firm to patents of the source (cited) firm in a given year. Consistent with the prior research (e.g., Jaffe et al., 1993; Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003), we assume that citations contained in patents provide valid proxies for knowledge diffusion. In a recent study, Alcacer and Gittleman (2006) show that government examiners add many of the citations reported in patent documents, thus calling into question whether applicants truly "know" about technologies embedded in other patents they cite. Lampe (2007) argues, however, that firms (and their inventors) may have strategic motives for omitting citations to patents that are technologically close, reporting supporting evidence of this claim in the semiconductor industry.[15] In the latter event, citations

[14] The disproportionate omission of startups is not surprising. Many startups in the larger sample fail or are acquired at very young ages, thus reducing the likelihood of observing patent awards for these firms.

[15] Legal requirements aside, firms can face conflicting strategic incentives when citing other patents in their applications. By failing to cite, firms risk losing their *own* patent if subsequently challenged: if others find prior art that establishes obviousness or lack of novelty (i.e., that should have been cited but wasn't), the rights granted can be rendered invalid. The effects of citations on risks that *others* will sue the patentee for infringement (and the penalties involved) are more ambiguous. On one hand, prior art citations may represent an attempt to "invent around" an earlier patent to avoid infringement. As noted earlier, however, it can be difficult and costly to determine whether 'design around' solutions are non-infringing (Moore *et al.*, 1999). On the other hand, in the event of an infringement suit, such citations could be used as evidence that the citing party knew about the patented invention and proceeded anyway without a license, thus fueling concerns that damages could be enhanced through a verdict of willful infringement. Lampe (2007) discusses these trade-offs in more detail.

added by examiners are useful in that they reveal technological linkages that otherwise would remain unobservable. In light of these unresolved controversies regarding the use and interpretation of patent citations data, we report below results that both include and omit examiner-added cites.

The dependent variable of citation counts is calculated at the dyad (source firm/recipient firm)-year level for all possible combinations of citing and cited firms in years when both firms in the dyad exist. Although knowledge diffusion is possible post-exit (Hoetker and Agarwal, 2006), we assume that the reputation effects of the cited firm cease to exist when the firm exits. After a source firm exits, it is removed from future dyad-year observations and citations to its patents are omitted. We make additional adjustments for acquisition events within the sample. In the event that one firm within the sample acquires another, the acquired firm exits the sample in the year of acquisition and its patents are added to the acquirer's portfolio from that point forward.[16] Our final database is an unbalanced panel with 506,374 unique dyad-years and 74,624 citations to source firms. Self-citations and citations made by firms outside of our focal sample are not included.

Main Independent Variables

There are six explanatory variables of main interest in our study. They enter interactively in the regressions and are described in more detail below. To preview, the first variable, *Mobility*, captures the movement of inventively productive employees from a source firm to a potential recipient. The second variable, *Litigiousness,* is the proxy used to capture a firm's "reputation for toughness" in patent enforcement. For the subgroup analysis, three indicator variables—*Private, Small*, and *Young*—are constructed to capture these characteristics of the recipient firm. The final variable, *CA Source firm,* is used to indicate whether the headquarters of a focal source firm is located in the state of California (or not).

Mobility, more specifically, is defined as the total number of inventors hired from a given source firm by a recipient firm over the last five years including a focal year, as measured by the

[16] To accomplish this, we first aggregate the citations at a dyad-year level up to and including the acquisition year. Second, starting with the "year of acquisition" + 1 we add all citations made to and from the acquired firm to the portfolio of the focal firm in the dyad. For instance, if firm A acquires firm B in 1990 and in 1991 firm C cites B, it is added to the citation count for the dyad "C citing A in 1991." The same is calculated for "made" citations. If B cites D in 1992, it is counted within the dyad of "A citing D in 1992."

application year of a mobile inventor's first patent at the recipient organizations. To determine mobility events, we implement the matching algorithm described in Appendix 1 that allows us to recreate unique inventor patenting histories, as well as inventor moves within our sample. For 28,123 unique inventor names listed in patents awarded to source firms, the algorithm yields 1,166 mobility events, of which 841 originate from California-based firms. An inventor is present in the data for 2.2 years on average, measured as the mean difference between the first and last patent application date. For 51,615 firm dyads over a roughly 30-year time window, the mobility rate is approximately 0.08% per dyad-year. This estimate appears slightly higher than 0.05% mobility rate reported in Rosenkopf and Almeida (2003), who find 120 events for 13,986 firm dyads and 15-year time window. The higher rates captured in our sample could be due to our inclusion of more recent data. As Kim and Marschke (2005) report, turnover among college educated electrical engineers has risen steadily over the past few decades. Other recent studies report mobility rates in the range of 1%-2% per inventor-year (Fallick *et al.*, 2006; Tzabbar *et al.*, 2006). On an inventor-year basis, our estimates are similar, at 1.88%.

Litigiousness, our measure for IP toughness, is a time-varying measure based on the observed behavior of a focal source firm in enforcing its exclusionary rights to patent-protected technologies. We measure "litigiousness" using a five-year moving sum of the number of unique patent infringement lawsuits launched by a focal source firm between 1973 and the focal year of observation.[17] We experimented with alternative measures such as lagged cumulative counts or moving sums using different time windows ranging from one year to all available years. The litigation counts are highly correlated over time and using the alternative measures has little qualitative effect on the estimated coefficients. The magnitude of the coefficient on the litigiousness variable appears to be largest for measures when using a roughly five-year window. This suggests

[17] Legal disputes over patents often involve multiple suits and countersuits between parties; the same dispute may also be counted multiple times in the data due to simple changes in venue. To provide a more conservative estimate of "litigiousness" in patent enforcement, we screen out such duplicative listings. For example, if three lawsuits involving Intel suing Broadcom for patent infringement are reported in 2000, the dispute is counted only once as a litigious action that year by Intel. Since we are interested in devising a firm-specific proxy for taking litigious action, we also omit instances in which the firm is defending against lawsuits filed by others.

that lawsuits older than five years have very little effect on the inventor behavior and aggregating more years only increases noise in the measure.

The three recipient firm characteristics used for the subgroup analysis—*Public, Small*, and *Young* are dummy variables set equal to 1 for firms that are private, small, and young firms respectively (else = 0). If a firm is listed on the New York or NASDAQ stock exchanges, we code it as public (else private). While we control for size using a more continuous measurement (see below), we define a firm as small if it employed less than 100 employees, which corresponds to the 60th percentile of the size distribution in any given year. A young firm is identified as one that that has existed less than five years in a given year based on years since founding. Alternative cut-offs (at 500 employees for size, and 12 years for age) yielded similar results.

