More Stars Stay, but the Brightest Ones Still Leave:

Job Hopping in the Shadow of Patent Enforcement

Martin Ganco
Carlson School of Management, University of Minnesota
mganco@umn.edu

Rosemarie H. Ziedonis
Lundquist College of Business, University of Oregon
Stanford Institute for Economic Policy Research
rmz@uoregon.edu

and

Rajshree Agarwal*
Robert H. Smith School of Business, University of Maryland
rajshree@umd.edu

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Abstract

Competitive advantage often rests on the skills and expertise of individuals that may leave for rival organizations. Although institutional factors like non-compete regimes shape intra-industry mobility patterns, far less is known about firm-specific reputations built through patent enforcement. This study formally models and empirically tests how a firm's prior litigiousness over patents (i.e., its reputation for IP toughness) influences employee mobility. Based on inventor data from the U.S. semiconductor industry, we find that litigiousness not only diminishes the proclivity of inventive workers to 'job hop' to others in the industry, it also shifts the *distribution* of talent released to the market. The study contributes new insights linking firm-level reputations as tough legal enforcers to the 'stay versus exit' calculus of knowledge workers.

Key words: employee mobility, intellectual property, innovation, patent enforcement, strategic management, reputation effects

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INTRODUCTION

Competitive advantage often rests on the skills and expertise of individuals (Barney, 1991; Hall, 1992). But the advantages firms derive from human capital can be fleeting: unlike tangible resources such as plants and equipment, employees may walk out the door to join rival organizations (Castanias and Helfat, 1991, 2001; Coff, 1997). Among the institutional forces shaping the bargaining power between firms and mobile talent, state laws governing non-compete agreements have received the lion's share of scholarly attention (Fallick *et al.,* 2006; Garmaise 2009; Marx *et al.,* 2009; Stuart and Sorenson, 2003). Far less is known about the reputations firms build through patent enforcement and their potential influence on employee mobility, despite anecdotal evidence suggesting linkages between this firm-level lever and turnover in markets for skilled labor.[1]

This study investigates how a firm's aggressiveness in patent enforcement casts a shadow over 'job hopping' by knowledge workers: does increased litigiousness alter the employee exit calculus? If so, are some employee types more likely to be affected? Answering these questions is important for several reasons. First, many U.S. technology companies are headquartered in California, where the vibrancy of the Silicon Valley region has been attributed to weak state-level support for non-competes and trade secrets (Gilson, 1999; Hyde, 2003; Png 2012b). Whether the federal protection provided by patents enables firms in 'employee-friendly' states to deter mobility remains unclear. Second, the past few decades have witnessed explosive growth in patent lawsuits in the United States, while the costs of such disputes have continued to climb (Landes and Posner, 2003). The implications of these twin developments on employer-employee dynamics remain under-explored in the literature. Kim and Marschke (2005) report that firms in sectors with higher turnover rates seek patent protection more aggressively, highlighting a patent's role in protecting innovating companies from 'insiders.' Emphasizing the added reputational gains from costly enforcement, Agarwal et al. (2009) find that a firm's litigiousness over patents significantly reduces the level of knowledge

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[1] For example, in response to a 'siphoning of engineering talent,' Intel sued Broadcom for patent infringement (Murphy, 2000). Similarly, Pixar Animation sued former employees Larry Gritz, Matt Pharr and Craig Kolb over patent violations when they co-founded Exluna (Business Wire, 2002), and iRobot litigated against ex-employee Jameel Ahed for patent infringement in the manufacture of defense robots (Shachtman, 2008).

spillovers from employee departures to join or form other companies within an industry. Left unanswered is how a reputation for 'IP toughness' alters the antecedent decisions of employees to move and how that decision in turn shapes the distribution of talent released to rivals.

To answer these questions, we formally model and empirically test the effects of an employer's litigiousness on employee mobility decisions. Consistent with Agarwal *et al.* (2009), we view patent enforcement as a reputation-building strategy rather than a particular tactic launched against a particular target: by engaging in costly and observable litigious action, firms build reputations for being 'tough' in the safeguarding of intellectual property (IP). In investigating the effects of an employer's reputation for IP toughness on employee mobility, we relax assumptions in prior models of employer-employee expropriation problems where the safeguards afforded by patents are either absent (Anton and Yao, 1994, 1995) or ineffectual (Franco and Filson, 2006). We test implications from the model using a database of patent lawsuits and employee-inventors from the U.S. semiconductor industry, a setting characterized by active job-hopping (Fallick *et al.*, 2006) and prolific patenting (Hall and Ziedonis, 2001).

To foreshadow our results, we predict and find that as firms grow more litigious over patents, employee-inventors become less likely to join or form rival companies. This result reflects stringent 'within-firm' estimates from fixed effects specifications and controls for the time-varying size, R&D intensity, and patenting activities of the employer. In supplemental analyses, we find no evidence that this finding is spuriously explained by an unobserved effect on recruitment, where firms attract less mobile workers as they grow more litigious, or by omitted time-varying factors within employers that could yield a simultaneous rise in litigation and retention. Consistent with the model, we also find that a firm's reputation for IP toughness alters the sorting process by which employees—and the quality of the ideas they carry—are released to labor markets. More specifically, the reputations for IP toughness are particularly helpful in retaining employees whose ideas are valuable internally to the firm. In contrast, those with the most lucrative prospects for outside advancement are relatively unaffected. Put simply, more stars stay but the brightest ones still leave.

The study contributes to the literature on micro-level dynamics in strategic factor markets

(Barney, 1991; Castanias and Helfat, 1991, 2001; Coff, 1997; Coff and Kryscynski, 2011). Complementing the vast literature on incentives-based human resource practices for employee retention (e.g., Bloom *et al*., 2011), we show how 'tough' reputations for patent enforcement can influence patterns of employee retention and exit. The study also contributes new insights and findings to the literature on knowledge transfer through mobility (Anton and Yao, 1995; Franco and Filson, 2006; Hellmann, 2007; Klepper and Sleeper, 2005; Palomeras and Melero, 2010; Rosenkopf and Almeida, 2001). Much of this work assumes that patents—as legal property rights to exclude others from making, using, or selling protected inventions—fail to shape the underlying mobility process. This study contributes to a nascent stream of research that relaxes this assumption (Agarwal *et al*., 2009; Hellmann 2007; Kim and Marschke, 2005), advancing prior work by allowing patent enforcement to endogenously affect employee exit decisions.

BACKGROUND

'Job hopping' as an expropriation problem

From a rent appropriation perspective, firms face dual challenges when managing the potential loss of human capital (Castanias and Helfat, 1991; 2001; Coff, 1997). In addition to eroding competitive advantage through *inter-firm* knowledge transfers (Almeida and Kogut, 1999; Aime *et al*., 2010), the threat of mobility can alter *intra-firm* (employer-employee) dynamics and input pricing (Campbell *et al*., 2012; Castanias and Helfat, 1991, 2001). Job hopping is therefore typically cast as an expropriation problem for innovating firms: after hiring and training employees and investing in costly R&D programs, engineers and scientists may leave to exploit discoveries at rival firms.[2] Accordingly, scholars have examined the strategic actions firms take to *retain* skilled workers and/or *deter* them from misappropriating technologies conditional upon exit.

In a seminal theoretical model, Pakes and Nitzan (1983) use a moral hazard framework to inform the optimal design of rewards systems: wages provide firms lacking formal property rights

[2] For expropriation to occur, employers must be unable to capture the total value of information leaked through labor markets. This assumption does not imply that all turnover poses expropriation hazards to innovating firms. Rather, it only requires a positive probability that upon employee exit, employers are not fully compensated for their prior investments in human capital and R&D. See Acemoglu and Pischke (1998) and Moen (2005) for a detailed discussion.

protection a means for inducing employees to exert optimal levels of innovative effort. Subsequent scholars nonetheless suggest that wage contracts are imperfect solutions due to the transactions costs of contract negotiation and enforcement (Acemoglu and Pischke, 1998). Imperfections can arise from multiple sources, including the existence of private information (Anton and Yao, 1995; Klepper and Sleeper, 2005; Hellmann, 2007) and the uncertainties of project implementation and transfer (Cassiman and Ueda, 2006; Franco and Filson, 2006; Hvide and Kristiansen, 2011).

Among the institutional levers available for property rights enforcement, state level differences in non-compete agreements have received the most systematic study. Gilson (1999) attributed job-hopping by engineers in California to the ineffectual enforcement of non-compete contracts within the state, famously challenging the alternative explanations of Saxenian (1994) of cultural and industry-specific factors. Empirical evidence largely supports the thesis that non-compete regimes 'matter' as mobility determinants, particularly in technology-intensive settings. Fallick *et al.* (2006) report higher turnover rates in California relative to U.S. states with stronger non-compete regimes, but only in computer-related industries. Exploiting legal shifts within states, others show that tougher non-compete regimes reduce mobility among executives (Garmaise, 2009), employee-inventors (Marx *et al.*, 2009, Marx, 2011), and entrepreneurial talent (Stuart and Sorenson, 2003; Samila and Sorenson, 2011). Most agree that California's non-compete regime is far more 'employee-friendly' than the regimes of other states, with the possible exception of North Dakota (Bishara, 2011). This finding is also confirmed in studies regarding state level differences in trade secrets protection (Png 2012a,b).

Patent acquisition and enforcement as a non-contractual solution

A smaller stream of research investigates whether the federal protection afforded by patents offers innovating firms an alternative safeguard against mobility-driven expropriation (Agarwal *et al.*, 2009; Kim and Marschke, 2005). Legal rights to patents based on discoveries by employees during work are assigned, with rare exception, to employers (Merges, 1999). Thus, increased patenting can restrict the ability of employees exiting the firm (and their new employers) to make, use, or build upon patented technologies unless explicit permission to do so has been granted through a license.

