

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

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## ABSTRACT

“Job hopping” by engineers and scientists is widely heralded as an important channel for knowledge spillovers within industries. Far less is known, however, about the actions firms take to *reduce* the outward flow of knowledge through markets for skilled labor. This study investigates the efficacy of a lever that has received little attention in prior research—corporate reputations for being “tough” in patent enforcement. Drawing on a unique database of enforcement activity, intra-industry inventor mobility events, and patent citations in the U.S. semiconductor industry, we find that a firm’s litigiousness significantly reduces the spillovers otherwise anticipated from departures of inventively productive employees, particularly when hiring organizations are entrepreneurial ventures. The effects of IP toughness are similar in magnitude for California-based firms relative to semiconductor firms headquartered in other US states. The study sheds new light on the strategic actions 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 (As quoted in Stephan, 2006)*

The mobility of scientists and engineers in labor markets provides a vibrant channel for knowledge dissemination within industries (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, Bhidé (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 lever for *reducing* knowledge spillovers in markets for skilled labor—building a corporate 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). 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 innovation-related investments (Somaya, 2003). Are there potential reputational effects of these litigious acts, and what are the 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 aggressively protect their exclusionary rights to technological know-how, often in direct response to unanticipated employee exits. National Semiconductor, for instance, filed a lawsuit 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, 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).<sup>1</sup> 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 systematically investigate the implications of such litigiousness for mobility-driven spillovers, we draw upon the strategy and economics literature on corporate reputations (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 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 to rivals. Second, we predict that tough reputations will be particularly powerful in curbing spillovers to “entrepreneurial firms” (i.e., organizations that are young, small, or private) given their relative disadvantage to fund and withstand an IP-related dispute. Similarly, we expect that entrepreneurial firms’ threat of litigious action will be perceived as less credible, thus eroding the reputation effects associated with IP enforcement. Finally, we predict that IP toughness will be less effectual as a spillover-reduction mechanism for California-based companies due to the unusually strong norms of informal knowledge trading and reciprocity characterizing innovative activity within the state (Saxenian, 1994; Gilson, 1999).

We test these predictions in the context of the U.S. semiconductor industry—a canonical setting used in prior studies to illustrate the technological spillovers associated with mobility of

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<sup>1</sup> This dispute is particularly interesting since Intel provided pre-IPO venture financing and technical assistance to Broadcom in hopes of creating complementarities in their product lines (AP Newswire, 2000).

engineers and scientists among firms (Angel, 1989; Almeida and Kogut, 1999). We integrate hand-collected data on patent litigation histories with broader patterns of inventor mobility and patent citation behavior within the industry in the 1973-2003 period. Building cumulatively on prior studies on “learning-by-hiring” in the semiconductor industry (e.g., Rosenkopf and Almeida, 2003; Almeida *et al.* 2003; Song *et al.*, 2003) we estimate spillovers using patent citations as a proxy.

The study contributes to three literature streams. In the context of the literature on knowledge spillovers through employee mobility, Agarwal *et al.* (2007) call for research on the boundary conditions and constraints on inter-organizational transfers of knowledge through employee mobility and entrepreneurship. Our study theorizes and provides evidence of the negative impact of reputations for toughness in IP enforcement on inter-organizational knowledge flows due to employee mobility. Second, our study 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 raises the possibility that litigious action may confer reputation effects that shape spillovers in markets for skilled labor, thus revealing a source of asymmetric stakes between litigating parties that has received little attention in prior work. In this context, our study also highlights the differential effects of IP enforcement on startups, which is relevant for policies aimed at fostering entrepreneurial activity and economic growth.

## **THEORETICAL FRAMEWORK**

### **Knowledge Spillovers through Employee Mobility**

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 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). 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; Phillips, 2002; Rosenkopf and Almeida, 2003; Agarwal *et al.*, 2004; Klepper and Sleeper, 2005). 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. Indeed, 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 by hiring employees from rivals.<sup>2</sup> 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 semiconductor firms that hire employees from other firms within the industry. Scholars have also examined whether employee mobility engenders explorative or exploitative search, and how firms should optimally organize themselves for knowledge transfer benefits (Madsen *et*

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<sup>2</sup> As in prior studies (Rosenkopf and Almeida, 2003), a *recipient* firm is a potential receiver of technological knowledge from another firm, and a *source* firm is a potential supplier of technological knowledge to others. Firms can assume both roles.

*al.*, 2003; Tzabbar *et al.*, 2007). Hiring experienced engineers and scientists from established firms is particularly important for innovation by entrepreneurial companies (Angel, 1989; Almeida *et al.*, 2003), and the related literature on spinouts—where employee mobility results in founding of new ventures—also extols the benefits of of inherited knowledge (Agarwal *et al.* 2004; Klepper and Sleeper 2005).

Less attention, however, has been given to the potential adverse effects on the *source* firm, particularly when the recipient firm is an actual or potential competitor within the same industry. Notwithstanding the benefits that source firms may receive when former employees join non-competing firms (Fleming *et al.*, 2007; Somaya *et al.*, 2007), there are two important reasons why employee mobility to rival firms may impose a negative externality: the source firm stands to lose valuable resources when employees leave and further, such departures potentially heighten the capabilities of rivals to the detriment of their own competitive advantage. Some scholars have examined contractual solutions, such as high wages, stock options and the inclusion of non-compete clauses in employment contracts as strategic levers against mobility-induced spillovers (Pakes and Nitzan, 1983; Fallick *et al.*, 2006; Marx *et al.*, 2007). However, labor economists have noted that such mechanisms may not solve the problem entirely, given positive transaction costs in the writing and enforcements of employment contracts (Acemoglu and Pischke, 1998; 1999; Kim and Marschke, 2005). Franco and Filson (2006) show that employees with entrepreneurial aspirations may not value monetary rewards alone, and Anton and Yao (1995) discuss why expropriation hazards in labor markets are imperfectly solved through contracts and incentives. Further, non-compete agreements are difficult to enforce in several states, including California where many technology-intensive companies are based.

Alternatively, firms may adapt their IP strategies in response to leakage concerns in labor markets. Kim and Marschke (2005) 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.<sup>3</sup> Left unanswered

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<sup>3</sup> 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: to establish theft, potential plaintiffs must reveal valuable private information, making them more reluctant to file suit. In contrast, patent-protected inventions are already public. Patents also confer a strategic advantage over trade secrets in contexts where improvements are easy to reverse engineer: while independent invention (through reverse engineering or other means) is a legal defense against trade secret theft allegations, reverse engineering of patented technologies can be held liable for infringement (Moore *et al.*, 1999).