Finally, the source firm dummy variable used in the subgroup analysis is the *CA Source firm.* Information about headquarter location was compiled from several sources, including Hoovers, Compustat, and VentureOne. Of the 129 source firms in the estimation sample, 80 are headquartered in California. A natural question is whether the lion's share of the employees engaged in these firms' inventive activities reside in the headquarter state. Within our sample (which restricts attention to innovative activity within the U.S.), this is generally the case. For the median California-based company, almost 90% of inventors list California as the state of primary residence. The percentage is somewhat lower (~70%) for firms headquartered in other states, which presumably reflects that semiconductor firms headquartered in other states often locate some R&D activity in California, in part to gain access to engineering talent and know-how.

Control Variables

Prior studies identify numerous factors (unrelated to a firm's litigiousness over patents) that influence the number of times a given firm may cite patents owned by another firm. We therefore include controls for firm- and dyad-level factors shown to affect citation behavior in general (Jaffe and Trajtenberg, 2002) and in semiconductors in particular (Rosenkopf and Almeida, 2003).

For each source and recipient firm, we construct the following time-varying firm-level variables. *Age* is defined as year t minus the founding year of the firm. *Log Patent Stock* is a count of patents awarded to a firm in a year t. It is measured in logs due to skewness. *Log Size* is the number of employees in year t, also measured in logs.[18] *Log Citability* is the number of citations a firm receives from all other sample firms in a year t. Following Rosenkopf and Almeida (2003), the *Citability* measure is used to establish a baseline likelihood that patents in a firm's portfolio are referenced by others and is used to control for the overall quality of a firm's patent portfolio.

We also include the following dyad-level characteristics. *Alliances* measures the moving sum of alliances formed between firms in a dyad over the last five years including the focal year. (Using other forms of cumulative counts had no effect on the results.) Similar to prior research, we recorded the entire range of alliances including marketing, licensing, design, support, manufacturing, and equity. When the alliance involved more than two firms, we recorded each alliance separately within the dyads. Our search of alliances reported in SDC Platinum complemented by an extensive search of the LexisNexis database identified 1,168 collaborative agreements among firms in the sample (199 originating in SDC Platinum, the remaining 969 in the LexisNexis database). *Technological distance* measures the Euclidian distance between patents awarded to source and recipient firms, based on the distribution across U.S. patent classes.[19] The measure theoretically ranges from 0 (perfect overlap) to a maximum of $\sqrt{2}$ for a perfectly distinct patent portfolio (all patenting in a single class distinct for each firm). In our sample, the mean of the variable is equal to 0.48 and the maximum is 1.22. *Geographic match* is set to one when both firms within a dyad have headquarters in the same Consolidated Statistical Area (CSA) based on the U.S. Census classification providing a more fine grained level of analysis than using regions (for instance, San Francisco and Silicon Valley constitute one CSA. However, San Diego area and Los Angeles area are separate CSAs). Finally, to

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[18] Since we obtain the size data from two different sources – the Compustat database for the public firms and the VentureOne database for the private ones - we do not have complete and longitudinal information for our entire sample. In fact, only the data for the public firms are time variant and unfortunately incomplete with missing information in a few years post founding and before the exit. We fill in the blanks by using the first and the last available size information for the early and late missing data. For instance, if a firm is founded in 1997 and the first size information is for 1999 with 25 employees, we assume that in 1997 and 1998, the firm had 25 employees as well. All private firms in the sample have time invariant size information but are also generally much smaller than the public firms.

[19] See Rosenkopf and Almeida (2003) for a more detailed discussion of how the measure is constructed. An earlier measure, which is very similar in spirit, is technological "proximity" (Jaffe and Trajtenberg, 2002). We employ the version used by Rosenkopf and Almeida given our desire to benchmark with their study.

allow the baseline citation rate to change over time, we include a series of period dummies in the regressions for the following intervals: pre-1980, 1980-1984, 1985-1989, 1990-1994, and 1995-1999. The omitted category comprises the years 2000-2003.

Summary Statistics

Table 1 and Table 2 provide summary statistics and bivariate correlations for the variables in our study, at the dyad-year level of observation. In viewing the statistics, it is important to note that the number of observations varies considerably among the dyads; pairs of longstanding firms within the industry will have more observations over the time period than will pairs involving a longstanding firm and a startup. Figure 1 plots the time distribution of patent infringement lawsuits initiated by source firms in our sample. Firms in this sector appear to have grown more litigious in enforcing patents since the mid-1980s. This trend is consistent with claims that "pro-patent" policy shifts triggered firms to adopt a more aggressive stance toward the acquisition and enforcement of patents (Landes and Posner, 2003; Bessen and Meurer, 2006). We nonetheless observe considerable heterogeneity among firms in their propensities to enforce patents: while 45% had initiated at least one patent infringement lawsuit by 2001, the remainder had not. Table 3 lists the top 20 litigants. The top two firms (Intel and Texas Instruments) are large, established firms within the industry. The other top litigants nonetheless range widely in age and size. The share of California-based firms on the list (60%) is on par with their broader representation in the sample (61%).

Estimation Method

As discussed earlier, several recent papers use patent citation data to investigate inter-firm knowledge spillovers due to movement of inventively productive employees (e.g., Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003). To build on this prior work and establish relevant baselines for comparison, we first reproduce a specification employed in Rosenkopf and Almeida (2003) before introducing the focal variables of interest in our study.

We select the Rosenkopf and Almeida (2003) model as a base specification for several reasons. First, their dyad-level specification incorporates insights from prior work (e.g. Jaffe *et al.* 1993; Mowery *et al.* 1996) and controls for firm-level as well as dyad-level characteristics known to affect citation behavior. Focusing on the dyad allows consideration of all possible citation pairs and the longitudinal form of the patent data allows for more precise modeling of the hypothesized causal mechanisms. Second, they introduce to the Almeida and Kogut (1999) model interaction terms (e.g., relating mobility events with various measures of distance) that are shown to significantly affect patterns of citation. Finally, and perhaps most important, their empirical context is the semiconductor industry, thus they provide a useful basis for comparison and benchmarking.

We extend the Rosenkopf and Almeida (2003) framework by including additional variables and modeling the analysis as a panel with the combination of the citing-cited firm dyad and year uniquely identifying the observation.[20] We then introduce to this base-line model the key variable of focal interest in our study—a firm's reputation for being tough in the enforcement of patents, and its interaction with employee mobility—and test for heterogeneous effects on different types of firms. As a final step, we conduct a series of additional robustness checks.

