Received: 15 November 2018 | Revised: 4 May 2020 | Accepted: 5 May 2020 | Published on: 22 June 2020

DOI: 10.1002/smj.3203

RESEARCH ARTICLE

STRATEGIC MANAGEMENT JOURNAL

WILEY

From litigation to innovation: Firms' ability to litigate and technological diversification through human capital

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Abstract

Research Summary: When firms diversify technologically, they often acquire human capital from competitors. Legal challenges emerge when intellectual property (IP) safeguards are involved. We examine a firm's ability to initiate IP litigation or protect against litigation (i.e., litigation ability) as an antecedent to its technological diversification. We demonstrate that an unexpected reduction in firm's litigation ability is associated with a temporary decline in its entry into new technological domains. Furthermore, we find that the negative effect is stronger when the firm's existing inventors cannot be easily utilized in the new domain or when interfirm mobility in the new domain is low. These findings extend prior work by highlighting a proactive role of the firm's litigation ability that spans beyond protecting the firm's existing IP.

Managerial Summary: To diversify successfully, the firm often needs new knowledge that can be acquired by hiring new research personnel. However, these inventors may come from competitors and their knowledge may be protected by IP safeguards. We examine how the firm's ability to initiate and protect against IP litigation influences its technological diversification. We find that an unexpected reduction in a firm's ability to litigate temporarily reduces its expansion. The negative effect is magnified when considering expansion into domains where the firm's existing inventors cannot be utilized or where the intermobility of inventors is low. Our findings suggest that the ability to both protect IP and avoid litigation are important factors in a firm's diversification strategy.

KEYWORDS

employee mobility, human capital, innovation, intellectual property, litigation, technological diversification

1 | INTRODUCTION

A firm often diversifies into new technological domains to introduce novel products or services (Galunic & Rodan, 1998; Helfat & Raubitschek, 2000; Markides & Williamson, 1994; Penrose, 1959). To enable such diversification, the firm may need more than to be able to leverage its existing knowledge (Ahuja & Katila, 2001; Folta, Helfat, & Karim, 2016; Helfat & Eisenhardt, 2004; Moeen, 2017); it could also need to access knowledge from the new domain that it does not yet possess (Coff, 1997; Galunic & Rodan, 1998; Helfat & Raubitschek, 2000; Kaiser, Kongsted, Laursen, & Ejsing, 2018; Miller, 2006; Rosenkopf & Almeida, 2003). The latter presents complications when such knowledge is embodied primarily within human capital, a phenomenon that is increasingly prevalent in knowledge-driven economies (Almeida & Kogut, 1999; Grant, 1996; Phillips, 2002; Song, Almeida, & Wu, 2003). Past research has shed much light on the former—issues about a firm utilizing its existing knowledge in new technological domains (Levinthal & Wu, 2010; Sakhartov & Folta, 2014), but paid less attention to the latter, leaving open pressing questions about when the diversifying firm might face difficulties when it tries to access such human capital.

The key complication is that the human capital in question usually resides within other firms already operating in the focal domain, and there are intellectual property (IP) safeguards in place to restrict the diversifying firm's access to it (Landes & Posner, 2003; Somaya, 2003; Starr, 2019). Much of the knowledge contained within human capital is tacit and hence tied to its conduit, leaving the diversifying firm with few options other than acquiring the human capital itself. Not surprisingly, IP-related battles are frequently fought over employees moving across firms.[1] The implications of human capital-related IP infringement litigation are nontrivial and they could potentially curb the firm's decision to diversify in the first place.[2] Such an effect may be especially salient if the firm is not equipped to deal with the ensuing IP-related battles. Yet, the literature has largely been silent on this antecedent of technological diversification.

The extant literature on strategic IP litigation in technological competition (Tan & Rider, 2017; Ziedonis, 2003) has mostly focused on how litigation protects the firm's existing IP. This literature shows that a firm actively uses IP-related litigation to dissuade its valuable employees from exit (Agarwal, Ganco, & Ziedonis, 2009; Ganco, Ziedonis, & Agarwal, 2015; Starr, Ganco, & Campbell, 2018). A firm's ability to litigate over IP-related matters has thus been conceptualized as a strategic lever (Agarwal et al., 2009; Clarkson & Toh, 2010). Thus far,

[1]For instance, over 85% of federal trade secret lawsuits involve the firm's employees or business partners (Almeling, Snyder, Sapoznikow, Mcollum, & Weader, 2010).
[2]Plaintiffs received favorable decisions in 69% of trade secrete lawsuits (O'Connell, 2019).

though, our understanding of litigation ability has been confined within the purview of the firm's current technological domains, specifically, how the firm uses its litigation ability to protect its own existing human capital or the associated IP. The question of whether and how litigation ability may come into play in the firm's decision to diversify remains unexplored. Such an issue is particularly salient when the firm is considering diversifying into technological domains where it needs to acquire human capital and will likely have to deal with IP safeguards.