As a deterrent mechanism, added advantages should arise through patent *enforcement* beyond the mere accumulation of such rights. In essence, patents confer an 'option to sue' (Merges, 1999). Even in technology-intensive sectors, many firms file patents aggressively but choose not to enforce them (Ziedonis, 2003). Importantly, the costs of patent litigation dwarf those associated with patent acquisition: between $3 and $5 million is required to litigate an infringement suit of average complexity, while only $35,000 is needed to file and obtain an average U.S. patent, inclusive of attorney fees (Graham *et al.*, 2010). Due to their high stakes, patent lawsuits also tend to attract media attention, thus increasing visibility to third parties. As costly and observable actions, patent lawsuits therefore serve a useful sorting function (Spence, 1974). Since passive employers find it costly to imitate tough rivals, prior litigiousness should credibly inform expectations of future action.

Agarwal *et al.* (2009) provide evidence that firm-specific reputations built through patent enforcement reduce spillovers to organizations that hire mobile workers. Consistent with the strategic deterrence literature (Kreps and Wilson, 1982; Milgrom and Roberts, 1982), they find the 'reduced spillover' effect holds regardless of whether a firm actively litigates against its ex-employees. As in the learning-by-hiring literature (Almeida and Kogut, 1999; Rosenkopf and Almeida, 2001), however, Agarwal *et al.* (2009) focus on inter-firm knowledge flows, conditional on employees leaving one firm to join another within an industry. Left unanswered is whether and how a firm's litigiousness shapes the antecedent decisions of employees to exit, a matter that we address below.

IP TOUGHNESS AND EMPLOYEE EXIT: A FORMAL MODEL

The Model Set-up

To investigate how reputations for IP toughness affect employee exit decisions, we draw insights from a formal model. Since patent acquisition and enforcement as legal safeguards against expropriation by employees have been examined by Kim and Marschke (2005) and Agarwal *et al.* (2009) respectively, their work serves as a useful starting point. Similar to these scholars, we assume that turnover poses expropriation hazards to innovating firms and that contracting frictions prevent firms from perfectly solving the problem through wages and trade in the market for ideas alone. Kim and Marschke (2005) model the effects of such turnover on an employer's decision to patent its inventions. We extend their work by investigating how a firm's prior litigiousness over patents affects its optimal wage offerings and, in turn, influences employee incentives to exit. In the model, an employer's prior litigiousness (i.e., its reputation for IP toughness) influences the focal scientist through the expectation of legal conflict, whether against the scientist (in the event of a spin-out) or the new employer. Consistent with Agarwal *et al.* (2009), we assume that, as a costly and observable action, prior patent enforcement credibly shapes expectations of future action and is pre-determined at the time of an individual employee's exit decision.[3]

The model has a two-period set up. In period 1, the scientist works at a firm for wages w_1 (greater than reservation wage $\overline{w}$) to develop a patented idea. We assume that the scientist works on one idea in a particular period, and a one-to-one correspondence between the value of the idea and the scientist. In period 2, the idea is produced. As in Kim and Marschke (2005), payoffs and probabilities are common knowledge, the employer can capitalize on the idea in the second period independent of the scientist, and discoveries arise from an employee's legitimate work at the firm.[4]

At the end of the first period, the value of the idea is revealed, which is captured by two random variables: the internal value to the firm ρ_i ($\in R^+$), and external value to the scientist if the idea is capitalized by other firms ρ_e ($\in R^+$). Specifically, ρ_i is the profit that the firm would make if it has a monopoly on utilizing the patented idea in period two for production, and ρ_e is the payoff to the scientist if the idea is capitalized at a competing firm or startup. We assume that ρ_i and ρ_e are defined by $(\bar{\rho}_i, \sigma_i)$ and $(\bar{\rho}_e, \sigma_e)$ respectively and are distributed according to joint density f ex-ante known to everyone. The employer makes the second period wage offer, w_2, to the scientist who then chooses whether to accept and stay, or leave to potentially profit from the idea elsewhere. Exit decisions thus

[3] Reputations for IP toughness may be driven by numerous factors unrelated to mobility-driven expropriation, including battles for market power such as Intel's dispute with rival AMD over microprocessors (Somaya, 2003; Lanjouw and Schankerman, 2004), efforts to thwart imitation by low-cost rivals (Ziedonis, 2003), and attempts to bolster bargaining positions with upstream technology providers (Galasso and Schankerman, 2010). Even if mobility-driven expropriation is of second-order importance to innovating firms as a determinant of litigation, we assume that the firm's reputation for such litigiousness is of first-order importance to employees in their mobility decisions. If the latter assumption fails to hold, our empirics should fail to reject the null hypothesis that the firm's prior litigiousness is an insignificant determinant on employee-level exits.

[4] In contrast, Hellmann (2007) assumes that worker effort is unobservable and absent intervention, employees could exert too much effort on 'side projects.' Firms then choose how to allocate formal property rights (e.g., letting employees retain ownership rights to patented inventions) in response to this multi-task agency problem.

hinge on if the second period offer w_2 exceeds the external value of the invention.

If the scientist decides to exit and use the idea elsewhere, the competition (i.e., expropriation of the patent) from the scientist lowers the firm's payoff by $\lambda\varrho_i$ with $\lambda\in[0,1]$. Should the scientist exit and infringe, the employer then has the choice to enforce the patent against the scientist and/or the hiring firm by engaging in costly litigation. With some probability γ the employer is expected to litigate. The likelihood γ is known to both parties ex-ante and is a function of the employer's reputation stock for IP toughness. If the firm sues, it will have to pay attorney and court fees, L ($\in R^+$). For simplicity, we assume that in case of litigation the scientist loses all the profit ϱ_e.

Table 1 summarizes the model timing (Panel A), the overall payoffs to the scientist and employer (Panel B), and payoffs in the likelihood of litigation (Panel C). In Panel C, the payoffs in the event of the scientist's departure reflect the litigation likelihood γ and the payoffs expected at the end of period one. Specifically:

E(Scientist Payoff|Move) = $(1-\gamma)(\overline{w}+\rho_e)+\gamma\overline{w}=\overline{w}+\rho_e-\gamma\rho_e$ (1)

E(Employer Payoff|Move) = $(1-\gamma)(1-\lambda)\rho_i+\gamma(\rho_i-L)=\rho_i-(1-\gamma)\gamma\rho_i-\gamma L$ (2)

Impact of Litigation: Reduction in Mobility

Appendix I derives the maximization problem, where the employer sets wages w_1, w_2 to maximize expected profits, subject to the participation constraint of the scientist. In period 2, and from (1), the minimum wage offer required to induce the scientist to stay is:

$$w_2=\overline{w}+\rho_e-\gamma\rho_e \quad (3)$$

The first term in (3) represents the marginal product of the scientist's time, and the second term reflects the compensation to the scientist for the foregone *realized* outside value of the idea ρ_e. If the threat of litigation reduces the outside earning potential of the scientist, however, the employer can offer the scientist a *lower* amount in period 2. Thus, the third term depicts that the wage offer decreases with the anticipated likelihood of litigation γ.

For the employer, the maximum period 2 wage offer is dictated by the costs associated with mobility, or the amount lost in the event that the scientist moves:

$$w_2 = \overline{w} + (1-\gamma)\lambda\rho_i + \gamma L \quad (4)$$

The first term in (4) captures the marginal product realized by the employer that is lost if the scientist moves. The second and third terms, from (2) above, represent the employer's probability-adjusted costs of increased competition and litigation respectively if the scientist leaves.

The period 2 wage offer that satisfies both (3) and (4) yields:

if $\rho_e - \gamma\rho_e > \lambda\rho_i - \gamma\lambda\rho_i + \gamma L$, the scientist moves. (5)

The left side of (5) reflects the net gains to the scientist from pursuing the idea externally. The right side represents the net gains from staying, above the reservation wage. Rearranging terms, the mobility condition is expressed as follows:

$$\rho_e > \lambda\rho_i + \frac{\gamma L}{1-\gamma} \quad (6)$$

Assuming that $\rho_e = \overline{\rho}_e + \varepsilon_e$ and $\rho_i = \overline{\rho}_i + \varepsilon_i$, equation (6) becomes:

$$\varepsilon_e > \lambda\varepsilon_i + \lambda\overline{\rho}_i - \overline{\rho}_e + \frac{\gamma L}{1-\gamma} \quad (7)$$

Equations (6) and (7) imply that the ex-ante likelihood of mobility falls as the right hand side of the inequalities grows larger. That is, the external value of the idea must be larger to entice the scientist to move. To further derive the unconditional probability of exit, we assume that ε_e and ε_i are independent.[5] Since the marginal densities of ε_e and ε_i are also normal, and the two random variables are independent, we have:

$$\varepsilon_i - \lambda\varepsilon_e \sim N\left(0, \sigma_i^2 + \lambda^2\sigma_e^2\right) \quad (8)$$

In the event that the scientist moves (D=1), equation (8) leads to the following expression:

$$\begin{aligned}\Pr(\mathrm{D}=1) &= \Pr\left(\varepsilon_e - \lambda\varepsilon_i > \lambda\overline{\rho}_i - \overline{\rho}_e + \frac{\gamma L}{1-\gamma}\right) \\ &= \Pr\left(\frac{1}{\sqrt{\sigma_i^2+\lambda^2\sigma_e^2}}(\varepsilon_e - \lambda\varepsilon_i) > \frac{1}{\sqrt{\sigma_i^2+\lambda^2\sigma_e^2}}\left(\lambda\overline{\rho}_i - \overline{\rho}_e + \frac{\gamma L}{1-\gamma}\right)\right) \\ &= \Phi\left[-\frac{1}{\sqrt{\sigma_i^2+\lambda^2\sigma_e^2}}\left(\lambda\overline{\rho}_i - \overline{\rho}_e + \frac{\gamma L}{1-\gamma}\right)\right]\end{aligned} \quad (9)$$

From (9), the probability that a scientist moves is increasing with the realized external value,

[5] This assumption is necessary to derive insights about the effects of ρ_e and ρ_i. Since we relate ρ_e and ρ_i using $\overline{\rho}_e$ and $\overline{\rho}_i$, the external value, ρ_e and the internal value, ρ_i may still be positively correlated.

and is decreasing with the realized internal value, the competitive loss to the employer, the probability of litigation, and litigation costs.[6]

Figure 1 maps the mobility condition in the internal-external value space of the patented idea. The x-axis depicts the realized internal value to the firm, with the realized external value to the firm shown on the y-axis. Line ON represents the mobility line for a non-litigious firm (i.e. $\gamma = 0$). In the region to the left, the external value of the idea ρ_e exceeds $\lambda\rho_i$, thus enticing the scientist to leave. Line AL shows the mobility line for a firm that is likely to enforce patents with probability γ, and represents an upward shift of the mobility line by the distance of the second term in (6). Accordingly, we have:

Implication 1: The likelihood of mobility decreases with the anticipated likelihood of litigation, γ.