Since the dependent variable is the number of citations that a recipient firm makes to patents owned by a focal source firm in a given year, we use count data models that allow for excess zeros in the empirical specification. Following Rosenkopf and Almeida (2003), we first estimate negative binomial regressions, which tend to be used when conditional variance exceeds the conditional mean.[21] We allow for non-independence across annual dyad-level observations and use error terms that are robust to heteroskedasticity. As an alternative approach, we ran all models using zero-inflated negative binomial models as well as Poisson models with robust variance matrix, which generated qualitatively similar results as those shown below.

RESULTS

To test H1, we examine the interaction effect of mobility events between a source firm and recipient (*Mobility*) with the source firm's reputation for toughness (*Litigiousness*). If our prediction holds, we should expect a negative and significant coefficient on the *Litigiousness*Mobility* interaction

[20] Rosenkopf and Almeida (2003) aggregate the data into two time windows (1980-1989 and 1990-1995) and assume that citations made during the second time period are a function of mechanisms measured during the first.
[21] Likelihood ratio tests strongly rejected the hypothesis of no over-dispersion ($p<0.001$) in our sample.

term. To test H2 and H3, we create subgroups based on the relevant variable of interest, and use a Wald test for differences in coefficients within a seemingly unrelated regression framework.

The main results are reported in Tables 4 and 5.[22] In Column 1 of Table 4, we reprint results published in Rosenkopf and Almeida's 2003 study. In Column 2, we present the results of an identical specification using our sample of firms and dyad-year observations. Despite differences in the years and firms represented in our sample,[23] the results in Column 4 mirror (albeit with some exceptions) findings reported in the Rosenkopf and Almeida (2003) study and previously shown elsewhere (e.g., Mowery *et al*., 1996): firms that are technologically distant from one another are less likely to build on (or cite) one another's patents whereas firms that are geographically proximate are more likely to do so. We also find support for the two main predictions posed in Rosenkopf and Almeida (2003) regarding mobility and alliances. Firms hiring inventors from others that are more technologically distant stand to gain more from such mobility events. Further, we find a positive effect for alliances, which is hypothesized but statistically indistinguishable from zero in their paper.

Column 3 of Table 4 introduces the litigiousness variable (which is positive and significant), while Column 4 adds the interaction term of focal interest (*Litigiousness**Mobility*). As predicted in H1, the coefficient on *Litigiousness**Mobility* is negative and significant. These results suggest that even though litigious firms have patents that are highly cited, their patents are built upon less extensively by firms that hire their employees than otherwise would be predicted given observable characteristics of these firms. This finding is consistent with the view that reputations for toughness in IP enforcement cast a shadow over knowledge dissemination activities.

Table 5 reports the results from the sub-group analysis. We find strong support for H2a,b, and c. The coefficients for *Litigiousness**Mobility* for private, small, and young firms are more than

[22] All models reported in Tables 4-6 include period dummies except for Models 5 and 6 in Table 6, where annual time dummies are used instead since these models are estimated on a sub-sample of recent data. Recall that error terms allow for non-independence in the dyadic annual citation counts. A one-tailed test is used for hypothesis testing.

[23] Rosenkopf and Almeida capture activity at an earlier point in time; 1995 represents the last citation year included in their study. Their source firm sample, unlike ours, includes diversified firms involved in semiconductor production (e.g., AT&T) and semiconductor producers headquartered outside the U.S. (e.g., Hitachi), thus introducing greater variance in dyad-level dimensions of geographic and technological proximity. In contrast, our sample provides more comprehensive coverage of the innovative activities of U.S. firms that compete primarily in semiconductor product markets, including recent private and public entrants.

double the size of their counterparts, and the Wald test strongly rejects the hypothesis that the coefficients are equivalent within the respective subgroups. Columns 7 and 8 test for whether the coefficient of *Litigiousness*Mobility* is significantly different for California and non-California source firms (H3). We find little evidence supportive of this prediction. In fact, the size of the coefficient (for the *Litigiousness*Mobility* interaction term) is *more* negative for California-based firms, which runs counter to our prediction. Based on the Wald test, however, the difference between the two coefficients is statistically insignificant.

Robustness Checks

A natural question is whether these results are driven by unobserved characteristics of a source or recipient firm (or their relationship to one another) that are imperfectly measured by our right-hand-side variables. Those unobserved traits could affect the propensity of others to cite a firm's patents for reasons unrelated to reputations for IP toughness. One way of dealing with this explanation (of an unobservable latent variable) is to employ a fixed effects specification. We view this approach as highly restrictive in the context of our study, which is intended to examine across-firm variation due to heterogeneity in strategic reputation building. Further, reputations for toughness arguably evolve slowly, therefore making estimation of "within firm" changes difficult. A second drawback with a simple fixed effects specification is the underlying assumption that the unobservable traits of focal interest remain stable over time. Given the thirty-year window of our study, such an assumption is quite strong in this setting. Nonetheless, the results in Table 6 (Columns 2-4), show that the *Litigiousness*Mobility* coefficient remains negative and significant even when subjected to these additional tests.[24]

As an additional robustness test, we omitted citations added by examiners from the sample and re-estimated the results with the subset of patents awarded since 2001 for which such data are available. The results, shown in Columns 5 and 6 of Table 6, are interesting. The *Litigiousness*Mobility* coefficient remains negative and highly significant irrespective of whether examiner-added cites are

[24] The number of observations differs across the specifications in Columns 2-4 of Table 6 since "within unit" changes must be observed over time for the effects to be estimated. Thus, for example, Column 2 (that includes recipient firm fixed-effects) drops observations for recipients that never cite source firms in our sample.

included or removed from the sample. The magnitude of the effect, however, is almost twice as large in Column 6, where examiner-added cites are omitted, than it is in Column 5, which includes both examiner- and applicant-added cites. While we can only speculate as to why this discrepancy might arise, this pattern is consistent with the view that patentees most concerned about being "caught" (for potential allegations of infringement) have stronger incentives to omit troublesome prior art references when applying for patents, as argued recently by Lampe (2007). Future research could examine this issue more closely, ideally through use of interviews and/or surveys.