We attempt to fill this gap by asking the following questions. *Does the firm's ability to litigate affect its decision to diversify into a new technological domain?*[3] *If so, is this effect contingent upon the characteristics of human capital needed within the new technological domain?* We address these questions by bringing together the literature on technological diversification, IP and knowledge-intensive human capital to study the relationships between a temporary reduction in the firm's ability to litigate, its decision to diversify technologically, and the characteristics of human capital, specifically, the characteristics of inventors needed in the new technological domain. Our main proposition is that a firm's loss of litigation ability will lower its likelihood of diversifying into a new technological domain. Furthermore, we propose that this main effect will be stronger (i.e., more negative) when the firm is less able to utilize its own existing inventors in this new domain or when the cross-firm inventor mobility in the new domain is lower.

We empirically capture changes (reductions) in a focal firm's ability to litigate and defend against IP infringement suits by exploiting unrelated exits, from 2002 to 2010, of firms' primary IP law firms.[4] Our empirical strategy relies on the fact that it is typical for a firm to form a long-lasting relationship with its primary law firm representing it in litigation.[5] Due to the complex nature of IP litigation and highly specialized expertise of IP attorneys, these services are not easily replicated by individual mobile attorneys. Consequently, the focal firm's switching costs are high, and the sudden exit of its law firm causes temporary reduction in its IP litigation ability. We employ a variety of empirical specifications and robustness checks including a difference-in-difference design to isolate the effects of the focal law firm exit firm from other potential contemporaneous influences. Empirically, we find results consistent with our theoretical predictions. Verifying the key mechanism, we also find that the firm's litigation propensity decreases shortly after the exit of its primary law firm. This helps to justify our use of the law firm exit as a proxy for reductions in a focal firm's IP litigation abilities. We also confirm that the reduction in the focal firm's overall patent filings upon the exit of its primary law firm is primarily attributable to its reduced diversification into new domains rather than to reduced patent filings in its existing domains. The findings are thus driven by the firm holding back from diversifying technologically rather than by the firm reducing its overall patenting activities.[6]

[3]As we describe below in more detail, we define the IP litigation ability as having means to both initiate an IP-related litigation and to defend against IP-related lawsuits filed by other firms. The IP litigation ability is necessary for enforcing existing IP (Ziedonis, 2003) or developing reputations for aggressive enforcement of IP (Agarwal et al., 2009).

[4]We qualitatively examined the reasons for the law firm exit and selected only those that are plausibly exogenous to their client firm characteristics. We elaborate on these details in a later section.

[5]Through repeated interactions, the law firm's attorney team builds up expertise and familiarity with the focal firm's technological portfolio and strategies. It becomes more efficient in providing focal-firm-specific legal services and more effective in giving counsel on issues of risk and procedures during IP litigations and disputes over trade secrets, patents or IP-related employment contract violations.

[6]The broader issue which this finding is meant to address is that the observed reduction in a firm's patent filings following the exit of its primary law firms could reflect a suppression of its patenting activities rather than its underlying innovative activities related to technological diversification. We revisit this issue in greater details in a later section.

Our study makes several contributions. First, we add to the literature on technological diversification by shifting the focus away from the examination of the firms' existing fungible knowledge as a prerequisite for technological diversification (Breschi, Lissoni, & Malerba, 2003; Helfat & Raubitschek, 2000; Leten, Belderbos, & Van Looy, 2007; Sakhartov & Folta, 2014). Instead, we study the drivers affecting the acquisition of resources necessary for technological diversification. By focusing on human capital as a conduit for the knowledge required for the diversification, we bring human capital to the forefront of the study of firms' technological diversification.