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. 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). Similarly, corporations admired by peers out-perform less reputable firms (Roberts and Dowling, 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. Imperfect information can result 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 (Milgrom and Roberts, 1982). 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 if 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 of 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, a pooling equilibrium would arise and the signaling function of strategic action would unravel (Spence, 1974; Weigelt and Camerer, 1988). Finally, to shape the expectations of third parties, the action also must 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 mobility. When employees discover a novel, non-obvious, and useful invention during work, legal rights to any patents based on those discoveries are assigned (with rare exception) to the employer (Merges, 1997).<sup>4</sup> 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/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 light of these ownership rights and legal ambiguities, patents may

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<sup>4</sup> Fisk (1998) describes the shift in the early 1900s from a shop rights regime (employees owned patents which were licensed to employers) toward a pre-invention assignment regime (employees signed over invention rights *ex ante* 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). Modern U.S. courts continue to uphold 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).

help firms not only in safeguarding against unauthorized use of knowledge by imitators and product rivals but also in protecting against misappropriation by “insiders” (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.<sup>5</sup> The costs required to enforce patents are several orders of magnitude larger than those required to acquire patents. Lemley (2004), for example, estimates that the cost of obtaining a typical U.S. patent, inclusive of filing and attorney fees, is approximately \$20,000. Meanwhile, the AIPLA (2007) estimate of litigation costs for a patent dispute of average complexity hovers between \$3 and \$5 million. Patent enforcement is therefore a particularly useful lever to firms seeking to build reputations for “toughness” against the unauthorized use of proprietary technologies. The costliness of the activity provides an important sorting function. Moreover, once filed, patent lawsuits are frequently monitored by the press, which makes them widely observable. Employees and their potential hirers can therefore gauge which firms are likely to adopt a more protective stance against unauthorized uses of proprietary technologies.

Thus, corporate reputations for patent litigiousness should moderate the extent to which proprietary technologies disseminate through employee exits. 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 and observable 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 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.

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<sup>5</sup> 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 exclude others from use of the patented invention; it does not grant the patentee the right to use the patented invention if such use infringes upon others’ rights.

We note that it is not necessary for a firm to actively pursue IP litigation against all, or even many, of its employees. Similar to the entry deterrence models for firms operating 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. Even if the costs outweigh the benefits of being litigious in a particular dispute, the deterrence of future knowledge spillovers can justify the source firm’s investment. This logic also suggests that reputations can be built through litigious actions that are not specifically directed against mobility-driven leakage. If the former employer has invested in prior litigation to bar direct product market rivals from unauthorized use of its patent-protected technologies, hiring organizations and employees may perceive that the firm is “tough” rather than “passive” when protecting its IP.<sup>6</sup> In line with the strategic deterrence literature, these reputations can shape others’ behavior irrespective of whether action is realized in a particular instance. Accordingly, we make the following prediction:

*H1: Reputations for IP toughness will reduce the spillovers otherwise anticipated from intra-industry inventor mobility.*

Our second set of predictions investigates whether the IP toughness is a more efficacious mechanism for deterring employee mobility related spillovers for entrepreneurial vs. established firms, given differences in access to financial or managerial resources. Extant literature typically differentiates between entrepreneurial and established firms based on three related yet conceptually distinct firm-level characteristics: (a) lack of access to public equity markets (i.e., private ownership status), (b) firm size, and (c) firm age. Each of these characteristics could differentially affect the organizational and financial burdens associated with IP litigation, thus altering firm behavior in anticipation of potential conflict. Since these attributes tend to be highly correlated with one another, we refer to private/small/young firms collectively as “entrepreneurial” and distinguish them from their more “established” counterparts.

If recipient firms are differentially affected by the potential costs and disruptions of an IP-related dispute, we should expect heterogeneous responses to reputations for IP toughness. Consistent with the law and economics literature (Lerner 1995; Lanjouw and Lerner, 2001), we anticipate that

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<sup>6</sup> For example, in the 1980s, Intel invested heavily in patent enforcement against its main product market rival, Advanced Micro Devices (Jackson, 1997). Even though the lawsuits against AMD did not pertain to employee exits, these actions inform perceptions about Intel’s “toughness” in safeguarding against unauthorized use of proprietary technology.

entrepreneurial firms are at a relative disadvantage to fund or withstand an IP lawsuit vis-à-vis established firms, and will take greater precautions to avoid conflict when hiring employees from firms with 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: he shows that firms with high litigation costs (firms with fewer financial resources and low litigation experience) 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.<sup>7</sup>

Turning to specific characteristics associated with entrepreneurial firms, imperfections in capital markets can disproportionately affect the ability of firms to finance costly litigation (Lanjouw and Lerner, 1999). Relative to public companies, private firms are at a disadvantage when raising funds required to defend against potential claims of infringement, either by issuing additional equity to investors or by securing loans. 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, IP legal disputes can be particularly deleterious for small firms. Small firms are more likely than large firms to forgo certain research opportunities because of the potential disruption and cost of legal IP disputes (Koen, 1991). Lanjouw and Schankerman (2004) suggest that small firms are disproportionately handicapped when settling IP-related disputes due to smaller patent portfolios than larger firms which putting them at a bargaining disadvantage when “trading” IP rights. 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 when 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

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<sup>7</sup> Related work in law and economics examines how costly regulations or legal expenses differentially affect firms. In an influential early study, 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). The authors find that “compliance asymmetries” among firms in the costs of meeting occupational safety and environmental regulations differentially favors large firms at the expense of smaller firms within an industry. While not commonly cited in the strategy literature, the literature directly informs how costly activities (including legal disputes over IP) may have heterogeneous effects on firm behavior and thus sources of competitive advantage.

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.

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

*H2a: Reputations for IP toughness will reduce the spillovers anticipated from intra-industry inventor mobility to a greater extent for recipient firms that are entrepreneurial vis-à-vis those that are established.*

The same characteristics of entrepreneurial firms that disadvantage hiring organizations in IP-related conflicts may similarly undermine the ability of firms to *establish* credible reputations for “toughness” in IP enforcement. As discussed above, for reputations to be built, others must perceive that prior action is informative in predicting future behavior. Even if an entrepreneurial firm initiates a patent lawsuit (i.e., it engages in costly and observable action), its relative lack of resources may lead others to discount the probability that future events would be met with retaliation. Thus, building on the arguments set forth in H2a above, we similarly predict:

*H2b: Reputations for IP toughness will reduce the spillovers anticipated from intra-industry inventor mobility to a lesser extent for source firms that are entrepreneurial vis-à-vis those that are established.*

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 the Massachusetts Route 128 region firms to a unique configuration of West Coast culture, detachment from the traditional hierarchical business practices, and norms established by early 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 in labor markets, given that California’s state laws typically do not enforce non-compete covenants in employment (Gilson, 1999; Stuart and Sorenson, 2003). These factors are credited with creating a unique environment within the state that is characterized by extensive job-hopping and fluid communication of technical information and best practices across firm boundaries (von Hippel, 1987; Appleyard, 1996; Rogers and Larsen, 1984; Saxenian, 1994).

A stylized fact emerging from these studies is that information technology firms based in Silicon Valley and in California more generally 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). In such an institutional and business environment, the efficacy of firm-level strategies targeted at reducing spillovers is likely to be weaker. Consequently, California-based employers may find signaling toughness built through prior litigious activity more difficult even if they choose to engage in such behavior. Accordingly, we predict:

*H3: Reputations for IP toughness will reduce the spillovers anticipated from intra-industry inventor mobility to a lesser extent for California-based source firms vis-à-vis those headquartered in other US states.*

## **EMPIRICAL CONTEXT AND METHODOLOGY**

### **Industry Context and Data Description**

The context of our study is the U.S. semiconductor industry. The industry exhibits a high degree of employee mobility and prior studies document that such mobility facilitates inter-firm transfers of technological knowledge (e.g., 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 be increasingly active in enforcing those patents (Ziedonis, 2003; Bessen and Meurer, 2006).