DISCUSSION AND CONCLUSION

"Don't let your employees do to you what you did to your former boss!"[25]

While "job hopping" by engineers and scientists is widely heralded as a vibrant channel for knowledge dissemination, far less is known about the actions firms take to *reduce* the outflow of know-how and talent from their own organizations. This study investigates the effectiveness of a lever that has received little attention in prior research—being "tough" in the enforcement of intellectual property. In doing so, we shed new light on the strategies firms use to capture value from their innovation-related investments.

Drawing on a unique and rich database of patent lawsuits, inventor mobility events, and patent citations in the U.S. semiconductor industry during a three-decade period, we find, in support of our hypothesis 1, that a firm's litigiousness over patents significantly curtails the outward dissemination of technological knowledge that would otherwise be expected from employee departures. These findings are consistent with the view that the filing of patent lawsuits, which are costly actions and observable to third parties, provides a sorting function whereby "tough" employers can be discerned more credibly from their passive counterparts. Such evidence of past litigiousness sends a strong signal to third parties (whether employees or their potential hirers), thus shaping their behavior. Building on earlier work on strategic deterrence and predation, this study

[25] Golden Rule attributed to Roger Borovoy, former General Counsel at Intel Corporation (Jackson, 1994: p. 214).

shows how corporate reputations for "toughness" can be valuable to firms seeking to deter against unauthorized transfers of proprietary technologies and know-how through employees departures.

Our results further suggest that firms disadvantaged to fund or withstand an IP-related dispute take added precautions to "avoid the shadows" of litigious firms. More specifically, consistent with our hypothesis 2, our estimates suggest that corporate reputations for toughness are particularly powerful in curbing knowledge outflows to firms that are young, small, or private, characteristics most often associated with entrepreneurial ventures. While entrepreneurial firms are widely viewed as an important source of creative destruction (Schumpeter, 1942) due to their novel innovations, our findings underscore the hurdles that these firms may face when introducing technologies that may disrupt market leaders. Given high costs and uncertainties associated with being involved in IP litigation, particularly when such suits can prolong over time, our findings show that entrepreneurial firms may choose not to enter technological arenas dominated by firms that have a reputation for being very litigious. Thus, these findings contribute new evidence to a handful of studies that explore how the high costs of patent enforcement may tilt advantage toward firms with superior resource endowments (Lerner, 1995; Lanjouw and Lerner, 2001; Lanjouw and Schankerman, 2001). From a policy perspective, these results suggest that current initiatives to lower the costs of adjudicating patent rights in the United States may warrant serious consideration.[26] If the costs and uncertainties of IP-related conflicts are more burdensome for startups than for more established enterprises, the organization of innovation activity could be redirected toward more incremental (or less disruptive) activities.

Finally, we theorized in hypothesis 3 that environmental conditions that foster entrepreneurial activity, as characterized the Silicon Valley and California in technology-based industries, reduce the impact of IP litigiousness on knowledge spillovers through employee mobility. Empirically, we find little evidence that reputations for patent litigiousness are less effective as a spillover-reduction mechanism for semiconductor firms headquartered in California than they are

[26] These initiatives and other proposed reforms to the U.S. patent system are discussed in Lemley and Shapiro (2005).

for firms headquartered in other states. The lack of supporting evidence for this prediction has important implications, both for firm strategy and for government policy. From a strategic perspective, the non-finding highlights the intriguing possibility that, when seeking to reduce leakage of proprietary know-how from employee departures, firms may be able to compensate for lower levels of environmental support by enacting aggressive strategies that build on firm level capabilities. Our results indicate that when firms are confronted with weaknesses in state-level laws governing employment contracts, they may nonetheless leverage federal-level policies governing IP protection, which have strengthened considerably over the past few decades (Jaffe, 2000). Importantly, even within the job-hopping culture and overall practice of "informal know-how trading" in California (von Hippel, 1987; Saxenian, 1994), California based firms that develop reputations for IP toughness are equally effective as similar firms that are not based in California, showing that such firm level strategic levers matter across different institutional settings. Further, the public policy implications of our lack of support for H3 are non-obvious. To the extent that aggressive IP enforcement helps reduce knowledge spillovers that would otherwise arise through the movement of employees, firms may have greater incentives to invest in human capital and R&D. At the same time, the vitality of innovative regions such as the Silicon Valley is widely attributed to such "job hopping" and the corresponding diffusion of technological know-how and discoveries across firm boundaries (Saxenian, 1994). If reputations for IP toughness curb the inter-firm dissemination of technological knowledge, particularly to startups, regional dynamics could be threatened.

Limitations and Future Research

Both the limitations and the findings of the study present avenues for future research. First, while the semiconductor industry represents a canonical context for examining the research questions, our findings may be limited in generalizability given this single-industry focus. Future research that examines whether reputations for IP toughness matter in other industry contexts will be useful, particularly as they may enable the identification of boundary conditions to when and where such strategies may be most effective. Second, while we use "IP enforcement" and "patent enforcement" interchangeably in the paper, our focus on patents and patent enforcement as IP enforcement does not account for the alternative mechanisms (such as trade secrets, non-compete agreements, copyrights, trademarks) available to firms for protecting their technological know-how. An interesting avenue for future research relates to whether litigiousness over other legal forms of IP rights reinforces corporate reputations for toughness gained through patent enforcement. If true, the magnitude of effects reported in this study would be understated. Similarly, our study focuses only the effects of IP toughness on a single channel of knowledge transfer—employee mobility. Future research that examines alternative strategies for building reputations for IP toughness, and compares the efficacy of such strategies across multiple channels of knowledge transfer (such as alliances, vicarious learning, or reverse engineering) will greatly enhance our understanding of the boundary conditions to value appropriation (Agarwal *et al.*, 2007).

Third, since our empirical analysis hinged on the use of patents data to identify the mobility events across firms, our observations are necessarily restricted to instances where the inventor was identified on patents assigned to more than one firm within our focal sample. Missing from the sample, thus, are instances where the mobile employee may have had minor involvements or had general awareness of the technology while it was being developed. Similarly, technologies that were in the initial stages of development, but were not patented prior to the employee departure, are not captured in our study. The resource intensity required to gather such data limits our ability to incorporate these issues in the study. However, a priori, there is no reason to expect that the reputations for IP toughness would differentially affect knowledge transfer through mobility of inventors peripherally involved in the technology development, or the mobility of non-scientific personnel.