Impact of Litigation: Type of Mobility and Value of Ideas

The model also yields insights regarding the effect of litigiousness on the average value of ideas undertaken externally and internally to the focal firm and, in turn, the distribution of employee exits. To develop these implications, we characterize the relationship between $\bar{\rho}_e$ and $\bar{\rho}_i$ as follows:

$$\bar{\rho}_e = g(\bar{\rho}_i) \qquad (10)$$

The slope $g'(\bar{\rho}_i)$ captures whether the internal and external values are independent or correlated with one other, without requiring us to specify their joint distribution. For realism, we assume that $0 \leq g'(\bar{\rho}_i) < \lambda$. We bound the slope to be non-negative because it is extremely unlikely that on average an idea of *higher* value to the focal firm will generate *lower* value when marketed outside the firm, and vice versa. Since firms are more likely to invest in technologies that have higher value when combined with their own complementary assets (Teece, 1986; Zhao, 2006), we further bound the positive values such that $g'(\bar{\rho}_i) < \lambda$. Higher firm specificity of the ideas implies that the firm chooses to invest in those ideas that on average result in lower external value, $g'(\bar{\rho}_i)$, relative to its loss, λ, stemming from the erosion of competitive advantage on account of employee exit with the

[6] We note that litigation costs decrease the probability that the scientist will move because the employer is willing to propose a higher wage offer to induce the scientist to stay, thus avoiding the litigation costs. If the future litigation costs are zero, the likelihood of litigation has no effect. In case of infringement, the employer could regain losses without expense. In the scenario of costless litigation, reputation effects also would fail to arise since prior litigiousness would no longer provide a credible mechanism by which firm types are sorted.

idea (Aime *et al.*, 2010; Campbell *et al*, 2012).[7]

In Figure 1 and for simplicity, we depict the case where the internal and external values of the idea are unrelated and uniformly distributed ($g'(\bar{\rho}_i) = 0$).[8] Given random distribution in the internal-external value space, the realized value could occur at any point in the square OINE, bounded by the maximum values $\bar{\rho}_i$ and $\bar{\rho}_e$. In Figure 2, we depict positive correlations with $g'(\bar{\rho}_i) < \lambda$ with a contour map representing percentile distributions for the jointly normal distribution of ρ_i and ρ_e.

[Insert Figures 1-2 about here]

Turning first to the implications for average external value of ideas taken by mobile inventors, Equation (6) shows that an increase in the probability of litigation increases the threshold of ρ_e above which the scientist moves, *regardless* of the relationship between the internal and external value of the idea. From (3) above, an increase in wage offer w_2 when the external value is higher induces scientists with ideas at or below the threshold of ρ_e to stay. Scientists with the best outside ideas (i.e., the 'brightest stars' with the highest ρ_e) will nonetheless exit, since their wage offers fall below their external value. Graphically, this scenario is represented by the area of the triangle ALE in Figure 1, and scientists whose ideas fall in the contours left of line AL in Figure 2. This leads to the following implication, which captures that litigiousness is less effective in retaining scientists with very high external value of ideas:

Implication 2: The average external value of ideas of scientists that exit the focal firm increases with the anticipated likelihood of litigation, γ.

At the same time though, an increase in litigiousness boosts the retention of scientists whose

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[7] This simplifying assumption is consistent with firm specificity of both human capital and the complementary assets owned by the firm. This results in higher value being created, on average, when the human capital and firm's complementary assets are jointly used in production rather than separately. Greater firm specificity of human capital (Becker, 1972) implies that $g'(\bar{\rho}_i)$ will have a flatter slope: changes in the external value of the ideas that the firm invests in will be less sensitive to changes in internal value. Similarly, greater complementarities between human capital and other capabilities of the firm imply that the loss of an idea results in a lower marginal product from the complementary assets as well, thus resulting in a higher competitive loss due to external exploitation of the idea. In the discussion section, we elaborate on the implications when the assumption may be violated. Briefly, we note that the model implications remain unchanged when there is a negative or zero correlation between internal and external values. The proof is available upon request. For cases when the positive correlation exceeds λ, implication 2 still holds, but implication 3 does not.

[8] The implications remain unchanged if the external and internal values have a jointly normal distribution.

ideas have higher internal value to the firm. In Figure 1, an increase in litigiousness shifts the mobility line to AL, thus retaining ideas with realized values of ρ_i and ρ_e in the shaded area ALON. The average internal value within the triangle ALE, which represents scientists who leave to market the ideas outside the firm with a higher litigation likelihood, is therefore lower than the average of the internal value of the triangle ONE, which represents scientists who leave to market the ideas outside the non-litigious firm. The same holds true in Figure 2, which depicts scientists retained due to increased litigiousness in the shaded area between lines ON and AL. Here again, the average internal value of ideas in the contours left of line AL is lower than the average of the internal ideas in contours left of line ON.[9]

Put differently, the model predicts that litigiousness will sort scientists among those that stay and leave such that the firm retains more scientists with ideas that are valuable internally. In the event of departure, the average internal value of ideas 'released' to the market therefore falls as litigiousness increases. Accordingly, we have:

Implication 3: Under the firm specificity assumption that $0 \leq g'(\bar{\rho}_i) < \lambda$*, the average internal value of ideas of scientists that exit the focal firm decreases with the anticipated likelihood of litigation,* γ*.*

In summary, our model predicts that an increase in an employer's litigiousness lowers the likelihood of mobility (Implication 1) and, through a sorting process, results in an upward shift in the average value of ideas that mobile inventors develop externally (Implication 2). Further, under the firm specificity assumption ($0 \leq g'(\bar{\rho}_i) < \lambda$), an increase in litigiousness allows the firm to retain individuals with higher internal value that otherwise would have left (Implication 3).

DATA AND EMPIRICAL ANALYSIS

We test implications from the model in the context of the U.S. semiconductor industry, a setting well known for active job-hopping and prolific patenting. Our analysis is based on the intra-industry mobility of employee-inventors from 129 public U.S. semiconductor firms. Consistent with prior studies (Rosenkopf and Almeida, 2003), these employers are considered to be potential sources of human capital to others in the industry and are therefore referred to as 'source firms.' The source-

[9] To formally prove this, it is sufficient to show that $\partial E(\rho_i))/\partial\gamma < 0$ for mobile inventors. A numerical simulation proof is available upon request.

firm sample comprises all publicly traded U.S. firms that a) compete primarily in semiconductor product markets and b) are founded prior to 1995. Restricting attention to firms that are public by the mid-1990s allows a sufficiently long window through which to view possible litigiousness and mobility events. Of the 129 employers, 80 are headquartered in California. The remainder resides in states with smaller semiconductor clusters and stronger non-compete regimes, including Texas, Arizona, Massachusetts, and New York.

For each source firm, we observe initiations of patent infringement lawsuits filed in U.S. courts between 1973 and 2001 from firm litigations histories in Ziedonis (2003), which merge case filings reported in legal databases (Litalert by Derwent) with supplemental information from archival 10-K filings, news articles, and press releases. For purposes of discerning reputations for 'toughness' built through patent enforcement, these data are particularly useful. They enable us to determine the extent to which, if at all, a firm initiates a patent infringement lawsuit against others in a time-varying manner. A more common approach is to identify whether patents awarded to a firm are involved in litigation, which subsumes instances where the firm is defending against legal challenges brought by others and instances where it sold the patents involved in the dispute.

Employee-inventor departures are traced from a focal source firm to either a) another source firm or b) another U.S. semiconductor company that owns patents but for which we lack enforcement histories. The latter category includes 266 venture-backed startups, identified from VentureOne, and 52 firms that went public after 1995, identified from Compustat. As Angel (1989) and others show, semiconductor engineers often leave established companies to join or form entrepreneurial ventures. We enlarge the pool of so-called 'recipient firms' to capture such movement. For the combined set of 447 firms, we integrate financial and founding year data from Compustat, Hoover's *Business Directories*, and VentureOne, patent data from Delphion and the National University of Singapore, and source-firm patent litigation histories from Ziedonis (2003). Between 1973 and 2003, sample firms collectively received 50,491 patents, of which 38,689 were awarded to firms for which we observe patent enforcement histories.

Methodology

Establishing a causal link between litigiousness and mobility poses numerous identification challenges. It is possible, for example, that 'better' firms have superior technologies to protect and are more litigious. 'Better' firms could retain more (and more valuable) knowledge workers for reasons unrelated to reputations built through patent enforcement. Our base specification therefore uses firm-specific fixed effects specifications that test whether *changes* in an employer's litigiousness lead to *changes* in employee exits. As discussed below, we add numerous time-varying observables at the employee-, firm- and macro-levels and employ a variety of methods, including use of court-based instruments and a falsification test, to further probe whether mobility is causally shaped by litigiousness in ways predicted by the model.

To facilitate consistency and comparison across models and simplify interpretation of the coefficient estimates, we report results using OLS (including Linear Probability Model) and 2SLS estimators. The results are fully robust to alternative specifications discussed below.