Empirically, we trace the innovative activities of 447 U.S. semiconductor firms over the 1973-2003 period. We distinguish between firms that are potential *sources* of knowledge spillovers 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 “citing”) firms respectively.

The source firm sample (n = 136) is drawn from a comprehensive list of U.S. firms that a) compete primarily in semiconductor industry and b) are publicly traded for at least one year during 1973-1995. 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 any initiation of patent infringement lawsuits in U.S. courts during 1973-2001 based on data in Ziedonis (2003). These data merge case filings reported in legal databases (Litalert by Derwent) with supplemental information reported in archival 10-K filings, news articles, and press releases. As a result, we are able to determine when a firm actually files a patent infringement lawsuit against a third party, not just whether patents awarded to that firm are involved in litigation as is common practice (e.g., Lanjouw and Schankerman, 2001; Somaya, 2003).<sup>8</sup> Importantly, the time-varying data for each firm’s “IP toughness” permits us to observe patent litigation histories over the entire lifespan of these companies (i.e., post-founding), thus enabling us to test H2b (on the differential effects of IP toughness among entrepreneurial vs. established source firms).

To assemble a larger pool of potential “recipients” firms, we add to source firms (a) 454 venture-backed semiconductor firms founded during 1980-2001, using data provided by VentureOne and (b) 59 firms in the industry (SIC3674) that went public post-1995, identified from Compustat. Including recent entrants and startups in the recipient pool is particularly useful for our tests of H2a (of heterogeneous effects of IP toughness among entrepreneurial vs. established recipient firms).

Since knowledge flows and mobility events are identified in our study using patent data, we 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. 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. The final sample therefore includes 129 source firms, 266 private startups, and 52 recent public entrants. For the combined set of 447 firms, we

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<sup>8</sup> 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 (Ziedonis, 2003).

integrate financial and founding year data from Compustat, Hoover's Business Directories and VentureOne, patent data from Delphion and the National University of Singapore, information on alliances and cross-licensing activities from SDC Platinum and searches of news articles and press releases in LexisNexis and Factiva, and patent litigation histories (for source firms) from Ziedonis (2003). Between 1973 and 2003, sample firms collectively received 50,491 patents, of which 38,689 were 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 firm to patents of the source firm in a given year. A higher (lower) level of citations made by a recipient firm to a focal source firm's patents is interpreted as evidence of heightened (reduced) knowledge spillovers.

Consistent with prior research, we acknowledge that while patent citations are the best available option for large scale studies, they are nonetheless a noisy proxy for knowledge diffusion (Jaffe et al., 1993; Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003; Alcacer and Gittleman, 2006; Deng, 2008). Alcacer and Gittleman (2006) show that government examiners also add citations reported in patent documents, thus calling into question whether applicants truly "know" about technologies embedded in other patents they cite. However, Lampe (2007) argues and shows that firms (and their inventors) may have strategic motives for omitting citations to patents that are technologically close, reporting evidence from the semiconductor industry.<sup>9</sup> In such instances, citations added by examiners are useful in revealing otherwise unobservable technological linkages. In light of these unresolved controversies, we report robustness checks that both include and omit examiner-added cites.

Although knowledge diffusion is possible post-exit (Hoetker and Agarwal, 2006), we assume that reputation effects cease to exist when the source firm exits. Upon exit, a source firm is removed

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<sup>9</sup>Legal requirements aside, firms face conflicting strategic incentives when citing other patents in their applications. By failing to cite, firms risk losing their *own* patent if subsequently challenged with prior art that establishes obviousness or lack of novelty. The effects of citations on risks that *others* will sue the patentee for infringement 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 but continued 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.

from future dyad-year observations. We make additional adjustments for acquisitions. If one firm in 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. 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 the focal sample are not included.

### ***Main Independent Variables***

Four explanatory variables are of central interest in our study. 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 latter two hypotheses, indicator variables—*Entrepreneurial firm* and *CA firm*—are constructed to capture salient firm-level characteristics.

*Mobility* is defined as the cumulative count of inventors hired from a given source firm by a recipient firm over the preceding five year period, as measured by the application year of a mobile inventor's first patent at the recipient organization. To determine mobility events, we implement the matching algorithm described in Appendix A that creates inventor patenting and employment histories at focal firms within our sample. For 28,123 unique inventor names listed in patents awarded to sample firms, the algorithm yields 1,166 mobility events, of which 841 originate from California-based firms.<sup>10</sup> An inventor is present in the data for 2.2 years on average, measured as the difference between the first and last patent application date. For 51,615 dyads over a 30-year time window, the mobility rate is approximately 0.08% per dyad-year. This estimate is slightly higher than the 0.05% mobility rate reported in Rosenkopf and Almeida (2003), which could be due to our inclusion of more recent data, given an increasing trend in turnover among college educated electrical engineers (Kim and Marschke, 2005). 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%.

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<sup>10</sup> Labor markets in California appear to be unusually "localized" relative to that in other states. 73% of mobile inventors from California firms accept re-employment at another semiconductor firm within the same Consolidated Statistical Area (CSA). This pattern is similar to Angel (1989), who traced career histories of semiconductor engineers and found that 78% of mobile engineers remained in Silicon Valley. In contrast, only 12% of inventors in our sample from firms outside of California stay within their CSA, with 55% accepting re-employment at semiconductor firms with headquarters in California.

*Litigiousness* is a time-varying measure based on the observed enforcement of a source firm's exclusionary rights to patent-protected technologies. We measure *Litigiousness* using a five-year cumulative count of the number of unique patent infringement lawsuits launched by a source firm between 1973 and the focal year of observation.<sup>11</sup> Legal disputes over patents often involve multiple suits and countersuits between parties, or may occur multiple times in the data due to simple changes in venue. To provide a more conservative estimate, 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 exclude instances in which the firm is defending against lawsuits filed by others. To capture reputation effects at the corporate level, we measure the litigious activity of the source firm against all defendants rather than against a particular recipient.

A firm (whether recipient or source) is considered to be *Entrepreneurial* if it is public, small, or young in a focal citation year; else it is considered to be *Established*. 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, we define a firm as small if it has less than 100 employees in a given year, which corresponds to the 60<sup>th</sup> percentile of the size distribution (else large). A firm is defined as young for the first five years since founding (else old). The results are robust to alternative cut-offs at 500 employees and 12 years for size and age.

Finally, the dummy *CA source firm* is set to 1 if the firm has headquarters located in California. 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. The majority of the firms' inventive activities occurs in the headquarter state. For the median California-based company, almost 90% of inventors list California as the state of primary

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<sup>11</sup> Our results are robust to several alternative measures for *Litigiousness*, and we chose to report the five year measure for several reasons. A simple indicator variable identifying whether the source firm had initiated a patent infringement suit by the focal year of citation implicitly treats firms filing one and numerous lawsuits as being equally "tough". A cumulative count of patent infringement lawsuits initiated by the firm in the sample period gives the same weight to lawsuits filed to very early vs. more recent lawsuits and permits no potential erosion of signal value of "old" lawsuits to the reputation stocks over time. Any assignment of weights over time may seem ad-hoc. Restricting attention to a 5-year window preceding a focal year of citation not only improved the predictive power of our models but also provides a measure that allows reputation stocks to evolve slowly while still being prone to some decay.