Second, by bridging the technological diversification and the IP literatures, we highlight an underappreciated role of IP strategy. The purpose and value of a firms' litigation ability goes beyond what is portrayed in much of the IP literature—serving to protect the firms' existing IP and human capital investments (Agarwal et al., 2009; Clarkson & Toh, 2010; Somaya, 2003). Our study thus resonates with the theory of "generative appropriability" (Ahuja, Lampert, & Novelli, 2013) arguing that IP not only enhances the firm's appropriation of its immediate innovations but also protects future related innovations. Importantly, we highlight the role of firm's litigation ability in this process. Our insights about the role of litigation ability in a setting where the firm has yet to acquire any human capital or IP implies a broader importance of IP strategy and highlights an "insurance-like" property of litigation in shaping managerial behavior and strategies. Overall, we are responding to the call to better comprehend the role of IP in the field of strategy research (Somaya, 2012).

Third, the study contributes to the literature on mobility of inventors and human capital (Agarwal, Echambadi, Franco, & Sarkar, 2004; Song et al., 2003; Wezel, Cattani, & Pennings, 2006). Mobility represents a fundamental channel through which knowledge diffuses across firm boundaries (Almeida & Kogut, 1999; Phillips, 2002). Given that employees are free to move (Coff, 1997), firms must manage the challenges associated with knowledge flows through human capital (Campbell, Ganco, Franco, & Agarwal, 2012; Rosenkopf & Almeida, 2003; Somaya, Williamson, & Lorinkova, 2008). Our study introduces a new angle to this literature by highlighting that firms may need to acquire human capital with the relevant IP.

2 | THEORY AND HYPOTHESES

2.1 | Technological diversification

Diversification via innovating in a new technological domain is a key mode of firm growth and a driver of performance of many modern firms (Haltiwanger, Hyatt, & McEntarfer, 2018; Rosenberg, 2004). When introducing innovative products and services, firms not only rely on the knowledge of its existing technologies but often need to master technologies that fall outside of their existing focus. In fact, innovation often stems from synergistically combining the firms' existing knowledge with knowledge that is new to them (Galunic & Rodan, 1998; Helfat & Raubitschek, 2000). This combination process acts as a mechanism driving the firms' technological diversification, pushing the firms toward new technological domains as they exploit combinatorial opportunities between the knowledge they currently have and knowledge in other domains (Miller, 2006; Rosenkopf & Almeida, 2003).

Prior research on technological diversification mostly focuses on the former, that is, how the existing knowledge that firms have is being leveraged into new domains and what are the attributes of this knowledge, such as its fungibility, the extent to which the knowledge can be applied to the new domain, its scalability, redeployability and intertemporal applicability, and the like (Ahuja & Katila, 2001; Helfat & Eisenhardt, 2004; Levinthal & Wu, 2010; Sakhartov & Folta, 2014). This literature has advanced substantially in explaining heterogeneity in firms' ability to utilize its existing knowledge in technological domains that are new to the firms.

In contrast, the latter issues surrounding the counterpart to this process—acquisition of new resources needed to enter the new domain—have received relatively less attention in the literature on technological diversification. Among the different resources the diversifying firm needs to acquire, knowledge embodied within human capital presents particular challenges, given the typical IP safeguards in place that restrict the firm's access to it (Somaya, 2003; Starr, 2019). These challenges are increasingly salient, as knowledge embodied within human capital is critical for economic growth (Grant, 1996; Song et al., 2003).

2.2 | Human capital, mobility, and IP litigation hazards

The knowledge that a diversifying firm needs to acquire is often embedded within human capital (Almeida & Kogut, 1999; Coff, 1997; Rosenkopf & Almeida, 2003). Harking back to the knowledge-based-view of the firm, employees are learning, accumulating knowledge, and applying it within the firm (Grant, 1996). A substantial fraction of this knowledge is tacit and not easily articulated (Zander & Kogut, 1995). This presents a challenge for the diversifying firm. It cannot easily extract, contract, and trade such knowledge with other firms, and is left with few choices other than to acquire the "knowledge conduit" itself, that is, hire the required human capital. In practice, this often means that technological diversification is associated with hiring employees from competing firms that are already operating in the new domains (Agarwal, Campbell, Ganco, & Franco, 2016).