Dependent variables

Mobility: The first dependent variable is a binary indicator set to 1 if our matching algorithm identifies the focal inventor on a subsequent patent assigned to a recipient firm other than the focal employer (another semiconductor firm in the sample). To identify instances when employee-inventors change jobs between source and recipient firms, we used a multi-filter algorithm described in Raffo and Lhuillery (2009). The algorithm refines Trajtenberg *et al.* (2006) and is equivalent to that used in Agarwal *et al.* (2009). Like other patent-based studies of mobility (Marx *et al.*, 2009, Singh and Agarwal, 2011), this approach captures the intra-industry movement of inventively productive employees. To focus on mobility events likely to pose expropriation hazards, we exclude instances where employees move to recipient firms owned by the focal source firm through acquisition or corporate venture capital investments. We also omit observations for failing firms in the year prior to and including liquidation to better capture voluntary exits rather than layoff-driven departures. For 28,123 unique inventor names listed in patents awarded to firms in the sample, 1,166 mobility events met these criteria. The mobility rate in our sample (for 51,615 dyads over a 30-year time window) is approximately 0.08% per dyad-year, slightly exceeding the 0.05% rate reported for semiconductor dyads in Rosenkopf and Almeida (2003).

External Value of Ideas of Mobile Scientists: Not surprisingly, we lack a direct measure of idea values. Following prior work by Hoisl (2007) and Palomeras and Melero (2010), we therefore proxy the value of the ideas by the number and quality of patents produced by the scientist. The value of the focal scientist's ideas outside of the source-firm context (i.e., external idea value) is captured by two proxies at the mobile inventor level: *post-mobility patent productivity* and *post-mobility patent quality*. *Post-mobility patent productivity* is the number of patents the inventor produces at the recipient firm divided by the years the individual is inventively active at that firm, while *post-mobility patent quality* measures the average annual number of citations to those patents in a five-year window, divided by the number of patents he or she produced at the firm. As Hall et al. (2001) discuss, the number of cites per patent is strong correlate for the underlying value of the invention.

Internal idea value: Analogous to external idea value, we use *pre-exit inventor patenting productivity* and *pre-exit inventor patenting quality* to proxy for the internal value of the idea to the source-firm. Correspondingly, *pre-exit inventor patenting productivity* tallies the annual number of inventor patents at the firm, while *pre-exit inventor patenting quality* measures the average number of citations to those patents in a five-year window.

Explanatory and control variables

Litigiousness, our proxy for IP toughness, is a time-varying measure based on the observed behavior of a focal employer in enforcing its exclusionary rights to patent-protected technologies. More specifically, it is a lagged three-year moving sum (over *t*-1 to *t*-3) of the number of unique patent infringement lawsuits launched by the firm. Results reported below are robust to use of alternative litigiousness measures, including separate lags. Use of a three-year lagged explanatory variable improves the precision of our estimates and allows reputation stocks to evolve slowly while still being prone to some decay. The measure also allows a firm's reputation for IP toughness to be pre-determined when the scientist makes a mobility decision, as assumed in the formal model.

Controls: Unless otherwise indicated, all specifications include a full set of year and source-firm fixed effects. In addition, we add time-varying controls at the employee, source-firm, and macro levels. At the employee-inventor level, *Gender* (1=female) and *Ethnicity* (1=non-white) allow demographic factors to influence mobility choices. *Inventor's Number of* Co-*inventors* allows for team-size effects, while *Tenure* measures the number of years the employee is inventively active at the source firm, thus allowing mobility decisions to be shaped by seniority or a deepening of firm-specific skills over time (Marx *et al.*, 2009).

At the source-firm level, firm patent awards let the simple ownership of patents shape employee exit decisions (Kim and Marschke, 2005). Following Hall *et al.* (2001), it is measured as the annual *number of U.S. patents awarded to the source-firm* dated by year of filing. Since larger firms file more patents (Hall and Ziedonis, 2001), this variable provides an indirect proxy for firm size as well, thus alleviating concerns that *Litigiousness*, our explanatory variable of interest, spuriously reflects the cost advantages of larger firms in patent enforcement (Lanjouw and Schankerman, 2004). Use of a direct size measure based on employment counts yields similar findings. The other source-firm controls, annual *R&D intensity* and the firm's overall *patenting quality* (average annual citations per patent in a five-year window) let R&D commitments and the quality of innovative output affect the retention of knowledge workers. Since larger firms tend to spend more on research, R&D spending is normalized by employee counts to disentangle the effects.

A final set of controls captures time-varying state and regional factors that could influence turnover in ways insufficiently captured by year dummies. The *Garmaise noncompete index* is based on the noncompetition enforceability index compiled by Garmaise (2009) for U.S. states. Across states, the index ranges from 0 to 9, with higher scores indicating stronger regimes of non-compete enforcement and California's score listed as 0. As listed in Table I, the index is time-varying for three states: Texas, Florida, and Louisiana. At the regional level, shifts in the supply of knowledge workers can affect wage rates and retention. We therefore control for the *Number of inventors in the region,* measured as the annual number of inventors in other semiconductor firms' patents (minus the source-firm) for inventors located in the same region as the focal firm. Regions are defined using 125 combined statistical areas (CSA) of the U.S. Census.

Table 1 provides summary information about the variables and their construction. Table 2 lists summary statistics and bivariate correlations.

RESULTS

Tables 3-6 report two main sets of results. In Table 3, we test Implication 1 from the model—that an increase in a firm's litigiousness will reduce the likelihood of employee exits. Tables 4-6 test Implications 2 and 3, which suggest that such litigiousness will systematically shift the distribution of who stays and exits.

Effect of litigiousness on mobility likelihood

Turning first to Table 3, Model 1 estimates the effects of the control variables on the likelihood of mobility using an OLS linear probability model. The unit of analysis is an inventor-year. Robust standard errors, clustered by firms, are reported. Among the controls, inventors with more highly cited patents have higher propensities to exit, as do those who are male, non-white, and more recently hired. Not surprisingly, inventors are more likely to leave firms with declining patenting quality and R&D intensity. As in Marx *et al.* (2009) and Garmaise (2009), mobility rates decline as the strength of non-compete enforcement increases: a one-point increase in the Garmaise enforceability index lowers the annual mobility likelihood by 11.3 percent among semiconductor inventors in our sample. Mobility declines as the supply of knowledge workers in a region increases.

Model 2 in Table 3 adds *Litigiousness*, the main explanatory variable of interest. Consistent with Implication 1, *Litigiousness* is negative and statistically significant. More specifically, the filing of an additional patent lawsuit reduces the annual turnover rate predicted for the focal employer by almost three percent. At an average of three lawsuits in the preceding three years for litigating firms, this translates into a nine percent reduction in estimated departures by knowledge workers each year.

As a robustness check, Model 3 omits firm-fixed effects from the specification. Although the results are qualitatively unchanged, the magnitude of the *Litigiousness* effect grows larger, to an estimated 6 percent drop in annual departures. In combination, Models 2 and 3 suggest that the estimated effect of *Litigiousness* is biased upward absent controls for time-invariant differences among employers. In unreported output,[10] we also omitted from the estimation sample inventors in the lowest quartile of a source-firm's patent producers to assuage concerns that our results are spuriously driven by involuntary exits (i.e., layoffs of less productive workers). The results were robust to this modification. Finally, our findings are also robust to the non-instrumented specifications in Table 3 using conditional logit, Probit, and Cox hazard-rate models.

Alternative explanations for findings related to Implication 1:

Models 4-6 in Table 3 investigate three main threats to identifying a causal relationship between a firm's litigiousness and the exit calculus of the firm's employees suggested by our model. Prominent among them is that as firms grow more litigious, they could attract less mobile workers. If true, a negative *Litigiousness* coefficient could reflect an underlying shift in individual types that 'select in' via recruitment, rather than a change in exit incentives due to litigious action. To investigate this possibility, Model 4 in Table 3 restricts the sample to employee-inventors hired by firms that switch *post-hiring* from passive to aggressive in enforcing patents, thus isolating attention to employees that joined companies when they were non-litigious. At odds with a recruitment-driven explanation, *Litigiousness* remains negative and significant, with a more pronounced effect.

Alternatively, the effect could be driven by an unobserved, time-varying 'shock' within firms. To elaborate, assume that a given source-firm has a positive opportunity 'shock' such as a breakthrough discovery that is insufficiently captured by our right-hand controls. The shock could yield a simultaneous increase in legal action, since the firm has more valuable technologies to protect, and employee retention, if the value of internal projects relative to outside options shifts upward. In this scenario, litigiousness and employee retention could be correlated without suggesting a causal link.

To investigate this second possibility, we instrument litigiousness with court characteristics likely to affect a firm's decision to sue but unlikely to coincide with a firm-specific shock in unobserved technological value. Kesan and Ball (2006, 2010) show that district court effectiveness and experience—both in civil disputes overall and in patent-related related matters—alter litigation

[10] All unreported output is available upon request.

outcomes and, in turn, directly affect decisions to file patent infringement lawsuits. These court-level characteristics are driven by numerous factors, including budget constraints and judicial expertise, which are reasonably exogenous to a time-varying technological shock within a focal source firm in our sample. Using annual statistics reported in Kesan and Ball (2006, 2010), we therefore instrument *Litigiousness* with characteristics of the U.S. District Courts in which source firms litigate patents, based on civil and patent caseloads heard on a per-judge basis.[11]

Model 5 in Table 3 reports 2SLS estimates with the court-based instruments shown at the bottom the column. The four instrumental variables are jointly significant at the 0.1% level in the first-stage regression, and the IV estimates pass the Hansen over-identification test with *p* value of 0.3. As before, firm-fixed effects are included and robust standard errors, clustered by firms, are reported. Assuming that court-level characteristics influence litigation choices for reasons exogenous to a time-specific shock within an individual firm, the estimates in Model 5 provide support for Implication 1: the *Litigiousness* coefficient remains negative and statistically significant.

A third, related concern is that our *Litigiousness* measure is picking up positive opportunity shocks within regions insufficiently controlled for in our regressions. Similar to the prior discussion, a region-wide opportunity shock could ignite more legal conflict due to the higher value of technological discoveries (possibility creating bottlenecks in judicial outlets), while also resulting in higher retention rates in local labor markets. If true, we should find a similar effect if our firm-specific *Litigiousness* variable is replaced with a 'false' measure based on lawsuits filed by other semiconductor firms within the region. Model 6 of Table 3 conducts this falsification test by replacing the firm-level *Litigiousness* variable with an equivalent measure based on the patent infringement lawsuits launched by other semiconductor firms in the region based on the CSA of the headquarter location, excluding the focal source firm. Consistent with the view that the *Litigiousness* effect stems from firm-specific reputational factors, the 'false' measure fails to predict employee exits at statistically significant levels.