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***

Consistent with prior studies, we 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; Song *et al.* 2003). For each source and recipient firm, we include the following time-varying 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*, measured in logs due to skewness. *Log Employee* is the number of employees in year *t*, also measured in logs.<sup>12</sup> *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 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, manufacturing, and equity. When the alliance involved more than two firms, we recorded each alliance separately within dyads. In total, we identified 1,168 collaborative agreements between firms, including 199 from SDC Platinum and an additional 969 alliances reported in news articles and press releases from Factiva and LexisNexis. Following Jaffe (1989), we measure *Technological proximity* as the angular separation between normalized vectors based on the distribution of patents awarded to source and recipient firms across U.S. patent classes. *Geographic match* is set to one when both firms within a dyad have headquarters in the same Consolidated Statistical Area (CSA) based on the 2000 U.S. Census classification. Finally, we include period dummies for the following intervals: pre-1980, 1980-1984, 1985-1989, 1990-1994, and 1995-

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<sup>12</sup> For public firms, the few missing annual employee counts were imputed from the data reported for the most proximate year. For private firms, employee counts are available only for the firm's last financing round in VentureOne. While time invariant, employee counts for private firms are generally an order of magnitude smaller than the public firms. In unreported regressions, we obtained similar results when (a) observations with imputed employee counts were removed from the sample, and (b) the control variable for firm size used in the baseline model was measured using log(assets) rather than log(employees). The latter restriction drops dyad-year observations for missing asset values.

1999. The omitted category comprises the years 2000-2003. The period dummies allow the baseline citation rate to increase over time (Jaffe and Trajtenberg, 2002), and also control for macroeconomic conditions that could affect the patenting and citation levels within the industry.<sup>13</sup>

### **Summary Statistics**

Table 1 and Table 2 provide summary and correlation statistics for the variables in our study for the dyad-year observations. The number of observations varies considerably among the dyads; pairs of longstanding firms within the industry have more observations over the time period than pairs involving a longstanding firm and a startup. Figure 1 plots the annual number of patents awarded and patent infringement lawsuits initiated by source firms. Figure 1 shows a spike in litigious activity in the mid-1980s, followed by a more gradual upswing in patenting activity, which is consistent with claims that “pro-patent” US institutional environment shifts triggered a more aggressive stance toward the acquisition and enforcement of patents (Hall and Ziedonis, 2001; 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. The two top litigant firms, Intel and Texas Instruments, are large, established firms within the industry, but there is significant variation among the top 20 litigants in terms of their age and size. Approximately 60% of all litigious firms are based in California. In total, we identified 270 unique U.S. patent infringement suits filed by source firms during 1973-2001.

### **Estimation Method**

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. Following Rosenkopf and Almeida (2003), we first estimate negative binomial regressions, which are used when conditional variance exceeds the conditional mean. A likelihood ratio tests rejects the hypothesis of no over-dispersion ( $p < 0.001$ ) in our sample. We allow for non-independence across dyad-year observations and use error terms that are robust to heteroskedasticity. Alternative models (zero-inflated negative binomial models, Poisson models with robust variance matrix) generated qualitatively similar results.

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<sup>13</sup> The results are robust to two alternative measures for business cycle effects—an annual Tobin’s q within the semiconductor industry (from Compustat data) and the annual VC investments in IT firms (from VenturXpert data).

By using control variables and estimation methods common in prior citations based studies of knowledge spillovers, we first establish a baseline estimate of the propensity of one firm to cite patents owned by another. We then introduce IP toughness and its interaction with inventor mobility as the key variables of interest in our study, and further test for heterogeneous effects on different types of firms. Importantly, we conduct robustness tests related to a) our use of patent citations as a proxy for knowledge diffusion, and b) the assumption of strict exogeneity of the key explanatory variables of interest, as discussed in detail below.

## RESULTS

To test H1, we examine whether the interaction effect of *Mobility* and *Litigiousness* is negative and significant (Table 3). To test H2 and H3, use a Wald test for differences in coefficients among the relevant subgroups within a seemingly unrelated regression framework (Table 4). Results of the baseline specification, reported in Column 1, Table 3 are consistent with prior work. The baseline citation rate is higher between firms that are technologically and geographically proximate; it also is higher between alliance partners and firms that hire away employees. Larger firms and firms with larger portfolios of patents tend to receive a higher baseline number of citations from a given recipient, as do firms with patents that receive higher citations more generally (thus suggesting that the baseline number of citations received by firms with more “important” patents is higher than that of firms with less influential patents). Column 2 of Table 3 introduces the litigiousness variable which is positive and significant, while Column 3 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.

In Columns 4 through 7 of Table 3, we test the robustness of this core finding in our paper in several ways. First, we re-estimate the model after excluding examiner added citations, for patents awarded since 2001 for which such data are available. As shown in Column 4, there is little evidence that our results are spuriously driven by biases introduced from examiner added citations. The

*Litigiousness*\**Mobility* coefficient remains negative and highly significant irrespective of whether examiner-added cites are included or removed from the dependent variable.

Next, we investigate a more fundamental issue regarding model specification. While the negative binomial model specification allows us to build cumulatively upon and replicate the results in prior work on “learning-by-hiring” (e.g., Rosenkopf and Almeida, 2003; Almeida *et al.*, 2003), the underlying assumption of strict exogeneity of key variables of interest may be particularly strong in the context of our study. Importantly, a firm’s prior litigiousness as well as other unobserved characteristics could affect not only citations conditional on job changes among inventors but also the underlying distribution of employees that decide to switch employment. Further, the use of variables based on cumulative counts violates the strict exogeneity assumption of the standard count estimation methods (Wooldridge, 1997). To test if our results are sensitive to these potential issues, we employ an instrumental variable approach recommended by Wooldridge (1997) and use the Generalized Method of Moments (GMM) estimation method. The GMM method permits the inclusion of explanatory variables that are correlated with past and current values of the error term. We estimate the GMM models using the GAUSS routine ExpEnd of Windmeijer (2002) and moment conditions based on quasi-differencing (Wooldridge, 1997). To correct for time-invariant heterogeneity within each dyad, we define the panel using the dyad-level fixed effects. Since “within unit” changes must be observed over time for the effects to be estimated, the number of observations drops accordingly. First, we correct for the violation of the strict exogeneity assumption due to the use of cumulative counts by using lagged variables as instruments. In Column 5 of Table 3, *Mobility*, *Litigiousness* and *Alliances* (and the relevant interaction terms) are instrumented using their one and two year lagged values. As Wooldridge (1997) discusses, this approach relaxes the strict exogeneity assumption of the negative binomial model by relying on weaker sequential moment restriction. Importantly, the coefficient on *Litigiousness*\**Mobility* in Column 5 remains negative and highly significant. Indeed, the estimated magnitude of the coefficient is larger when we use lagged values as instruments to relax the strict exogeneity assumption.

Second, in Column 6 of Table 3, we employ an even more stringent specification by fully instrumenting *Mobility* with an exogenous inventor level differences variable rather than lagged values.

Following Kim and Marsche (2005), we instrument *Mobility* using the annual percentage of each source firm’s inventors that are female (*Percentage Female*).<sup>14</sup> The logic behind this instrument is straightforward—the ratio of women inventors is likely to be correlated with exit decisions (women tend to be less mobile) and is also likely to be uncorrelated with unobserved quality differences. As seen in Column 6 in Table 3, the fully instrumented *Litigiousness\*Mobility* remains negative and highly significant.