Fourth, while our results are robust to alternative measures of the litigiousness, our study naturally invites further investigation of the following questions: How and in what manner should a firm *build* a reputation of toughness? For instance, as mentioned in the introduction, Intel's CEO Andy Grove had initiated a strategy of temporarily filing two IP suits per quarter. Is such a strategy of filing a series of legal attacks in short sequence particularly powerful? Or, given the costliness of litigious action, is one strong and highly visible act of aggression sufficient? Similarly, do reputations for toughness need to be *maintained* once they are built? Our robustness checks indicated some erosion of the "stock" of IP toughness reputation over time, given that the 5-year litigiousness measure out-performs the proxy based on total cumulative counts. More generally, little is known about the extent to which, if at all, the time path required to build (or lose) corporate reputations are domain-specific or similar across different sets of activities. Are "reputations for toughness" over IP rights quicker to build (and slower to erode) than reputations for "goodness" in product markets or in environmental and other social responsibility activities? Future research examining the cost-benefit tradeoffs for building alternative forms of reputations can help shed light on these questions.

Fifth, our findings for the moderating effect of IP toughness on knowledge spillovers through employee mobility have important implications for issues relating to individuals' decisions to join or leave an organization, as well as for shaping their behavior during their tenure at the firm. Examining this interwoven set of issues is beyond the scope of this paper. A resulting limitation of the study is that we do not explicitly model the potential effects of IP toughness on employee decisions to enter or exit an organization (and the corresponding incentives and motives of potential hiring organizations). Understanding the longer-term consequences of building reputations for IP toughness in terms of employee recruitment, incentives, and retention is an important avenue for future research. For instance, the immediate effect of building a tough reputation may be to reduce employee exit, thus causing an even lower transfer of knowledge. However, such reputations may also influence the decisions of employees to disclose novel ideas to their employers (Anton and Yao, 1995), thus adversely affecting the development of new knowledge within organizational boundaries. In the longer term, aggressive IP enforcement may alter the ability of the organization to hire skilled labor. Moen (2005) and Franco and Filson (2007) find that individuals with entrepreneurial aspirations often accept a reduction in pay to apprentice for the "best" firms. Given our findings that entrepreneurial firms are relatively more disadvantaged in the face of litigious behavior, such individuals may be reluctant then to join a firm that is reputed to be "tough," since it curtails their chances for better advancements outside the firm's boundaries. Thus, if such reputations make it more difficult or costly to attract key talent, or trigger an exodus of "star" inventors, it is possible that firms could win the battle but lose the war by adopting a litigious stance toward proprietary know-how and technologies. Similarly, the trade-offs between such "toughness" and more rewards-based systems (e.g., use of bonuses, stock options, and/or vestment periods) remain unaddressed in this study, which naturally invites continued research.

Contributions

These limitations notwithstanding, our study makes several important contributions. Prior studies of knowledge spillovers through employee mobility (e.g., Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003; Song *et al.,* 2003) implicitly assume that former employers of mobile talent play a passive role in the process by which knowledge diffuses across firm boundaries. By relaxing this implicit assumption, we contribute to a nascent stream of research on the mechanisms firms use to safeguard against the inadvertent leakage of know-how and proprietary technologies. In addition to "keeping a distance" from key rivals when entering foreign countries (Alcacer and Chung, 2007), altering the composition of inventive teams (Zhao, 2006), and enforcing non-compete agreements in employment contracts (Gilson, 1999; Stuart and Sorenson, 2003; Marx *et al.*, 2007), we show that firms may also engage in reputation-building activities by enforcing legal rights to intellectual property.

The study also builds on and extends the literature on reputation effects in corporate strategy. While much recent work emphasizes the benefits of being "good," either as socially responsible corporate citizens or as high quality producers (see Roberts and Dowling, 2002), earlier studies have highlighted the reputational benefits of being "tough" or "aggressive" (Kreps and Wilson, 1982; Milgrom and Roberts, 1982). Our study shows that the insights from such strategic interaction models of competitive dynamics in product markets can also inform the interplay between an employer's IP litigiousness and employee-driven risks of expropriation. Just as reputations for predatory pricing may enhance monopoly advantage by curtailing entry, so may reputations for aggressively initiating patent infringement lawsuits limit knowledge transfer through a key conduit—mobile employees. To the best of our knowledge, our study is the first to provide systematic evidence on this issue, thus reinforcing impressions drawn from anecdotal evidence discussed in the introduction of the paper.

Finally, within the literature on IP litigation, prior studies show that firms are more likely to enforce economically valuable patents (e.g., Lanjouw and Schankerman, 2004; Allison *et al.*, 2004) and are more litigious when the strategic stakes are higher (Somaya, 2003). By casting IP enforcement as a broader "reputation-building" strategy that is salient to employer-employee dynamics, we add new insights to this literature. In this respect, our paper is perhaps most similar in spirit to recent work by Kim and Marschke (2005), which emphasizes a patent's role in protecting firms from expropriation by insiders who leave to join rival firms or to start new companies of their own. While Kim and Marschke find that firms file for patent protection more aggressively when faced with increased rates of employee turnover, they do not consider the added reputation effects that accrue through patent enforcement. Our study also provides new evidence on how the high costs associated with IP litigation can differentially affect the behavior of small firms, thus contributing to prior research on this important topic (Lerner, 1995; Lerner and Lanjouw, 2001; Lanjouw and Schankerman, 2001).

In conclusion, our study theorized and found evidence that corporate reputations for "toughness" in IP enforcement significantly influence the knowledge spillovers that arise when employees leave to join rivals or form new companies of their own. Such reputations have a stronger effect on knowledge transfers to entrepreneurial firms and are equally effective in institutional domains and cultures known to foster inter-firm knowledge exchanges. The study sheds new light on the strategic levers firms use to capture value from investments in human capital and R&D and reveals promising pathways for continued research.

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Appendix: Methodology for Matching Inventor Names

We match the patent inventor records using the following procedure. First, we aggregate inventors on the patents assigned to the firms using exact match on the first and last name within each firm.[27] Next, we generate two subsets: the first uses the last patent associated with that inventor at the source firm; the second uses the first patent associated with that inventor at each recipient. We then match the two sets against each other using exact match on the first and last names. All matches that occur following an acquisition by one firm of another are omitted, which removes about 15% of the observations. Put differently, if inventor XY patents at the firm A in 1997 and at the firm B in 1998 and B acquires A in 1997, it is not treated as a mobility event.

If the middle initials are the same, a match is recorded; if they are different, the event is discarded (for instance, M and Michael is considered the same middle initial). If one or both of the records have missing middle initials, the record is flagged and matched manually using other criteria like geographical proximity, metropolitan density, and common name frequency. For instance, John Smith is less likely to be a match to any other John Smith than Vladimir Rumennik to Vladimir Rumennik. As discussed by Trajtenberg et al. (2006), the likelihood of a match is amplified in small metropolitan areas and over small distances.