[11] As described in Table 1, the variable is based on all district courts in which the focal source firm has litigated patents in the prior three years. Although plaintiffs in patent infringement lawsuits have some latitude for selection of legal venues (Moore, 2001), we assume non-trivial adjustment costs in switching venues.

Effect of litigiousness on external value of ideas

The remaining sets of analyses investigate whether a firm's reputation for IP toughness yields differential sorting, thus altering the mobility calculus of some employee types more than others. Implication 2 of the model predicts that, as employers grow more litigious, the average value of ideas carried by mobile scientists to rival companies will shift upward. Lacking a direct measure of idea value and following Hoisl (2007) and Palomeras and Melero (2010), we test Implication 2 with indirect proxies defined earlier based on the post-exit patenting productivity (Table 4) and post-exit patenting quality (Table 5) of mobile inventors. Tables 4 and 5 are therefore conditioned on employee-inventor movement from a source firm to another U.S. semiconductor company, with a mobile inventor as the unit of analysis.

Consistent with Implication 2, Tables 4 and 5 reveal a robust empirical pattern: regardless of whether external idea value is captured by the inventor productivity or quality measure, *Litigiousness* shifts the value-distribution of mobile inventors. Specifically, in the main Model 2 of Table 4, the *Litigiousness* coefficient predicts that the additional filing of a patent infringement lawsuit will lead to 2.1 percent increase in average patent productivity of mobile employees post-exit. At an average of three lawsuits in the last three years, this estimate suggests a 6.3 percent increase in post-mobility productivity for the average litigant. Model 2 in Table 5 reveals a similar pattern, with the additional filing of a patent infringement lawsuit yielding a 3.2 percent increase in the predicted number of patent citations of a mobile employee post-exit, a 16 percent increase for the average litigant.

Alternative explanations for findings related to Implication 2:

Similar to the alternative explanation tests for Implication 1, in the remaining models of Tables 4 and 5, we find no evidence the findings are spuriously driven by shifts in recruitment (Model 3), latent technological shocks within employers (Model 4), or regional dynamics insufficiently controlled for in our regressions (Model 5). As an additional robustness check, we re-ran the non-instrumented models using a Poisson quasi-maximum likelihood estimator more suitable for skewed counts (Gourieroux *et al.*, 1984) and obtained similar results. In combination, we interpret the evidence in Tables 4 and 5 as consistent with the view that litigiousness increases the value threshold required for knowledge workers to leave in pursuit of outside opportunities. As per Figure 1, the evidence suggests that—absent the intensified threat of legal action, more ideas near the mobility constraint would have been carried to other firms through employee exits.

Effect of litigiousness on internal value of ideas

If litigiousness boosts the retention of scientists with ideas of higher value internally, the average internal value of ideas carried by mobile workers should fall (Implication 3). Table 6 tests this final implication of the model. Analogous to Tables 4 and 5, the internal value of ideas is proxied by the pre-exit patent productivity and quality of mobile inventors in Panels A and B respectively. For brevity, we report parallel results in one table.

The results in Table 6 are further indicative of differential sorting. Consistent with Implication 3, an increase in litigiousness shifts the distribution of employee/idea types that leave toward those with lower internal value pre-exit. Specifically, the estimates in Model A1 predict that one additional patent infringement lawsuit lowers the pre-exit patent productivity of mobile inventors by 2.1 percent. Model B1 similarly suggests a significant drop in pre-exit patenting quality by 4.5 percent.

Alternative explanations for findings related to Implication 3:

The results for Implication 3 are largely robust to alternative explanations. They hold in subsamples of mobile inventors from firms that switched to litigious post-hiring (Models A2 and B2), and do not appear to be driven by latent regional dynamics as per Models A4 and B4. Although the court-base instruments pass the Hansen over-identification test in Models A3 and B3 with p-values of 0.71 and 0.52, the statistical significance of *Litigiousness* on internal idea value is sensitive to the value proxy, falling below conventional significance levels for the quality-based measure in Model B3, but remaining negative and significant in Model A3.

Finally, to view the differential effects of litigiousness on employee sorting suggested by Implication 3 from another vantage point, we conducted supplemental analyses using the unconditioned sample of employee-inventors and interaction terms between litigiousness and the pre-exit patent productivity and quality of employee-inventors respectively. While the use of two endogenous variables (the main effect and each interaction) undermines the strength of the instruments in 2SLS regressions, the OLS estimates nonetheless mirror the pattern revealed in Table 6: the retention effect of litigiousness is stronger among employee-inventors who are more productive or highly cited pre-exit. Evidence from this analysis is available upon request.

DISCUSSION AND CONCLUSION

This study reveals new linkages between firm-level variations in reputations built through patent enforcement to employee-level mobility decisions. Our findings, drawn from the U.S. semiconductor industry, are consistent with the view that reputations for IP toughness reduce the relative payoffs employees anticipate from switching jobs within an industry, thus deterring voluntary departures (Implication 1). We also find that litigiousness alters the *distribution* of employee exits, affecting the departure calculus of some employee types more than others (Implications 2 and 3). As predicted by the formal model, we find that litigiousness exerts a stronger pull on 'star' inventors, helping retain those pursuing ideas of high internal value that otherwise would leave in pursuit of outside development options. In contrast, the 'brightest' of inventors—those with ideas most highly valued externally—are relatively unaffected.

Thus, our study enables the answers to several important questions that motivated it. Firm level variations in reputations for patent enforcement matter in *intra-firm* dynamics related to employee retention vs. expropriation of ideas. Our findings suggest that 'job hopping' by skilled workers is not only shaped by state laws governing non-compete enforcement (Fallick *et al.*, 2006, Marx *et al.*, 2009), but is also influenced by firm-specific reputations built through patent enforcement. Given our empirical context of semiconductors, our study shows that U.S. technology companies that are headquartered in 'employee-friendly' states such as California may avail themselves to federal protection provided by patents. Indeed, the explosive growth in patent lawsuits in the United States in spite of climbing costs (Landes and Posner, 2003) have important implications for employer-employee dynamics, not just for product market rivalry (Agarwal et al, 2009; Somaya, 2003; Lanjouw and Schankerman, 2004). In addition to establishing intellectual property rights in sectors with higher turnover rates (Kim and Marschke, 2005), by aggressively enforcing these rights, firms can strategically alter both employee decisions to move, and the shape of distribution of talent released to rivals. The latter sheds light on how firm level decisions regarding patent enforcement matter in the sorting or matching of employees to firms in labor markets: reputations for patent enforcement differentially sort among employees, such that those whose ideas have higher internal value stay, while those with greater opportunities elsewhere leave.

An important point of discussion relates to the firm specificity assumption made for the derivation of Implication 3. Recall that this assumption implied that the ideas pursued within a firm results in the average external values of the idea being lower than the loss to the firm if the idea is exploited outside its boundaries. We note that this assumption does not rule out the cases where the *realized* external value exceeds the *realized* internal values, it only requires that *on average*, the firm chooses to invest in those ideas that have higher value in conjunction with the firm specific knowledge and complementary assets. While plausible, the assumption rules out an alternative case depicted in Figure 3. Here, the contour maps reflect positive correlations between external and internal values such that $g'(\bar{\rho}_i) > \lambda$, and the shaded areas between lines ON and AL represent scientists retained from the higher likelihood of litigation. In this alternative scenario, the reverse prediction to Implication 3 would hold: the average internal values of ideas in the contours left of line AL is higher than the average internal value of ideas in the contours left of line ON. Thus an increase in litigiousness would retain more scientists and ideas, but would sort scientists among those that stay and leave such that mobile scientists have higher external *and* internal value. This sorting implies that litigation is ineffectual in retaining those ideas and scientists that are universally important both internally and externally, rather than a differential sorting where those of higher internal value stay with the focal firm, and those that of higher external value leave for outside opportunities.

[Insert Figure 3 about here]

Within our empirical context, we do not find support for this alternative prediction. Thus, the semiconductor industry seems to represent a context where the average internal and external values are either independent, or where there is firm specificity of ideas and assets. Nonetheless, Figure 3 highlights the theoretical scenario wherein litigation may *increase* the average internal value of ideas that are exploited outside firm boundaries. Such scenarios, while outside the scope of this study, are worthy of future attention.

Extensions to our work also arise due to its limitations and implications. The analytical set-up of Kim and Marschke (2005), a natural starting point for our model, invokes simplifying assumptions that could be relaxed in future work. In the spirit of Anton and Yao (1995), for example, it is possible that employees with the most promising ideas disproportionately fail to disclose discoveries to litigious employers. Adding private information to the model could capture this effect. Whether IP toughness differentially affects employee effort pre- versus post-departure is also worthwhile to consider. In a broad sense however, we note that the internal and external values allow for an effort-induced effect. Our predictions should hold whether due to the relative value of know-how to new employers, the added stimulus to productivity post-departure, or both.

Assuming that reputation stocks are given at the time of an individual employee's mobility decision, our model yields useful insights about how employer-employee dynamics are altered by litigious behavior. This approach nonetheless limits our ability to inform how employers should determine optimal levels of toughness. Firms file patent infringement lawsuits for numerous reasons, including but not limited to potential expropriation through employee turnover. Clearly, larger forces are at play. Somaya (2003), for example, finds that rivals are more likely to sue one another when strategic stakes grow larger. Lerner (1995) further documents that a firm's ability to credibly threaten a patent lawsuit deters entry by product-market rivals. To the extent that firms compete in both product and resource markets, our study highlights the need to investigate how actions in one market space may have consequences in the other. By bolstering the retention of skilled workers, litigious action in product markets could reinforce the safeguarding of technologies and know-how in both channels. If such litigiousness undermines a firm's efforts to recruit talent in resource markets or to transfer technological discoveries from other firms as per Corredoira and Rosenkopf (2010), however, longer-term sources of advantage could be threatened (Coff 1997). Additional research on how firms balance these potential trade-offs is needed.