Finally, we note that our theory views reputations for “toughness” as a corporate-level construct. In the final column of Table 3, we investigate an alternative explanation for our H1 findings. If IP toughness reduces the spillovers associated with employee mobility only between firms directly involved in legal conflict, our results could be explained by dyad level dynamics rather than broader reputation effects within the industry. If this alternative explanation is correct, *Litigiousness\*Mobility* should become statistically indistinguishable from zero or drop sharply in magnitude once we control for dyad level litigation. To test this issue, we constructed a new variable, *Direct Target*, which is set to 1 if a given recipient firm had ever been sued for patent infringement by a given source firm by a focal year of citation.<sup>15</sup> We also created an interaction term, *Direct Target\*Mobility* to permit differences in the effect of litigiousness on mobility-driven spillovers between litigating and non-litigating dyads. Column 7, Table 3 reports results that add these two variables to our main model in Column 3. Importantly, the coefficient on *Litigiousness\*Mobility* remains highly significant and similar in magnitude even after taking into account the dynamics introduced by actual legal conflict between dyads. These results provide corroborating evidence that litigation acts shape the behavior of hiring organizations more broadly within the industry, even absent the filing of an actual lawsuit, as predicted by reputation based theories.

Perhaps not surprisingly, the estimates reported in Column 7 suggest that the effects of IP toughness are amplified for firms directly involved in legal conflict. The positive and significant coefficient on *Direct Target* indicates that recipient firms have a higher propensity to cite patents owned by source

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<sup>14</sup> This variable outperformed all other candidate variables (e.g. immigrant workers) as an instrument. To compile this variable, we created a dummy variable called “female”, which was manually coded as 1 based on the first names of inventors listed on patents in our sample. For each source firm, we then divided the total number of female inventors by the total number of inventors at the source firm in a focal year, thus allowing the percentage to change over time.

<sup>15</sup> We are grateful to a reviewer for this valuable suggestion. Of the 270 unique patent infringement suits initiated by source firms, 113 (42%) were against recipient firms in the sample. Most out-of-sample disputes are filed against non-US firms or firms that were in other industries.

firms that have directly sued them for patent infringement. Legal conflict could result in settlements that confer recipient firms greater access to patent-protected technologies owned by focal source firms in our sample, thus increasing citation counts at the dyad-level. Alternatively, source firms may be more likely to sue recipient firms that are disproportionate beneficiaries of knowledge spillovers emanating from their organizations, thus resulting in a positive correlation between observed legal conflict and recipient firm citations to source firm patents. For purposes of our study, it is more relevant to observe that, between litigating dyads, IP toughness reduces the spillovers associated with inventor mobility events. In fact, comparing coefficient estimates on *Litigiousness\*Mobility* and *Direct Target\*Mobility* (-0.057 and -1.095 respectively), the deterrent effect of IP enforcement on spillovers in labor markets is greater when accompanied by the costly filing of an actual lawsuit.<sup>16</sup>

In summary, Table 3 provides evidence that IP litigiousness moderates the extent to which recipient firms “learn-by-hiring” inventors from rivals within the industry. We find little evidence that our results are spuriously affected by biases introduced from citations added by examiners or by endogeneity concerns regarding our variables of interest. Finally, our results are consistent with the view that IP toughness casts a more general shadow over behavior in the industry rather than being confined to pairs of firms directly involved in legal conflict.

We now turn in Table 4 to our sub-group analyses and corresponding tests for H2a,b (for heterogeneity among firms) and H3 (on California-specific effects). Columns 1 and 2 in Table 4 present evidence consistent with H2a that IP toughness will deter spillovers to a greater degree for hiring organizations who are entrepreneurial rather than established. While *Litigiousness\*Mobility* is negative and significant for both established (Column 1) and entrepreneurial (Column 2) recipients, the magnitude of the effect is about double for entrepreneurial recipients relative to their more established counterparts. The Wald test rejects the hypothesis that the coefficients are equivalent within the respective subgroups, thereby supporting H2a. Similarly, Columns 3 and 4 of Table 4 provide evidence consistent with H2b that the deterrent effects of IP toughness will be lower for source firms when they are

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<sup>16</sup> While not reported formally, we conducted robustness checks to test a second alternative explanation: hiring of inventors from more litigious firms induced recipient firms to keep a greater share of their subsequent innovations secret as opposed to seeking patents. We found little evidence of a decline in the propensity of recipient firms to patent post the mobility event, which is reflective of strong pressures to file patents in this industry (Hall and Ziedonis, 2001; Ziedonis, 2003)

entrepreneurial relative to when they are more established, albeit in a stronger form than we predicted. More specifically, for the subset of source firms in our sample, we find that IP toughness reduces the spillovers associated with inventor hiring *only* when source firms are relatively established. In contrast, when source firms are less well established, the coefficient on *Litigiousness\*Mobility* is indistinguishable from zero. This latter finding does not appear to be driven by an absence of litigation among source firms while they are in the entrepreneurial stages of development; roughly 10 percent of the total patent infringement lawsuits were initiated by source firms when they were small, young, or private<sup>17</sup>.

Finally, we predict in H3 that IP toughness will have a diminished deterrent effect on employee mobility related spillovers for source firms based in California relative to firms based in other U.S. states. The subgroup analysis for H3 is reported in Columns 5 and 6 of Table 4. Overall, the coefficient on *Litigiousness\*Mobility* remains negative and significant at the 1% level for source firms irrespective of whether they headquartered in California or other states. While the magnitude of the coefficient is slightly smaller for California-based firms (at -0.05) relative to non-California firm (at -0.06), the Wald test fails to reject the null hypothesis that the effects are statistically equivalent in size. At odds with our H3 prediction, we therefore fail to find that coefficient of *Litigiousness\*Mobility* is significantly different for California and non-California firms. As a robustness check, we divided the source firm sample into “Silicon Valley” and “non-Silicon Valley” firms and obtained similar results.

## DISCUSSION AND CONCLUSION

*“Don’t let your employees do to you what you did to your former boss!”<sup>18</sup>*

While “job hopping” by engineers and scientists is widely heralded as a vibrant channel for knowledge transfer, far less is known about the actions firms take to *reduce* knowledge outflows through markets for skilled labor. Assuming that employee mobility to rival firms imposes a negative externality

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<sup>17</sup> In unreported analysis (available upon request), we explored finer grained asymmetries between source and recipient firms. The results largely mirror those reported Columns 1 and 2 of Table 4: IP toughness reduces employee mobility related spillovers to a greater extent when the relative differences in resource constraints is large—established source firms are more effective against entrepreneurial recipients relative to established recipients, while entrepreneurial source firms are ineffective against established recipients but effective against entrepreneurial recipients. Further, we tested for differential effects of IP toughness for employee entrepreneurship. We included a dummy variable *Spinout* if the mobility event represented the founding of a new firm by the employee, as well as its interaction with *Litigiousness*. The results are similar to the *Direct Target* analysis: the coefficient of *Spinout* is positive and significant (spinouts cite the source firm to a greater extent) and the coefficient of *Litigiousness\*Spinout* is negative and significant (spinouts cite litigious firms less than other hiring recipients).