Finally, we impose the rule that the application date of the last patent for a given inventor in a source firm must precede the application date of that inventor's first patent in a recipient firm. To correctly recreate the movement history, each event is matched against the first possible move.[28] The

[27] Using the exact match appears as a robust and parsimonious way to generate matches. Complete manual match on a subset of the data revealed that misspellings and different name versions on first and last name account for less than 2% of the actual mobility events — type I error. The differences in the middle initial account for about 3% of the events but such events are correctly recorded by our procedure. We also discovered that using fuzzy match on the first and last name would dramatically increase the amount of false matches — type II error — excessively increasing the burden on the manual cleaning.

[28] For instance, the result of the matching algorithm can be:
Inventor AB events:

Event	Source Firm	Last Patent Date	Target Firm	First Patent Date
1	X	1/1/1999	Y	12/4/2000
2	X	1/1/1999	Z	4/22/2002
3	Y	3/5/2001	Z	4/22/2002

Only events 1 and 3 are recorded as mobility events.

events are then manually cleaned for patent co-assignments (patent may be assigned to both source and target firm at the same time; we have 50 such occurrences in our sample) and concurrent patenting at more than one assignee (appearing as moving back and forth between the firms). Any instances where the same inventor appears at more than one assignee at the same time or any questionable patterns (all patents at different employers in the same year) are excluded as mobility events and checked for possible separate patent histories—two inventors with the same name.

Figure 1: Annual # of Patent Infringement Suits Initiated by Source Firms: 1973-2001

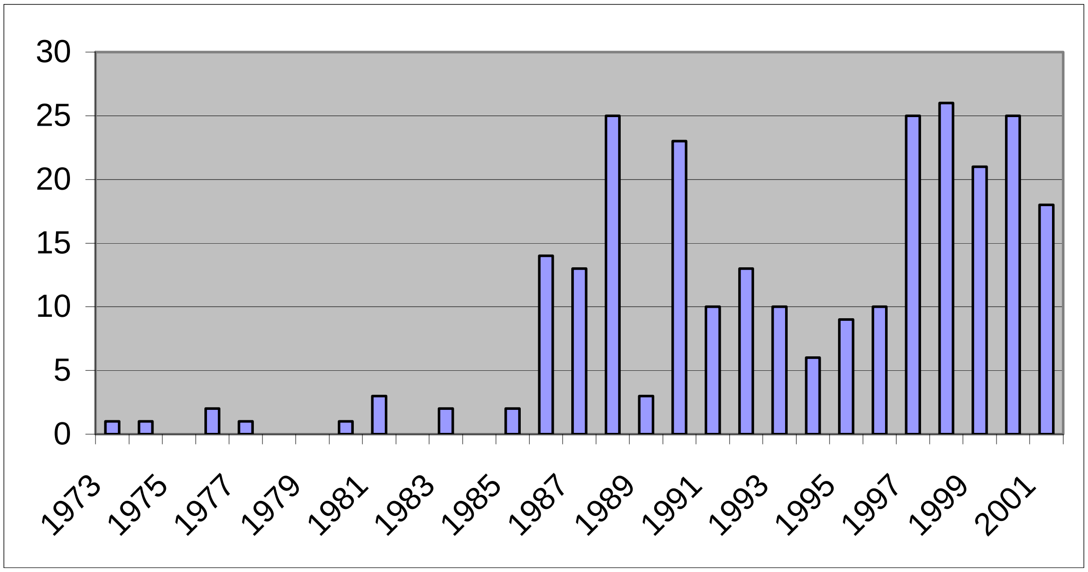

Figure 2: Dyad Observations by Year

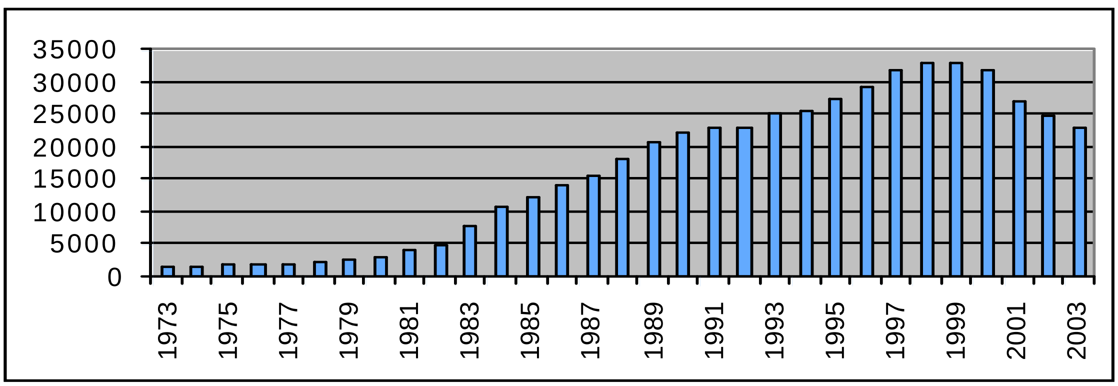

Table 1: Variable Definitions and Summary Statistics
(Dyad-Year Unit of Analysis)

Variable	Definition	Mean	St. Dev.
Dependent Variables			
(1) Total citations	Annual number of citations made by the recipient to the source firm's patents.	0.116	3.061
Main Independent Variables			
(2) Litigiousness	Moving sum of patent litigation lawsuits over the last five years including the given year by the cited firm.	0.579	1.987
(3) Mobility	Moving sum of mobility events from the citing to the cited firm over the last five years including the focal year as measured by the application year of the citing firm patent.	0.007	0.119
Control Variables			
(4) Age (recipient)	Recipient firm age: Focal year-founding year.	10.202	10.709
(5) Age (source)	Source firm age: Focal year-founding year.	16.313	12.205
(6) Log citability (source)	Log of the number of citations the source firm received from all sample firms within the preceding five years, as measured by the application year.	0.966	1.541
(7) Log patent stock (recipient)	Log of the number of patents the recipient firm received in a focal year, as measured by the application year. Patents of acquired firms are counted starting with acquisition year + 1.	0.805	1.160
(8) Log patent stock (source)	Same as (7).	1.089	1.420
(9) Log size (recipient)	Log of the number of employees in a focal year. Time invariant for firms from the VentureOne database. Missing data filled in using the first and last record available (see text for details).	4.993	1.675
(10) Log size (source)	Same as (10).	5.913	1.682
(11) Alliances	Moving sum of alliances over the last 5 years including the given year between the firms in a dyad.	0.002	0.050
(12) Technological distance	Technological distance between the source and recipient firms. Calculated as Euclidian distance between the normalized vectors representing proportions of patents in each patent class. See Rosenkopf and Almeida (2003) for details.	0.489	0.193
(13) Geographic match	Dummy = 1 if cited and citing firms have headquarters in the same Consolidated Statistical Area (CSA).	0.251	0.434
Subgroups			
(14) Recipient Private firm	Dummy = 1 if recipient firm is privately owned; 0 if public.	0.418	0.493
(15) Recipient Small Firm	Dummy = 1 if recipient firm's size is below 60% percentile (<100 employees), 0 if large.	0.570	0.495
(16) Recipient Young Firm	Dummy = 1 if recipient firm's age is less than five years, 0 if more.	0.435	0.496
(17) Source CA firm	Dummy = 1 if headquarter location of source firm is in California; else = 0.	0.613	0.487