Future studies also could test the implications from our model more directly through use of confidential wage data like that used in Moen (2005) and Campbell *et al.* (2012). In addition to revealing actual wage rates, such data would help alleviate concerns of measurement bias in patent data (see Trajtenberg *et al.* [2006] for discussion). More substantively, new questions could be explored. For example, little is known about how the efficacy of patent enforcement—as a deterrent against mobility-related expropriation—interacts with other levers available to employers, including incentive schemes such as stock options. Similarly, the effects of corporate litigiousness on individual-level behavior could be probed more deeply with surveys or qualitative research methods. In a survey of engineers, for example, Hannah (2005) provides a fascinating glimpse into how trade secret procedures shape employee behavior, reporting that employees entrusted with such secrets respond favorably to the enforcement actions of their employers. Qualitative evidence by Marx (2011) provides a less sanguine view of employee reactions to non-compete agreements, reporting anger and dismay over limitations inked in employment contracts. Whether IP toughness results in increased loyalty and commitment as per Hannah (2005) or alienation and resentment as per Marx (2011) is an intriguing question in need of further study. Absent such research, it is difficult to gauge the broader impact of litigiousness on employee morale and recruitment.

Limitations notwithstanding, this study contributes to three related streams of research. First, by revealing an under-studied mechanism affecting employee retention—corporate reputations for IP toughness, we contribute to a literature that examines how mechanisms within existing firms give rise to employee mobility and entrepreneurship (Anton and Yao, 1995; Franco and Filson, 2006; Hellmann, 2007; Klepper and Sleeper, 2005). Building on Kim and Marschke (2005), we relax a common assumption that patents are ineffectual safeguards against expropriation by 'insiders.' Importantly, we advance prior work by modeling and empirically showing that an employer's aggressiveness in patent enforcement (i.e., its reputation for IP toughness) alters the antecedent proclivity of employees to exit.

Findings from this study also are salient to the strategic management literature on micro-level dynamics in strategic factor markets (Barney, 1991; Castanias and Helfat, 1991; 2001; Coff, 1997), as they relate to changes in bargaining power between firms and their employees (Campbell *et al.* 2012).

While most of the literature focuses on the efficacy of human resource practices on employee retention (Bloom *et al*., 2011), we show that employee exit decisions are significantly altered by corporate reputations for IP toughness. We therefore add to a growing literature on the legal instruments used to bind employees to incumbent firms, including non-compete clauses (Marx *et al*., 2009) and work visas (Mithas and Lucas, 2010). Our model and empirical findings further suggest, however, that patent enforcement—as a strategic lever for shaping mobility decisions—has different effectiveness across employees. The differential effect depends on employee opportunities for outside advancement relative to opportunities within the parent firm. This insight opens up a rich set of questions for future research relating to the optimal balance of different strategic levers that influence rent appropriation (Coff, 1997) and the conditions under which such levers are particularly limited or influential in shaping the behavior of engineers and scientists.

Finally, the study contributes to a more targeted literature on learning-by-hiring (Almeida and Kogut, 1999; Palomeras and Melero, 2010; Rosenkopf and Almeida 2003). Prior learning-by-hiring studies typically trace knowledge flows and mobility events using evidence from patents and the citations within them, yet implicitly assume that patent protection fails to shape the underlying mobility process. We advance this literature by allowing patent enforcement to endogenously affect employee exit decisions. In doing so, we provide new evidence that patent enforcement not only curtails the inter-firm knowledge transfers anticipated from mobility events (Agarwal *et al*., 2009), but also reduces the baseline probability that skilled workers will leave in pursuit of outside options. From an inter-firm knowledge transfer perspective, we further contribute by showing that IP toughness skews the type of employees leaving, thus affecting the distribution of knowledge transported through labor markets.

In summary, this study models and empirically demonstrates that a firm's aggressiveness in patent enforcement affects the job-hopping activities of its skilled workers. We find that litigiousness not only reduces the likelihood of employee exits but also serves a sorting function—altering the exit calculus of some employee types more than others. The study sheds new light on the strategic levers firms use to capture value from R&D and human capital investments.

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Figure 1. Increase in litigiousness and mobility (internal and external values are independent and uniformly distributed)

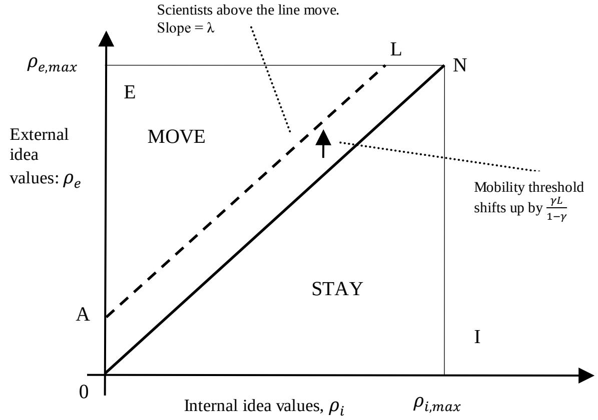

Figure 2. Increase in litigiousness and mobility (internal and external values are normally distributed and positively related while $\frac{\partial g(\bar{\rho}_i)}{\partial \bar{\rho}_i} < \lambda$)

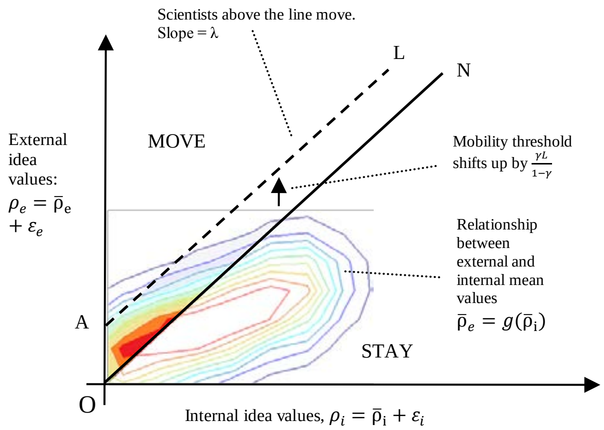

Figure 3. Increase in litigiousness and mobility (internal and external values are normally distributed and positively related while $\frac{\partial g(\bar{\rho}_i)}{\partial \bar{\rho}_i} > \lambda$)

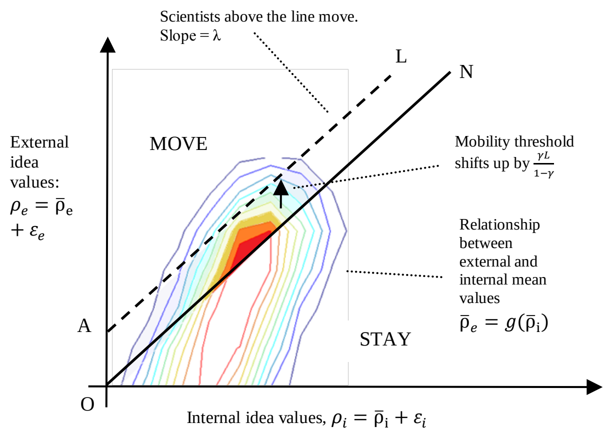

Table 1: Model Timing and Payoffs to Employer and Scientist

Panel A: Model Timing	
In Period 1	The scientist works for the employer to develop a patentable idea, and is paid w_1.
End of Period 1	i. The scientist and employer learn the values ϱ_i, ϱ_e of the idea. ii. The employer offers w_2 for the scientist to stay in period 2. iii. If w_2 exceeds the expected value of exiting, the scientist stays; otherwise, he leaves.
Period 2	Employer produces and sells based on the patented idea. If scientist leaves to capitalize on the same idea elsewhere, employer decides whether to sue.

Panel B: Period 2 Payoff Matrix (scientist, employer)

		Scientist Moves	
		NO	YES
Employer Litigates	NO	w_2, $\overline{w} + \varrho_i - w_2$	$\overline{w} + \varrho_e$, $(1-\lambda)\varrho_i$
	YES		$\overline{w}$, $\varrho_i - L$

Panel C: Expected Payoffs under Likelihood of Litigation (γ)

	Scientist Moves	
	NO	YES
Scientist expected payoff	w_2	$\overline{w} + \varrho_e - \gamma\varrho_e$
Employer expected payoff	$\overline{w} + \varrho_i - w_2$	$\varrho_i - (1 - \gamma)\lambda\varrho_i - \gamma L$

Table 1. Variable Definitions

Dependent Variables	
Intra-industry mobility event	A binary indicator set to 1 if source-firm inventor appears on a subsequent patent assigned to another firm in recipient sample
Post-mobility patent productivity	Number of patents produced by ex-employee at recipient firm divided by the number of years at the recipient firm.
Post-mobility patenting quality	Number of forward citations over a five-year window made to patents by ex-employee at the recipient firm divided by the number of patents at the recipient firm.
Pre-exit inventor patenting quality	Annual number of employee's citations per patent at source-firm
Pre-exit inventor patenting productivity	Annual number of employee's patents at source-firm
Main Explanatory Variable	
Litigiousness (3-year moving sum)	Moving sum of the number of unique patent infringement lawsuits initiated by the source firm from year *t*-1 to year *t*-3.
Controls	
Inventor # co-inventors	Annual mean number of co-inventors at source-firm.
Inventor tenure	Last minus first year of source-firm inventive activity for employee.
Gender (1=female)	1 if female, else 0 based on first name of inventor
Ethnicity (1=non-white)	1 if Asian, Middle-Eastern or Indian sounding name on patent document, 0 otherwise.
Firm patenting productivity	Annual number of firm's patents
Firm patenting quality	Annual number of firm's citations per patent
R&D intensity	Source-firm R&D expenditures divided by employee counts in focal year.
Number of inventors in the region	Log of the number of inventors in the inventor's combined statistical area (CSA) excluding the focal firm.
Garmaise noncompete index	Noncompete enforceability index for U.S. states listed in Garmaise (2009, Table A1); time-varying for Texas, Florida, and Louisiana.
Instruments[12]	
# civil lawsuits	Average number of civil lawsuits litigated in courts used by the focal firm between the years *t*-1 to *t*-3.
# patent lawsuits	Average number of patent lawsuits litigated in courts used by the focal firm between the years *t*-1 to *t*-3.
# patent lawsuits per judge	Average number of civil lawsuits per judge litigated in courts used by the focal firm between the years *t*-1 to *t*-3.
# civil lawsuits per judge	Average number of patent lawsuits per judge litigated in courts used by the focal firm between the years *t*-1 to *t*-3.