<sup>18</sup> Golden Rule attributed to Roger Borovoy, former General Counsel at Intel Corporation (Jackson, 1994: p. 214).

on source firms and that contractual and other legal mechanisms provide imperfect solutions, this study investigates the effectiveness of a lever that has received little attention in prior research—building reputations for “toughness” 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 uniquely 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 H1) that a firm’s patent litigiousness 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—costly and observable actions—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 shows how corporate reputations for “toughness” can be valuable to firms seeking to deter unauthorized transfers of proprietary knowledge through employee exits.

Our results further suggest that the costs and distractions associated with IP enforcement may affect both the precautions firms take to “avoid the shadows” of litigious firms and the credibility with which others in the industry perceive threats of litigious action. Consistent with H2a, our estimates suggest that corporate reputations for toughness are particularly powerful in curbing knowledge outflows to entrepreneurial firms. An important implication of this finding is that entrepreneurial firms, which prior studies have shown stand most to gain from hiring skilled workers from established firms (Almeida, Dokko, and Rosenkopf, 2003; Agarwal *et al*, 2004), are disproportionately affected by tough reputations of industry incumbents. We also find, consistent with H2b, that IP toughness reduces mobility-driven spillovers to a lesser extent when source firms are young, small, or private relative to when they are more established. While entrepreneurial firms are widely viewed as an important source of creative destruction (Schumpeter, 1942) due to their novel innovations, these findings collectively underscore the hurdles that these firms may face when introducing technologies that may disrupt market leaders. 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, as discussed by Lemley and Shapiro (2005) among others. Otherwise, the costs and uncertainties of IP-related conflicts may redirect innovative activity toward more established, resource-rich organizations.

Finally, we hypothesized 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 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 partially compensate for lower levels of environmental support by enacting aggressive strategies that build on firm level capabilities. 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). The public policy implications are non-obvious. To the extent that aggressive IP enforcement helps reduce knowledge spillovers that otherwise would arise through the movement of employees, firms may have greater incentives to invest in human capital and R&D. By increasing the market power of employers over mobile workers, it is possible therefore that the “pro-patent” shift in US policies helped stimulate investments in on-the-job training and R&D projects of value to other firms within an industry. In this view, our study suggests that a broader strand of research on human capital investments (e.g., Acemoglu and Pischke, 1998, 1999) may be fruitfully informed by paying greater attention to the role of firm-level IP strategies. At the same time, however, the vitality of innovative regions such as the Silicon Valley is widely attributed to active “job hopping” among skilled workers

and the corresponding diffusion of technological know-how and discoveries across firm boundaries (Saxenian, 1994; Gilson, 1999). 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. In theory, we should expect reputations for IP toughness to be valuable as a spillover deterrent in strong legal regimes and in sectors characterized by significant investments in innovation that are eroded by uncompensated “leakage” through employee exits. Following this logic, our findings should generalize to other pro-patent legal regimes and to other knowledge-intensive sectors, such as biotechnology or medical devices. Future research that examines other industry contexts will be useful, particularly as it enables the identification of boundary conditions to when and where IP toughness strategies are most effective.<sup>19</sup> Also, there may be conditions under which inter-organizational transfers of knowledge are strictly *beneficial* to firms, in which case reputations for IP toughness should hold little value as a deterrent mechanism. Future studies could investigate this issue by investigating the role of IP toughness in sectors such as software, where success often hinges on rapid adoption and use by others.

Second, while we use “IP enforcement” and “patent enforcement” interchangeably in the paper, our focus on patents does not account for the alternative mechanisms (i.e. trade secrets, non-disclosure agreements, non-compete agreements in employment contracts, copyrights, trademarks) available to firms for protecting their technological know-how. von Graevenitz (2007), for instance, found that past aggressive protection of trademarks increases the likelihood of current disputes being settled more speedily. 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

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<sup>19</sup> While they do not examine reputation effects associated with patent enforcement, Kim and Marschke (2005) provide evidence that may be instructive in future cross-industry studies. They find that an increase in employee turnover stimulates more aggressive patenting by firms in “high technology” industries relative to less R&D-intensive sectors. Given recent developments of cross-industry patent litigation databases (e.g., Lanjouw and Schankerman, 2001, 2004; Bessen and Meurer, 2006), future studies could investigate the differences in magnitude of effects among sectors.

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 (i.e. alliances, vicarious learning, 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 not patented prior to the employee departure are not captured in our 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 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 pay-cut to apprentice for the "best" firms. Given our findings that entrepreneurial firms are relatively disadvantaged in the face of litigious behavior, such individuals may be reluctant then to join a firm that is reputed to be "tough" if doing so curtails opportunity for future 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 win the battle, but lose the war by adopting a litigious stance toward proprietary knowledge. Similarly, the trade-offs between IP "toughness" and rewards-based systems (e.g., use of bonuses, stock options, and/or vestment periods) remain unaddressed in this study. This naturally invites continued research with a more "general equilibrium" approach examining the effect of various strategies that firms may employ to attract and retain inventive employees while at the same time restricting leakage of knowledge through employee exit.

Finally, our study opens up interesting avenues for continued research on “learning by hiring” and more generally, “make-or buy” decisions for inventive talent: Why do firms risk litigation through “learning-by-hiring” when they could conceivably develop knowledge in-house? What are the costs and benefits of the “learning-by-risking litigation” strategy? We hope that our study will trigger additional research that examines the costs and tradeoffs faced by recipient firms as well.

### **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 a passive role for source firms 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 also may 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 insights from such strategic interaction models of competitive dynamics in product markets also can 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.

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. Spillover deterrence through labor market channels can be viewed as an added benefit of being litigious more generally. By credibly signaling a firm’s “type”, firms could reap indirect reputational benefits even from disputes propelled by broader motives. Our study also provides new evidence on how the high costs associated with IP litigation can differentially affect the behavior of entrepreneurial 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 effect for firms located 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 A: 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.<sup>20</sup> 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 X patents at firm A in 1997 and at firm B in 1998 and B acquires A in 1997, the observation is not treated as a mobility event.

If middle initials are the same, a match is recorded; if they are different, the event is discarded. Thus, the letter “M” and the name “Michael” would be treated as a match on middle initial whereas the letter “M” and the name “John” would not. 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.<sup>21</sup> The 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 are assumed to represent two inventors with the same name.

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<sup>20</sup> 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.