As an example, consider Google's recent technological diversification into hardware devices such as cellphones, home automation, and virtual reality. Expansion into these markets allowed Google to leverage its unique existing knowledge in Internet technologies but also required Google to acquire new knowledge and other resources necessary for the introduction of hardware-based products. While such knowledge may be novel to Google, there are many other firms already holding it. Google needed to compete with these firms as both a software and a hardware company. For instance, introducing the Nexus (2015) and later the Pixel (2016) line of cellphones meant that Google needed access to technologies that are also utilized by Apple, Samsung and other electronics manufacturers. Eventually, in 2016, Google acquired the U.S. cellphone manufacturer Motorola for $12.9B. As many industry experts agreed, the primary reason for acquiring Motorola was to obtain its talents such as hardware engineers and Motorola's president of hardware development, and its patent portfolio. Illustrating the immense challenges posed by technological diversification, this proved insufficient and, in 2018, Google hired 2,000 cellphone engineers from Chinese manufacturer HTC (in this case, HTC "sold" the engineering team for $1.1B).[7] These resources provided a foundation for Google's ecosystem of hardware devices including Google Home and Google Assistant.

[7]https://www.theverge.com/2017/9/20/16340108/google-htc-smartphone-team-acquisition-announced, and https://www.theverge.com/2017/10/4/16405184/rick-osterloh-interview-new-google-hardware-vision-htc-deal, accessed on August 8, 2018. Google eventually sold off Motorola to Lenovo for $2.9B and the acquisition was deemed unsuccessful given the large size and the diversified nature of Motorola.

As the example illustrates, technological diversification for the purpose of introducing new products or services is often associated with the need to acquire human capital. Employees, including inventors, are largely free to quit at will and often leave with knowledge that is highly valuable to their previous employers (Blyler & Coff, 2003; Coff, 1999). As the employees are poached by the focal firm entering the domain, they provide the firm with access to valuable knowledge and IP that used to reside with their previous employers (Aime, Johnson, Ridge, & Hiss, 2010; Blyler & Coff, 2003; Kim, 2014). However, problems arise when there are legal mechanisms in place potentially inhibiting such hiring, including patents, trade secrets, or restrictive employment contracts (Agarwal et al., 2009; Starr, Balasubramain, & Sakakibara, 2017; Starr, Bishara, & Prescott, 2018). Employee mobility and poaching are key triggers of IP-related lawsuits (Beckerman-Rodau, 2002; Bishara, 2006; Freedman, 2000; Kim, 2014; Stone, 2002). The practical importance of employee mobility and poaching-based litigation is also reflected in the fact that such lawsuits often make news headlines (Bohrer, 2016; Girard, 2002; Lobel, 2017; Neumeyer, 2013).[8] Over 85% of Federal-level trade secret lawsuits and over 93% of state-level trade secret lawsuits involve former employees or business partners (Almeling et al., 2010; Almeling, Snyder, Sapoznikow, Mcollum, & Weader, 2011; Elmore, 2016).[9] These cases tend to center on whether the incumbent firm or the former employee own the IP behind the patent, whether the employee infringed or likely will infringe on the patent in the course of the new employment (Contigiani, Hsu, & Barankay, 2018). Thus, technological diversification can be fraught with the risk of infringing upon the IP held by firms that are already operating in the domain into which the focal firm expands.

With such IP hazards, the strategic considerations related to the expansion become salient. The diversifying firm would conceivably consider if it can acquire human capital in the new technological domain and defend against the likely litigations that follow. Existing work on IP protection has been largely silent on this possible antecedent. While prior studies have found evidence consistent with firms using IP strategies (e.g., aggressive enforcement of patents against potential infringement by former employees) to reduce knowledge outflows and employee exit (Agarwal et al., 2009; Ganco et al., 2015) or deter competitive entry into its existing technological domain (Clarkson & Toh, 2010),[10] the focus has been on how a firm enforces its *existing* IP. It remains unclear whether the firm's ability to litigate over IP-related issues influences its decision to expand into new technological areas where it may not possess any IP yet.

2.3 | Hypotheses

Our key argument is that a firm needs its litigation ability *in place* when it diversifies into a technological domain that is new to it. This will prepare the firm to deal with IP-related challenges that may likely arise from competitors when the firm tries to hire their employees. We define the "litigation ability" as having means to both initiate an IP-related litigation and

[8]Prominent examples include Borland International suing Microsoft to deter its further recruitment of Borland software engineers (Ricciuti, 1997) and Steve Jobs threatening to sue Palm to stop its poaching of Apple engineers (Murphy, 2013).

[9]Analysis of trade secret cases filed at the Federal level reveals that 37% also involve a simultaneous patent lawsuit (Elmore, 2016; Nemec, Sammi, & Flanz, 2018).