[12] All instruments are imputed with 0 if the focal firm does not litigate in *t*-1 to *t*-3. As an alternative, we have imputed the average value of the measure across all litigating firms over *t*-1 to *t*-3 as a way of capturing the 'expected' value of the measure. The results remained unchanged to either specification of the instruments.

Table 2. Summary statistics and correlations

	Mean	Std. Dev.	Min	Max	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)
1) Post-exit inventor patenting quality (citations per patent)	24.515	29.472	0.0	361.84	1													
2) Post-exit inventor patenting productivity (patents per year)	1.466	1.103	0.2	14.00	0.0698	1												
3) Mobility	0.015	0.122	0.0	1.00	0.0021	-0.0186	1											
4) Litigiousness (3-year moving sum)	3.052	4.392	0.0	17.00	-0.0004	0.0193	-0.0457	1										
5) Pre-exit inventor patenting quality (citations per patent)	5.265	9.246	0.0	203.00	0.0822	0.0599	0.0256	-0.0078	1									
6) Pre-exit inventor patenting productivity (patents per year)	1.114	1.922	0.0	54.00	0.0659	0.0615	0.01	-0.0425	0.1742	1								
7) Average # co-inventors	1.431	1.795	0.0	20.00	0.0307	0.0342	0.0027	-0.0219	0.2794	0.2386	1							
8) Tenure within firm	3.744	3.715	1.0	27.00	-0.0524	-0.0478	-0.0256	0.1761	-0.1196	-0.0208	-0.1297	1						
9) Gender (1=female)	0.024	0.152	0.0	1.00	0.0042	0.0073	-0.0129	0.006	0.0155	-0.0058	0.0442	-0.0509	1					
10) Ethnicity (1=non-white)	0.244	0.429	0.0	1.00	0.0795	-0.0009	0.0289	-0.0383	0.0305	0.0238	0.0616	-0.0892	-0.051	1				
11) Firm patenting productivity (patents per year)	299.969	261.609	0.0	989.00	-0.0256	0.022	-0.0564	0.3554	0.0866	0.0896	0.0988	0.1158	0.0271	0.0234	1			
12) Firm patenting quality (citations per patent)	0.419	1.812	0.0	29.50	-0.0041	-0.0789	-0.0161	-0.0781	-0.0887	0.0106	0.0597	-0.0024	0.0003	0.0318	-0.117	1		
13) R&D intensity	0.029	0.025	0.0	0.21	-0.0113	0.0295	0.0026	-0.2935	0.0438	0.0972	0.1594	-0.1204	0.0164	0.1172	-0.071	0.2855	1	
14) # inventors in region (excluding focal firm, log)	5.712	2.089	0.0	8.26	-0.038	0.0916	0.0224	-0.3075	0.1508	0.1238	0.1399	-0.1728	0.0261	0.1395	-0.0227	0.0296	0.5542	1
15) Garmaise noncompete index	2.578	2.470	0.0	9.00	-0.0133	-0.0357	-0.0539	0.3569	-0.029	-0.033	-0.0114	0.1119	-0.0138	-0.1698	0.2853	-0.0684	-0.3767	-0.5864

Table 3. Litigiousness and the probability of employee-inventor exits (inventor-year observations)

DV = mobility	Controls only Model 1 (OLS)	Main model Model 2 (OLS)	No firm FE, Model 3 (OLS)	'Switchers' only Model 4 (OLS)	IV Estimates Model 5 (2SLS)	Falsification test Model 6 (OLS)
Litigiousness (3-year moving sum)		**-0.0003****	**-0.0006****	**-0.0009****	**-0.0017****	0.0039
		(0.0001)	(0.0003)	(0.0004)	(0.0008)	(0.0031)
Inventor-level controls						
Inventor patenting quality	0.0003***	0.0003***	0.0003***	0.0005**	0.0003***	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)
Average # co-inventors	0.0004	0.0004	0.0002	0.0013*	0.0003	0.0004
	(0.0004)	(0.0004)	(0.0004)	(0.0007)	(0.0004)	(0.0004)
Tenure within firm	-0.0002*	-0.0002*	-0.0003***	-0.0009	-0.0002	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0005)	(0.0001)	(0.0001)
Gender (1=female)	-0.0084***	-0.0083***	-0.0091***	-0.0196***	-0.0082***	-0.0083***
	(0.0020)	(0.0020)	(0.0023)	(0.0037)	(0.0019)	(0.0020)
Ethnicity (1=non-white)	0.0062***	0.0061***	0.0068***	0.0065	0.0060***	0.0063***
	(0.0020)	(0.0020)	(0.0021)	(0.0045)	(0.0020)	(0.0019)
Firm-level controls						
Firm patenting quality	-0.0011***	-0.0010***	-0.0005**	-0.0006	-0.0009***	-0.0013***
	(0.0003)	(0.0003)	(0.0002)	(0.0006)	(0.0003)	(0.0003)
Firm patenting productivity	0.0000	0.0000	-0.0000***	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
R&D intensity	-0.1790**	-0.1860**	-0.0034	-0.2110*	-0.2267**	-0.1959**
	(0.0841)	(0.0869)	(0.0853)	(0.1186)	(0.1037)	(0.0891)
Region-level controls						
# inventors in region	-0.0071**	-0.0071**	(0.00)	-0.0093**	-0.0075***	-0.0084**
(excl. focal firm, log)	(0.0033)	(0.0032)	(0.0012)	(0.0036)	(0.0028)	(0.0035)
Garmaise noncompete index	-0.0017*	-0.0017*	-0.0020*	-0.0016	-0.0015*	-0.0015*
	(0.0010)	(0.0010)	(0.0010)	(0.0012)	(0.0009)	(0.0008)
Constant	0.0544***	0.0540***	0.0324***	0.0614***		0.0952*
	(0.0145)	(0.0143)	(0.0065)	(0.0162)		(0.0482)
First-stage instruments in Model 5						
# patent cases					0.0033** (0.0015)	
# civil cases					-0.0001* (0.0001)	
# patent cases per judge					0.1069 (0.3552)	
# civil cases per judge					0.0098 (0.0124)	
Hansen over-id test (p-value)					0.304	
Pseudo R2/R2	0.003	0.0033	0.009	0.005	0.002	0.003
N	50,360	50,360	51,614	22,597	50,360	48,177

* p<.1, ** p<.05, *** p<.01. Robust standard errors, clustered by firms, are reported. Year dummies are included, as are firm-fixed effects except in model 3.

Table 4. Litigiousness and the patent productivity of employee-inventors post-exit (mobile inventors only)

DV= post-exit patenting productivity	Controls only, OLS Model 1	Main model, OLS Model 2	'Switchers' only Model 3	IV, 2SLS Model 4	Falsification test Model 5
Litigiousness (3-year moving sum)		**0.0307****	**0.0217***	**0.1407***	-0.0409
		(0.0127)	(0.0131)	(0.0855)	(0.0518)
Inventor-level controls					
Pre-exit inventor patenting productivity	0.1854***	0.2007***	0.2755**	0.2140***	0.2141***
(patents per year)	(0.0685)	(0.0672)	(0.1221)	(0.0573)	(0.0695)
Average # co-inventors	-0.0344	-0.0277	-0.0134	-0.0320	-0.0237
	(0.0290)	(0.0309)	(0.0343)	(0.0306)	(0.0307)
Tenure within firm	-0.0041	-0.0002	-0.0013	0.0045	0.0020
	(0.0134)	(0.0147)	(0.0142)	(0.0171)	(0.0124)
Gender (1=female)	0.0619	0.0237	0.5579***	-0.1062	0.0569
	(0.1486)	(0.1529)	(0.1335)	(0.2855)	(0.1353)
Ethnicity (1=non-white)	0.0065	0.0224	-0.0479	0.0306	0.0246
	(0.0945)	(0.0955)	(0.0868)	(0.0944)	(0.0949)
Firm-level controls					
Firm patenting quality	-0.6414	-0.3804	-0.0624	-0.4839	0.1441
	(0.3909)	(0.4366)	(0.3843)	(0.4270)	(0.3296)
Firm patenting productivity	-0.0003*	-0.0005***	0.0000	-0.0007***	-0.0005***
	(0.0002)	(0.0002)	(0.0004)	(0.0001)	(0.0001)
R&D intensity	-4.7325	-5.3954	-4.6431	-4.1828	-3.9781
	(3.3659)	(4.0034)	(3.1091)	(4.5083)	(3.5085)
Region-level controls					
# inventors in region	-0.0539	-0.0766	-0.1383	-0.0444	-0.1003
(excl. focal firm, log)	(0.1135)	(0.1188)	(0.0836)	(0.1025)	(0.0716)
Garmaise noncompete index	0.0183	0.0138	-0.0101	0.0016	0.0082
	(0.0205)	(0.0191)	(0.0278)	(0.0170)	(0.0204)
Constant	0.7041**	0.7631***	2.4480***		1.6861***
	(0.2923)	(0.2553)	(0.8595)		(0.6311)
Firm-fixed effects	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES
Hansen over-id test (p-value)				0.35	
Pseudo R2/R2	0.07	0.08	0.07	0.03	0.05
N	744	744	488	744	744

* p<.1, ** p<.05, *** p<.01. Robust standard errors, clustered by firms, are reported.