Table 2: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(2)	0.054	1														
(3)	0.219	0.059	1													
(4)	0.027	0.001	0.024	1												
(5)	0.033	0.155	0.054	0.007	1											
(6)	0.078	0.282	0.064	-0.001	-0.010	1										
(7)	0.121	0.002	0.100	0.166	0.004	0.049	1									
(8)	0.086	0.334	0.073	0.000	0.058	0.858	0.043	1								
(9)	0.065	-0.021	0.067	0.490	-0.040	-0.006	0.534	-0.012	1							
(10)	0.069	0.392	0.090	0.003	0.393	0.424	-0.009	0.549	-0.016	1						
(11)	0.046	0.036	0.061	0.032	0.012	0.036	0.051	0.039	0.059	0.045	1					
(12)	-0.042	-0.010	-0.045	-0.104	-0.031	-0.044	-0.160	-0.052	-0.199	-0.080	-0.028	1				
(13)	0.013	0.031	0.039	-0.110	-0.128	0.101	0.045	0.093	-0.002	0.016	0.029	-0.003	1			
(14)	-0.025	0.037	-0.028	-0.407	0.086	-0.029	-0.243	-0.003	-0.556	0.037	-0.027	0.174	0.037	1		
(15)	-0.035	0.025	-0.039	-0.393	0.052	-0.003	-0.358	0.008	-0.773	0.021	-0.034	0.178	0.004	0.549	1	
(16)	-0.023	-0.002	-0.022	-0.643	-0.011	-0.027	-0.164	-0.018	-0.363	0.002	-0.030	0.090	0.062	0.378	0.349	1
(17)	0.003	0.056	0.013	0.000	-0.298	0.134	0.004	0.096	-0.013	0.018	0.019	0.007	0.384	0.015	0.013	0.000

All correlations above |0.01| are un-informatively significant at $p<0.05$

Table 3: Top 20 Source Firms in terms of Patent Litigiousness, 1973-2001[a]

Rank	Firm Name	HQ State	Founding Year	Employees (millions, firm-year median)	# infringement suits initiated
1	TEXAS INSTRUMENTS INC	TX	1951	66.2	39
2	INTEL CORP	CA	1968	21.7	38
3	OAK TECHNOLOGY INC	CA	1987	0.4	17
4	INTL RECTIFIER CORP	CA	1947	2.7	12
5	ADVANCED MICRO DEVICES	CA	1969	12.1	9
6	SKYWORKS SOLUTIONS INC (formerly Alpha Industries)	MA	1962	0.9	9
7	RAMBUS INC	CA	1990	0.1	9
8	ATMEL CORP	CA	1984	4.6	9
9	MAXIM INTEGRATED PRODUCTS	CA	1983	1.3	8
10	LINEAR TECHNOLOGY CORP	CA	1981	1.0	7
11	DALLAS SEMICONDUCTOR CORP	TX	1984	0.7	6
12	BROOKTREE CORP	CA	1981	0.6	6
13	CIRRUS LOGIC INC	TX	1984	1.3	6
14	MICROCHIP TECHNOLOGY INC	AZ	1989	2.0	5
15	MICRON TECHNOLOGY INC	ID	1978	4.9	5
16	NATIONAL SEMICONDUCTOR CORP	CA	1959	25.2	5
17	ANALOG DEVICES	MA	1965	5.2	5
18	CYPRESS SEMICONDUCTOR CORP	CA	1982	1.9	4
19	MENTOR GRAPHICS CORP	OR	1981	2.3	4
20	XILINX INC	CA	1984	1.3	4
	Top 20 Litigants (median values)	60% CA	1981	1.9	6.5
	All Source Firms (median values)	61% CA	1982	0.3	0

[a] Based on the total number of patent infringement lawsuits initiated by a focal firm during 1973-2001. Duplicate cases, changes of venue, and countersuits filed in a given year against the same party are omitted.

Table 4: Impact of IP Litigiousness on Knowledge Spillovers through Mobility
(Y=Annual # Citations made by Recipient to Source-Firm Patents; Negative Binomial Estimation)

	Rosenkopf & Almeida (RA) 2003 Results (Table 2, col 7)	**Replication of RA Baseline Model but w/ our data and dyad-year**	**Add Litigiousness**	**Main Model: Interact Litigiousness w/ Mobility**
Model	**(1)**	**(2)**	**(3)**	**(4)**
Main Variables				
*Litigiousness * Mobility*				**-0.070*** **
Litigiousness (source)			0.034***	0.038***
Dyad-Level Controls				
Technological distance	-1.7***	-4.330***	-4.352***	-4.356***
Geographic similarity (CSA match)	0.33***	0.524***	0.529***	0.529***
Alliance	-0.80*	-0.28	-0.258	-0.246
Mobility	-0.89**	-0.186	-0.169	0.005
*Mobility * geographic similarity*	*not significant (1)*	-0.007	0.003	-0.048
*Alliance * geographic similarity*	*not significant (1)*	-0.506*	-0.517*	-0.478
*Mobility * technological distance*	2.4***	3.066***	3.010***	3.050***
*Alliance * technological distance*	1.5***	2.031**	1.984**	1.928**
Firm-Level Controls				
Age (recipient)	-0.058***	-0.027***	-0.026***	-0.026***
Log Size (recipient)	0.083**	-0.230***	-0.231***	-0.232***
Log Patent Stock (recipient)	1.1***	1.412***	1.412***	1.414***
Log Patent Stock (source)	0.030**	0.096**	0.093**	0.093**
Log Citability (source)	1.1***	0.347***	0.341***	0.341***
Non-US firm (source)	0.36***			
Age (source)	*not included*	-0.001	-0.001	-0.001
Log Size (source)	*not included*	0.496***	0.472***	0.471***
Constant	-6.9***	-6.066***	-5.922***	-5.922***
Log Likelihood	-4,663	-47,051	-47,023	-47,007
Unit of Analysis	dyad	dyad-year	dyad-year	dyad-year
# Observations	13,986	506,374	506,374	506,374