[10]The literature has also shown that there is significant heterogeneity in how much firms litigate over IP (Agarwal et al., 2009). While some firms have extensive litigation experience, other firms rarely litigate over IP (Ziedonis, 2003).

defend against IP-related lawsuits filed by other firms (i.e., be a plaintiff or defendant in a lawsuit).[11] The abilities to initiate and defend against a lawsuit are often intertwined. The firm, in response to being sued for IP violations, may initiate a countersuit as a defensive legal strategy (Hansen, 2006). As we describe in more detail in a later section, the litigation ability is a function of a stable relationship between a focal firm and a legal team that is typically external (i.e., in-house attorneys may not have litigation expertise or the capacity to manage the litigation process) and that has extensive expertise and experience with the technological portfolio of the focal firm.

Having its litigation ability ready when diversifying into a new technological domain is important for multiple reasons. First, the firm's diversification may induce competitors already in the domain to initiate lawsuits when they observe or anticipate the diversifying firm's moves, especially when they realize that the firm may not hold its own IP in the new domain and hence could be vulnerable. Second, when the diversifying firm tries to acquire human capital away from its competitors, the competitors may use IP-related litigation to block the firm from doing so or from using the knowledge embedded within this human capital (Agarwal et al., 2009). These litigations may not only be triggered by the competitors' genuine concerns over the diversifying firm's violations of their IP but can be used to impede the firm's diversification efforts. Third, beyond litigation, there exists a variety of effective IP-related strategies that these competitors can potentially use against the former employees (Agarwal et al., 2009; Starr et al., 2017), all toward having a similar effect on the diversifying firm. Thus, having the ability to litigate over IP-related matters prior to the diversification can serve as an "insurance" that will become handy if the firm finds itself in a legal battle postdiversification. It will also serve to protect the diversifying firm's investments in acquiring knowledge pertaining to the new domain, or likewise knowledge that it develops internally for use in the domain if it so chooses. Due to the frequent countersuits, having the litigation ability in place may also serve as a deterrent against competitors considering legal actions (Agarwal et al., 2009; Clarkson & Toh, 2010; Ganco et al., 2015).

When the firm considers diversifying into a new technological domain, it compares the expected benefits relative to the expected costs. The level of benefits depends on factors such as market size, price, customer demand, and competition in the domain (i.e., factors affecting revenue realized postexpansion). Costs are driven by investments needed to realize the revenues. They include the acquisition or development of human capital or other resources that are necessary in the new domain (e.g., hardware engineers in the case of Google's diversification into hardware devices). Costs also include potential royalties, settlement payments, or other litigation expenses. If, posttechnological diversification, the firm is sued by competitors already operating in the new domain and it loses the lawsuit (or has to settle unfavorably), it either has to exit the domain (if an injunction is issued), losing the investment, or operate with a lower profitability (due to the royalty payments or a settlement), lowering its returns on investment in the new domain.[12] The ability to litigate will thus be critical in protecting both revenues against an injunction and costs from additional payments.

[11]We consider this ability to be separate from the existing stock of patents that the firm holds and that could be used when bargaining during litigation.

[12]Losing IP cases can be very costly (Mani & Sancheti, 2016). The high costs stem from the possibility that the judgment will include actual losses and a penalty for "unjust enrichment" or an injunction (Uniform Trade Secrets Act with 1985 Amendments [4]). Awards and settlements related to employee poaching can often exceed $100 million and are frequently higher than patent suits alone (Mani & Sancheti, 2016).

In other words, a reduction in the firm's ability to litigate over IP prior to the potential diversification will lower its net expected returns. In turn, the reduced expected returns of the technological diversification will reduce the likelihood that the firm undertakes the technological diversification. Consequently, we propose the following.

Hypothesis (H1) *A reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm diversifying into a new (to the firm) technological domain.*

Next, we examine contingencies in which the litigation ability will be more salient, as driven by attributes of the human capital that the diversifying firm needs in the new domain. The contingencies help to illustrate our main theorized mechanism because they affect the expected costs of technological diversification and thus affect the benefits of litigation ability. As we maintain, the diversifying firm benefits from its litigation ability as a way of dealing with the potential lawsuits initiated by competitors. However, the salience of the litigation ability may vary based on both the firm's need for new human capital and ease of acquiring the human capital from competitors. We posit that when the need for acquiring new inventors is greater, or when acquiring inventors is more difficult, then the diversification is costlier and associated with greater investment.[13] The benefits of protecting such investments by having the ability to litigate IP in place prior to diversification will then increase. Specifically, we posit that the main effect in H1 will be strengthened when either the diversifying firm has greater difficulties utilizing its own existing inventors in the new technological domain or the mobility of inventors is typically lower in the new domain and thus the inventors cannot be easily hired from competitors.