Table 5. Litigiousness and the patent quality of employee-inventors post-exit (mobile inventors only)

DV = post-exit patenting quality (citations per patent)	Controls only, OLS Model 1	Main model, OLS Model 2	'Switchers' only Model 3	IV, 2SLS Model 4	Falsification test Model 5
Litigiousness (3-year moving sum)		**0.7781***	**2.0842****	**9.4193*****	1.9065
		(0.4291)	(0.8443)	(3.5932)	(2.4824)
Inventor-level controls					
Pre-exit inventor patenting quality	0.2318***	0.2277***	0.2439*	0.3251**	0.2208***
(citations per patent)	(0.0801)	(0.0771)	(0.1499)	(0.1597)	(0.0793)
Average # co-inventors	0.4977	0.0994	-0.8024	-0.5585	0.2087
	(1.0574)	(1.0750)	(0.6275)	(1.1683)	(1.1154)
Tenure within firm	0.6557**	0.6612**	0.4105	0.9071*	0.6544*
	(0.3055)	(0.3184)	(0.2559)	(0.4733)	(0.3326)
Gender (1=female)	6.7268	5.6363	13.1852***	-8.1922	6.5643
	(4.8637)	(5.3493)	(4.0956)	(14.2818)	(4.8260)
Ethnicity (1=non-white)	3.3145	3.3687	-0.3792	3.3376	2.9016
	(2.4743)	(2.5254)	(2.7308)	(2.8999)	(2.4745)
Firm-level controls					
Firm patenting quality	-4.45170	-6.62110	-20.0823	-9.19260	-7.07760
	(8.1164)	(10.3122)	(13.2214)	(12.1484)	(10.8909)
Firm patenting productivity	0.0118*	0.0086	0.0007	-0.009	0.0103
	(0.0060)	(0.0064)	(0.0110)	(0.0100)	(0.0068)
R&D intensity	27.0207	72.0429	153.2404	169.4125	60.3844
	(138.92)	(149.89)	(193.41)	(162.82)	(151.43)
Region-level controls					
# inventors in region	-2.4472	-2.4414	-4.6370**	-3.8551	-3.1206
(excl. focal firm, log)	(2.2760)	(2.2743)	(2.1962)	(2.4632)	(2.7795)
Garmaise noncompete index	-0.2636	-0.4924	-0.2233	-1.3628	-0.4771
	(0.4905)	(0.5220)	(0.6424)	(0.9657)	(0.5108)
Constant	16.4961	15.4298	45.0023**		20.5171
	(19.7720)	(22.1258)	(19.5519)		(25.5815)
Firm-fixed effects	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES
Sargan-Hansen over-id test (p-value)				0.21	
Pseudo R2/R2	0.037	0.038	0.09	0.038	0.036
N	744	744	488	744	744

* p<.1, ** p<.05, *** p<.01. Robust standard errors, clustered by firms, are reported.

Table 6. Litigiousness and the patent productivity and quality of employees pre-exit (mobile inventors only)

DV	A. Pre-exit patent productivity				B. Pre-exit patent quality			
Model	Main, OLS Model A1	'Switchers' only Model A2	IV, 2SLS Model A3	Falsification test Model 4A	Main, OLS Model B1	'Switchers' only Model B2	IV, 2SLS Model B3	Falsification test Model B4
Litigiousness	**-0.0235****	**-0.0572*****	**-0.0583***	0.0690	**-0.2489***	**-0.3512*****	**0.4661**	0.3797
(3-year moving sum)	(0.0098)	(0.0164)	(0.0342)	(0.0651)	(0.1357)	(0.0982)	(0.6736)	(0.8145)
Inventor-level controls								
Average # co-inventors	0.0602***	0.0466	0.0577***	0.0550***	0.7113***	0.9537***	0.6829***	0.7012***
	(0.0188)	(0.0287)	(0.0175)	(0.0194)	(0.2556)	(0.3143)	(0.2426)	(0.2663)
Tenure within firm	0.0035	-0.0138	0.0008	0.0027	-0.0894	-0.0271	-0.0639	-0.069
	(0.0077)	(0.0141)	(0.0088)	(0.0079)	(0.0747)	(0.0896)	(0.0886)	(0.0847)
Gender (1=female)	-0.1641	-1.0549***	-0.0926	-0.2021	5.0969	-0.7365	4.3539	4.8617
	(0.3138)	(0.1570)	(0.2980)	(0.3554)	(6.6044)	(1.7350)	(6.3074)	(6.6677)
Ethnicity (1=non-white)	-0.0463	-0.0709	-0.0553	-0.0641	0.3055	0.2984	0.3603	0.3728
	(0.0883)	(0.1074)	(0.0803)	(0.0825)	(0.7328)	(0.8153)	(0.6992)	(0.7454)
Firm-level controls								
Firm patenting quality	-0.9173**	-0.7861*	-1.0697**	0.1189	-11.583***	-15.945***	-12.41***	-12.377***
	(0.4124)	(0.4318)	(0.4921)	(0.3897)	(4.0247)	(4.2124)	(4.0714)	(4.0613)
Firm patenting productivity	0.0005***	-0.0001	0.0005***	0.0001	-0.0045*	-0.0051	-0.0060**	-0.0047*
	(0.0002)	(0.0004)	(0.0002)	(0.0003)	(0.0023)	(0.0036)	(0.0025)	(0.0025)
R&D intensity	-4.3474	-7.4124	-4.3908	-5.2150*	43.2097	67.3562	51.0318	47.1239
	(2.7894)	(4.5164)	(2.9132)	(2.7023)	(32.9187)	(43.2930)	(35.8046)	(34.4102)
Region-level controls								
# inventors in region	0.1991***	0.1562*	0.1369**	0.0697	-0.2735	-0.1712	-0.2379	-0.298
(excl. focal firm, log)	(0.0618)	(0.0969)	(0.0660)	(0.0740)	(0.7823)	(0.9804)	(0.6666)	(0.8209)
Garmaise noncompete	0.0193	0.0188	0.0259	0.0141	0.2667	0.2731	0.1979	0.2472
index	(0.0172)	(0.0203)	(0.0188)	(0.0135)	(0.1718)	(0.2649)	(0.1697)	(0.1759)
Constant	1.4291***	2.0807**		0.6682	16.41**	20.1865**		16.7358**
	(0.5918)	(0.9039)		(0.4705)	(7.67)	(9.4541)		(7.9556)
Firm-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES	YES	YES	YES
Hansen over-id test (p-value)			0.71				0.52	
Pseudo R2/R2	0.05	0.05	0.07	0.05	0.14	0.19	0.09	0.14
N	744	488	744	744	744	488	744	744

* p<.1, ** p<.05, *** p<.01. Robust standard errors, clustered by firms, are reported.

Appendix I. Employer's Maximization Problem

The employer maximizes the expected profit from hiring a scientist:

$$E(\pi) = -w_1 + \iint_S [\rho_i - w_2 + \overline{w}] f(\rho_e, \rho_i) d\rho_e d\rho_i + \iint_M [\rho_i - (1-\gamma)\lambda\rho_i - \gamma L] f(\rho_e, \rho_i) d\rho_e d\rho_i \quad \text{(A.1)}$$

where S is a set of ϱ_i, ϱ_e such that scientist stays and M is a set where he moves. The employer hires a scientist when the expected profit is positive. The scientist accepts the offer at the beginning of the first period if:

$$2\overline{w} \le w_1 + \iint_S w_2 f(\rho_e, \rho_i) d\rho_e d\rho_i + \iint_M [\rho_e - \gamma\rho_e + \overline{w}] f(\rho_e, \rho_i) d\rho_e d\rho_i \quad \text{(A.2)}$$

The employer's problem is to choose w_1, w_2 to maximize (A.1) subject to the participation constraint of the scientist (A.2). A time consistent equilibrium is assumed such that both the employer and the scientist take the other parties' decision in the second period as given. At the beginning of the second period, the employer offers a wage that maximizes her second period payoff and sets w_1 so that the participation constraint holds with equality. Substituting for w_1 in (A.1) and simplifying we obtain:

$$E(\pi) = -\overline{w} + \iint_S \rho_i f(\rho_e, \rho_i) d\rho_e d\rho_i + \iint_M [\rho_e - \gamma\rho_e + \rho_i - (1-\gamma)\lambda\rho_i - \gamma L] f(\rho_e, \rho_i) d\rho_e d\rho_i \quad \text{(A.3)}$$

The term $\varrho_e - \gamma\varrho_e$ in the second integral represents wage savings due to the value of the mobility option for the scientist.

To obtain w_2, we only need to realize that to induce the scientist to stay, the employer has to offer at least $\varrho_e - \gamma\varrho_e + \overline{w}$.

$w_2 = \varrho_e - \gamma\varrho_e + \overline{w}$ for ϱ_i, ϱ_e such that the scientist stays (A.4)

Note that the second period wage offer decreases with the anticipated likelihood of litigation γ. Higher γ decreases the value of mobility for the scientist; the wage offer required to induce the scientist to stay is therefore reduced.

The participation constraint can be used to solve for w_1:

$$w_1 = 2\overline{w} - \iint [\rho_e - \gamma\rho_e + \overline{w}] f(\rho_e, \rho_i) d\rho_e d\rho_i \quad \text{(A.5)}$$

Following Kim and Marschke (2005), we assume that $\rho_e = \overline{\rho}_e + \varepsilon_e$ and $\rho_i = \overline{\rho}_i + \varepsilon_i$, where $(\varepsilon_e \in R, \varepsilon_i > -\rho_i)$. ε_e, ε_i are mean zero random variables with joint density q and $\overline{\rho}_e$, $\overline{\rho}_i$ are constant means of ρ_e and ρ_i.

For w_1, we get:

$$w_1 = \overline{w} - \overline{\rho}_e + \gamma\overline{\rho}_e$$

$$\begin{aligned} w_1 &= \overline{w} - (1-\gamma)\iint \rho_e f(\rho_e, \rho_i) d\rho_e d\rho_i \\ &= \overline{w} - (1-\gamma)\int \rho_e f(\rho_{ei}) d\rho_e \\ &= \overline{w} - (1-\gamma)\ \overline{\rho}_e \end{aligned} \quad \text{(A.6)}$$

Note that the w_1 is increasing with the likelihood of litigation γ. Put differently, an increase in γ lowers the value of the mobility option. Since the value of mobility is part of the wage offer, the employer has to offer a higher initial wage to entice the scientist to join.