* p<.1, ** p<.05, *** p<.01
1. Coefficients are not reported in RA 2003 main model but are insignificant when added separately

Table 5: Subgroup Analysis for Impact of IP Litigiousness on Knowledge Spillovers through Mobility

(Y=Annual # Citations made by Recipient to Source-Firm Patents)

	Public Recipient	Private Recipient	Large Recipient	Small Recipient	Old Recipient Firm	Young Recipient Firm	California Source	Non-California Source
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Main Variables								
*Litigiousness * Mobility*	**-0.057*** **	**-0.144*** **	**-0.064*** **	**-0.154*** **	**-0.057*** **	**-0.121*** **	**-0.073*** **	**-0.064*** **
Litigiousness (source)	0.037***	0.052***	0.049***	0.037***	0.040***	0.032***	0.077***	0.002
Dyad-Level Controls								
Technological distance	-6.761***	-0.969***	-6.635***	-1.662***	-6.635***	-1.860***	-4.609***	-3.821***
Geographic similarity (CSA match)	0.518***	0.784***	0.490***	0.813***	0.521***	0.749***	0.621***	-0.031
Alliance	-0.553	3.9	-0.697**	1.984	-0.723**	2.628	-0.238	-0.537
Mobility	-0.151	4.108***	-0.225	2.876***	-0.139	0.846	-0.028	0.646*
*Mobility * geographic similarity*	-0.083	-1.773***	-0.001	-1.099**	-0.181*	0.091	-0.266*	1.685**
*Alliance * geographic similarity*	-0.366	-2.182*	-0.403*	-0.98	-0.409*	-1.162	-0.452	-11.424***
*Mobility * technological distance*	3.066***	-0.941	3.263***	0.358	3.060***	2.400**	3.632***	0.219
*Alliance * technological distance*	2.564**	-2.719	2.873***	-1.213	3.222***	-1.333	1.871**	2.89
Firm-Level Controls								
Age (recipient)	-0.026***	-0.077***	-0.035***	-0.056***	-0.033***	-0.044**	-0.024***	-0.030***
Log Size (recipient)	-0.210***	-0.314***			-0.131***	-0.248***	-0.214***	-0.251***
Log Patent Stock (recipient)	1.229***	2.027***	1.033***	2.057***	1.209***	1.828***	1.370***	1.477***
Log Patent Stock (source)	0.128***	0.149***	0.139***	0.034	0.154***	-0.005	0.168***	0.093
Log Citability (source)	0.338***	0.234***	0.325***	0.379***	0.309***	0.412***	0.349***	0.261***
Age (source)	-0.003**	0.009***	-0.002	0.004	-0.005***	0.009***	0.012**	-0.010**
Log Size (source)	0.396***	0.528***	0.396***	0.502***	0.414***	0.501***	0.295***	0.665***
Constant	-4.176***	-8.770***	-5.103***	-9.234***	-4.749***	-8.074***	-5.164***	-7.215***
Log Likelihood	-36,520	-9,249	-34,032	-11,687	-33,525	-12,604	-31,338	-15,478
# Observations	294,886	211,488	217,688	288,686	286,002	220,372	310,210	196,164

Walt Test Statistic for equality of Coefficient of (Litigiousness * Mobility)

	(1)–(2)	(3)–(4)	(5)–(6)	(7)–(8)
Wald Test Statistic $\chi 2(1)$	11.21***	12.52***	8.24***	0.28

* *p*<.1, ** *p*<.05, *** *p*<.01

Table 6: Robustness Checks

(Y=Annual # Citations made by Recipient to Source-Firm Patents)

	Main Model (Table 3, Model 4)	**Recipient Firm Fixed Effects**	**Source Firm Fixed Effects**	**Dyad Fixed Effects**	**Patents issued post-2001, All citations**	**Patents issued post-2001, Inventor-added citations only**
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Main Variables						
*Litigiousness * Mobility*	**-0.070*** ***	**-0.010*** ***	**-0.003***	**-0.004*** *	**-0.045*** ***	**-0.084*** ***
Litigiousness (source)	0.038***	0.014***	-0.004	0.010***	0.034**	0.050**
Dyad-Level Controls						
Technological distance	-4.356***	-3.505***	-3.298***	-1.583***	-2.865***	-3.210***
Geographic similarity (CSA match)	0.529***	0.335***	0.341***	0.443***	0.413***	0.463***
Alliance	-0.246	0.053	0.152	0.595***	0.243	-1.767***
Mobility	0.005	0.007	-0.268***	-0.015	0.211	0.465
*Mobility * geographic similarity*	-0.048	-0.046***	0.018	0.004	-0.15	0.237
*Alliance * geographic similarity*	-0.478	-0.177***	-0.387***	-0.237***	0.139	-0.157
*Mobility * technological distance*	3.050***	0.767***	1.350***	0.135	2.241**	1.102
*Alliance * technological distance*	1.928**	0.721*	0.511	-2.390***	-1.416	-1.009
Firm-Level Controls						
Age (recipient)	-0.026***	0.008***	-0.018***	-0.015***	-0.014***	-0.044***
Log Size (recipient)	-0.232***	-0.124***	-0.071***	-0.256***	-0.338***	-0.494***
Log Patent Stock (recipient)	1.414***	0.797***	0.992***	1.046***	1.663***	1.910***
Log Patent Stock (source)	0.093**	0.141***	0.107***	0.132***	0.104*	0.11
Log Citability (source)	0.341***	0.221***	-0.003	-0.045***	0.354***	0.387***
Age (source)	-0.001	0.007***	0.025***	0.033***	0.003	0.001
Log Size (source)	0.471***	0.448***	0.415***	0.180***	0.572***	0.598***
Constant	-5.922***	-7.034***	-7.378***	-3.493***	-7.956***	-8.303***
Log Likelihood	-47,007	-43,412	-40,544	-22,529	-19,089	-10,905
# Observations	506,374	426,758	468,309	45,101	172,889	172,889

*p<.1. **p<.05, ***p<.01