First, the firm's litigation ability is a more relevant antecedent to its diversification (i.e., H1 is stronger) when the firm is less able to utilize its own existing inventors in the new technological domain and must rely more heavily on acquiring inventors from its competitors. As the firm diversifies into a new technological domain, it has the option of utilizing its own existing inventors in the new domain. The necessary (though not sufficient) condition for such utilization is its technical feasibility. The feasibility depends on the knowledge that these inventors hold and whether they are likely to learn, absorb, and implement the knowledge necessary in the new domain. The firm could ex ante form an expectation about whether this utilization is feasible, for instance, by assessing whether it is common for inventors in the field to successfully transition between the domains. If such utilization is feasible, the focal firm would reasonably expect that it does not have to rely as much on poaching inventors from competitors as it diversifies into the domain or that it can use its own inventors when acquiring external human capital proves too costly. Thus, the need to have its litigation ability in place prior to diversification would lessen.

Note that this condition, while necessary, may not be sufficient. Even if it is technically possible to utilize firm's existing inventors in the new domain, the firm may decide not to do so. Human capital is typically non-scale-free (Levinthal & Wu, 2010). Whether the firm chooses to transfer an inventor from its existing domain into a new one depends on a variety of factors related to whether the inventor can generate more net value for the firm in the new domain relative to the previous (Sakhartov & Folta, 2014).[14] We do not argue that, given technical

[13]In technological diversification, inventors represent a key form of human capital that the firm would likely need. We focus on inventors when examining attributes of human capital as contingencies.

[14]We thank an anonymous reviewer for raising this point.

feasibility of utilization, the firm will always or systematically transfer its inventors across domains. Whether the firm actually transfers the inventors or not, the feasibility of utilizing its existing inventors in the new domain affects the firm's calculus, lessening the anticipated need to hire inventors from competitors, and thus weakening the main effect.[15]

Conversely, if the firm expects that it cannot utilize its existing inventors in the new domain (e.g., Google did not have many hardware engineers prior to its expansion into the device segments and it is generally difficult to retrain software engineers to work on hardware), then the firm would expect that it likely has to acquire new inventors from competitors as it diversifies into the new domain. This triggers the firm's expectation of facing lawsuits subsequently, and hence strengthens its need of having litigation ability in place prior to diversification. In short, it is in these higher-stakes situations when the "insurance-like" property of the ability to litigate over IP becomes more valuable. This leads us to formulate the following contingency:

Hypothesis (H2a) . *The less that the firm can utilize its existing inventors in the technological domain new to the firm, the more that a reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm diversifying into this domain.*

Second, the firm's litigation ability is a more relevant antecedent to its diversification (i.e., H1 is stronger) when inventors in the technological domain into which the firm is diversifying are less mobile. In those settings, there are fewer available inventors with requisite knowledge needed by the firm, and thus it is costlier for the firm to acquire the inventors. There is significant heterogeneity across domains in the ease with which inventors can move across firms (Neal, 1995; Neffke & Henning, 2013). The propensity to switch organizations may vary with technological domains due to the variation in knowledge transferability across organizations related to human capital specificity (Neal, 1995; Starr, Bishara, et al., 2018; Wang, He, & Mahoney, 2009) or other mobility frictions (Campbell, Kryscynski, & Olson, 2017; Starr, 2019). In situations when the firm does not have many alternatives and cannot easily hire competitors' inventors (holding constant the ease of utilizing its own existing inventors), acquiring these inventors would require nontrivial investments. This increases the firm's resources "at stake" within the new technological domain, and, consequently, the insurance-like property of the litigation ability will become more critical in protecting the firm's investments. In our example of Google, the company required many hardware engineers for its expansion into the device market. However, there were not enough of these workers readily available on the labor market. This led Google to spend $1.1 billion on the acquisition of 2,000 hardware engineers from HTC.[16] Such a large human capital-related investment then increased the importance of its IP-related strategies such as holding a strong portfolio of patents (e.g., to be used as bargaining