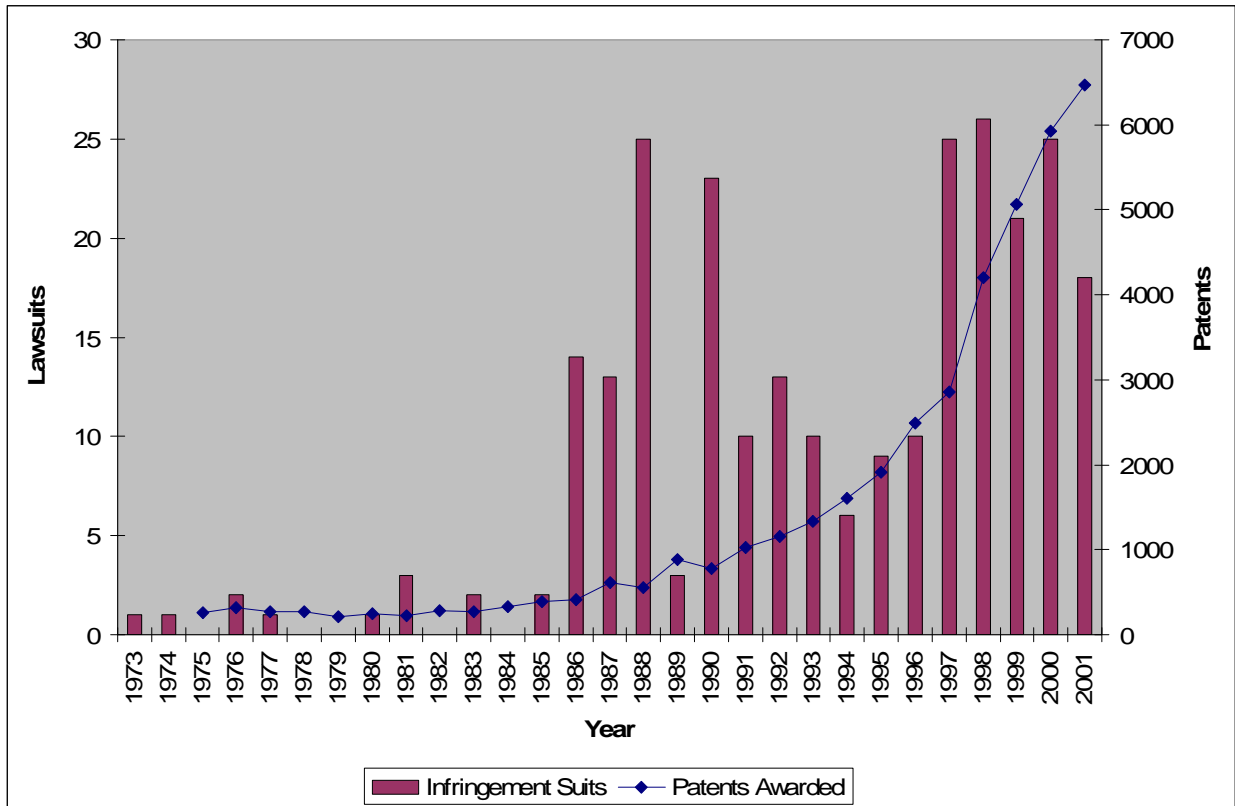
<sup>21</sup> For instance, the result of the matching algorithm would be as follows:

Inventor AB events:

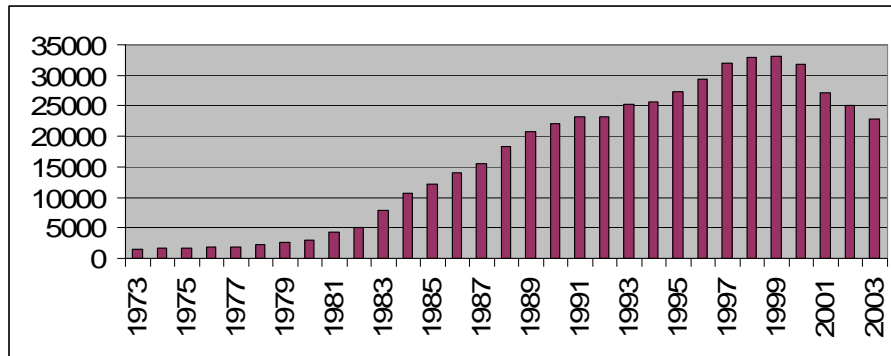
Event	Source Firm	Last Patent Date	Target Firm	First Patent Date
1	X	1/1/1999	Y	12/4/2000
2	X	1/1/1999	Z	4/22/2002
3	Y	3/5/2001	Z	4/22/2002

Only events 1 and 3 are recorded as mobility events.

**Figure 1: Annual # of US Patent Infringement Suits Initiated by Source Firms vs. the Annual # of US Patents They Received, 1973-2001**



**Figure 2: Dyad Observations by Year**



**Table 1: Variable Definitions and Summary Statistics**

<b>Variable</b>	<b>Definition</b>	<b>Mean</b>	<b>St. Dev.</b>
<b>Dependent Variables</b>			
<i>Total citations</i>	Annual number of citations made by the recipient to the source firm's patents.	0.116	3.061
<b>Main Independent Variables</b>			
<i>Litigiousness</i>	Moving sum of patent litigation lawsuits over the last five years including the given year by the cited firm.	0.579	1.987
<i>Mobility</i>	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
<b>Dyad-Level Controls</b>			
<i>Technological proximity</i>	Technological proximity between the source and recipient firms. Calculated as angular separation between the normalized vectors representing proportions of patents in each patent class, as per Jaffe (1989).	0.153	0.259
<i>Same region</i>	Dummy = 1 if cited and citing firms have headquarters in the same Consolidated Statistical Area (CSA).	0.251	0.434
<i>Alliances</i>	Moving sum of alliances over the last 5 years including the given year between the firms in a dyad.	0.01	0.122
<i>Direct Target</i>	Dummy = 1 if recipient firm directly targeted by lawsuit initiated by the source firm in the focal year or in the past; 0 otherwise	0.0015	0.039
<b>Firm-Level Controls</b>			
<i>Age (recipient)</i>	Recipient firm age: Focal year–founding year.	10.202	10.709
<i>Log employees (recipient)</i>	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).	4.993	1.675
<i>Log patent stock (recipient)</i>	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
<i>Log patent stock (source)</i>	Analogous to Log Patent Stock (recipient).	1.089	1.420
<i>Log citability (source)</i>	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
<i>Age (source)</i>	Source firm age: Focal year–founding year.	16.313	12.205
<i>Log employees (source)</i>	Analogous to Log Size (recipient)	5.913	1.682
<b>Subgroups</b>			
<i>Entrepreneurial recipient</i>	Dummy = 1 if, in focal year, recipient firm is privately owned OR has 100 or fewer employees OR is less than five years old (based on founding year); 0 otherwise	0.69	0.462
<i>Entrepreneurial source</i>	Dummy = 1 if, in focal year, source firm is privately owned OR has 100 or fewer employees OR is less than five years old (based on founding year); 0 otherwise	0.36	0.481
<i>CA source firm</i>	Dummy = 1 if headquarter location of source firm is in California; else = 0.	0.602	0.489

**Table 2: Correlation Matrix**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
<b>(1) Citations</b>	1															
<b>(2) Litigiousness</b>	0.0536	1														
<b>(3) Mobility</b>	0.219	0.0589	1													
<b>(4) Technological proximity</b>	0.0868	0.1388	0.1037	1												
<b>(5) Same region</b>	0.0125	0.0311	0.0388	0.0794	1											
<b>(6) Alliances</b>	0.1537	0.0555	0.1398	0.1363	0.0565	1										
<b>(7) Direct Target</b>	0.1857	0.0689	0.1227	0.0857	0.0146	0.0796	1									
<b>(8) Age (recipient)</b>	0.0268	0.0009	0.0244	0.0953	-0.1099	0.071	0.036	1								
<b>(9) Log employees (recipient)</b>	0.0649	-0.021	0.0672	0.1859	-0.002	0.1193	0.0592	0.4904	1							
<b>(10) Log patent stock (recipient)</b>	0.1207	0.0018	0.0995	0.3024	0.0447	0.1266	0.0588	0.1661	0.5337	1						
<b>(11) Log patent stock (source)</b>	0.0861	0.3339	0.0733	0.2191	0.0925	0.0973	0.0571	0.0002	-0.0122	0.0429	1					
<b>(12) Log citability (source)</b>	0.078	0.2817	0.0635	0.1869	0.1005	0.0906	0.0523	-0.0005	-0.0061	0.0485	0.8579	1				
<b>(13) Age (source)</b>	0.0331	0.1551	0.0536	0.0651	-0.1282	0.0291	0.0229	0.0072	-0.0396	0.0039	0.0578	-0.0102	1			
<b>(14) Log employees (source)</b>	0.0685	0.392	0.0899	0.2095	0.0158	0.0902	0.0601	0.0033	-0.0155	-0.0086	0.5485	0.4236	0.3927	1		
<b>(15) Entrepreneurial recipient</b>	-0.0421	0.0116	-0.0437	-0.1648	0.018	-0.0911	-0.0454	-0.5797	-0.7186	-0.3671	0.0007	-0.0058	0.0237	0.0113	1	
<b>(16) Entrepreneurial source</b>	-0.0264	-0.1837	-0.0361	-0.1728	-0.031	-0.0464	-0.0274	-0.0055	0.0277	-0.0091	-0.3255	-0.2361	-0.3727	-0.6788	-0.0174	1
<b>(17) Calif. source</b>	0.0034	0.0615	0.0141	0.0779	0.394	0.044	0.0075	0.0002	-0.0138	0.0043	0.1113	0.147	-0.3013	0.0343	0.0083	-0.0231

Table 3: Impact of IP Litigiousness on Mobility-Driven Spillovers

	Main Results			Robustness Checks			
	Baseline Model, Controls Only	Add Litigiousness	Main Model: Interact Litigiousness w/ Mobility	Patents issued post-2001, Inventor-added citations only	GMM fixed effects, lagged values as instruments†	GMM fixed effects, mobility fully instrumented††	Main Model (Col 3), with controls for Litigating Pairs
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<b>Main Variables</b>							
<i>Litigiousness * mobility</i>			-0.057***	-0.052***	-0.171***	-0.061**	-0.057***
<i>Litigiousness (source)</i>		0.023***	0.027***	0.01	0.142***	0.037**	0.027***
<b>Dyad-Level Controls</b>							
<i>Technological proximity</i>	3.571***	3.568***	3.569***	3.864***	2.147***	1.576***	3.461***
<i>Same region</i>	0.346***	0.348***	0.347***	0.314***	-	-	0.368***
<i>Alliances</i>	0.156**	0.159**	0.164**	0.249	0.5	0.458	0.017
<i>Mobility</i>	0.607***	0.613***	0.752***	0.625***	2.342***	0.662	0.818***
<b>Firm-Level Controls</b>							
<i>Age (recipient)</i>	-0.027***	-0.027***	-0.027***	-0.046***	0.007	0.004	-0.026***
<i>Log employees (recipient)</i>	-0.165***	-0.165***	-0.166***	-0.426***	-0.554***	-0.483***	-0.191***
<i>Log patent stock (recipient)</i>	1.257***	1.256***	1.258***	1.745***	1.295***	1.255***	1.276***
<i>Log patent stock (source)</i>	0.101***	0.099***	0.099***	0.066	0.129**	0.136**	0.068**
<i>Log citability (source)</i>	0.273***	0.271***	0.271***	0.330***	0.108**	0.052	0.297***
<i>Age (source)</i>	0.009***	0.009***	0.009***	0.013***	0.033***	0.0066	0.012***
<i>Log employees (source)</i>	0.406***	0.387***	0.387***	0.519***	0.183***	0.264***	0.379***
<i>Direct target (recipient sued by source)</i>							2.718***
<i>Direct target * mobility</i>							-1.095***
Constant	-9.234***	-9.132***	-9.134***	-10.936***	Dyad fixed eff.	Dyad fixed eff.	-9.007***
Log Likelihood	-44,764	-44,749	-44,734	-10,358	--	--	-44,334
Unit of Analysis	Dyad-year	dyad-year	dyad-year	dyad-year	dyad-year	dyad-year	dyad-year
# Observations	506,374	506,374	506,374	172,889	38,691	38,691	506,374

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

Notes: All models include time period dummies as defined in text, except for model 4 that is based on a sub-sample of recent data and uses annual year dummies instead.

† GMM fixed effects are at the dyad level, with 1 and 2 year lags of *Mobility*, *Litigiousness* and *Alliances* used as instruments.

†† GMM fixed effects are at the dyad level, with 1 year lag of firm-level proportion of female inventors used as an instrument for *Mobility*. *Litigiousness* and *Alliances* instrumented as in Model 5.

**Table 4: Subgroup Analyses for Entrepreneurial and California-based Firms†**  
(Y=Annual # Citations made by Recipient to Source-Firm Patents)

	Established Recipient	Entrepreneurial Recipient	Established Source Firm	Entrepreneurial Source Firm	California Source Firm	Non-California Source Firm
Model	(1)	(2)	(3)	(4)	(5)	(6)
<b>Main Variables</b>						
<i>Litigiousness * mobility</i>	-0.051***	-0.104***	-0.054***	-0.063	-0.051***	-0.062***
<i>Litigiousness (source)</i>	0.047***	0.016**	0.024***	0.203***	0.060***	0.001
<b>Dyad-Level Controls</b>						
<i>Technological proximity</i>	3.526***	3.473***	3.580***	3.290***	3.466***	3.716***
<i>Same region</i>	0.172***	0.612***	0.271***	1.036***	0.426***	0.442**
<i>Alliances</i>	0.163***	0.398**	0.134*	0.560***	0.2***	-0.093
<i>Mobility</i>	0.520***	1.581***	0.713***	1.107***	0.785***	0.654***
<b>Firm-Level Controls</b>						
<i>Age (recipient)</i>	-0.019***	-0.066***	-0.028***	-0.014*	-0.024***	-0.030***
<i>Log employees (recipient)</i>	-0.294***	-0.223***	-0.153***	-0.311***	-0.140***	-0.212***
<i>Log patent stock (recipient)</i>	1.130***	1.617***	1.262***	1.311***	1.221***	1.329***
<i>Log patent stock (source)</i>	0.163***	0.054	0.099**	0.219*	0.142***	0.111**
<i>Log citability (source)</i>	0.225***	0.310***	0.264***	0.334***	0.3***	0.194***
<i>Age (source)</i>	0.0003	0.017***	0.007**	0.024***	0.017***	-0.002
<i>Log employees (source)</i>	0.345***	0.420***	0.402***	0.05	0.250***	0.540***
Constant	-7.208***	-9.891***	-9.222***	-7.793***	-8.597***	-9.920***
Log Likelihood	-27,755	-16,165	-40,307	-4,242	-29,865	-14,730
Unit of Analysis	dyad-year	dyad-year	dyad-year	Dyad-year	dyad-year	dyad-year
# Observations	156,671	349,703	321,616	184,758	305009	201365
Wald Test Statistic $\chi^2(1)$	7***		0.02		0.42	

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

Note: All models include time period dummies as defined in the text.

† Entrepreneurial firms are defined as firms that have less than 100 employees, or are less than 5 years old, or are private in a focal year of observation; else, firms are consider to be more established. California firms are headquartered in California; “non-California” firms are headquartered in other US states.