[15]One can further complicate the argument by suggesting that even as the firm's existing inventors are non-scale-free and the firm decides not to move them to the new domain, the knowledge that the inventors have may be partially scale-free and thus could be utilized in the new domain (Helfat & Eisenhardt, 2004). This still means that the firm must hire new inventors who need to acquire knowledge from the firm's current inventors. This may involve hiring new inexperienced inventors and then training them. However, to evaluate feasibility, the costs and time of such training need to be compared with costs of hiring from competitors. These arguments open potential additional nuances in the main effect which are beyond the scope of the current analysis. Importantly, we note that these possibilities do not negate our main, simpler point, which is that if it is technologically feasible for the firm to utilize its existing inventors in the new domain, then the main effect is weakened.

[16]Bloomberg: https://www.bloomberg.com/news/articles/2017-09-21/google-buys-htc-engineers-for-1-1-billion-to-aid-hardware-push accessed on August 28, 2018.

chips) in the device market in preparation to fight over IP. In an extreme case of a granted injunction against the firm, Google may be unable to recover these investments. Even avoiding injunction but still paying significant royalties or settlements may dramatically decrease its return on the investments in the focal domain. The logic leads us to our second inventor-related contingency:

Hypothesis (H2b) . *The lower the interfirm mobility of inventors within the technological domain new to the firm, the more that a reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm diversifying into this domain.*

2.4 | Empirical design: IP Law firm exits

We examine our propositions with data from U.S. firms in the years 2002–2010. The empirical tests of the relationship between a firm's ability to litigate and its expansion into technological domains could be susceptible to selection issues. For instance, unobserved firm abilities may enable the firm's expansion as well as draw others to contest its IP via patent lawsuits. To mitigate this potential issue, we exploit exits of the focal firm's primary IP law firm to capture changes (reductions) in the focal firm's ability to litigate, and trace resulting variations in its expansion into new domains. We elaborate on the rationale of this empirical design below.

A firm typically forms a long-lasting relationship with its primary IP law firm.[17] Thus, it can be costly to switch law firms. Over time and through repeated interactions, this law firm would have developed teams of attorneys who are experts in the focal firm's technological domains. Due to the complexity of technology fields, IP attorneys are typically highly specialized professionals who focus their practices on domains in which they have scientific or engineering expertise. This specialization takes time to develop and is not easily switched.[18] Given the high level of specialization, often teams of IP attorneys are deployed to deliver services to their clients. Furthermore, IP litigation tends to be global in nature and innovating firms may rely on their IP law firm to represent them in multiple jurisdictions. Consequently, though individual attorneys may easily move to another law firm, the role of the law firm as an organization is highly relevant. To the extent that the mobile IP attorneys cannot easily replicate all services of the

[17] We base this assertion on a variety of evidence. First, in our conversations with IP lawyers, they stressed that a long-term relationship is in the best interest of both the client and the firm because law firms that have client-specific experience can offer higher quality services and handle work more efficiently than law firms without client-specific experience. Second, several IP law trade articles emphasize the importance of a long-term relationship between clients and their IP law firm in achieving desired results (Bower & Taleyarkhan, 2019; Coulter, 2014). Third, IP law firms often highlight the importance of creating long-term relationships with clients in their documents and sometimes advertise the length or their relationships with clients (e.g., https://klarquist.com/about/). Fourth, we find that the client firms in our sample whose primary law firm failed, used that law firm over the prior 5 years for 76% of patent litigation cases on average and 100% at the median.

[18] Along with passing the legal bar in a state, U.S. patent attorneys must pass a United States Patent and Trademark Office (USPTO) examination to demonstrate their knowledge of USPTO policies and procedures. The USPTO requires attorneys to demonstrate knowledge of a scientific field through either a degree or work experience before sitting for the USPTO bar exam (https://www.uspto.gov/sites/default/files/documents/OED_GRB.pdf). Typically, IP attorneys have scientific and engineering backgrounds, which include either an undergraduate and/or graduate degree in a scientific or engineering discipline and discipline-specific work experience. Some IP law firms recruit science and engineering doctoral and post-doc candidates to join the firm as law clerks and then support their law school training.

exiting law firm post move (Agarwal et al., 2016), the law firm exit will be disruptive for its clients.

The primary IP law firm provides the focal firm with three types of services: IP counseling, patent prosecution, and IP litigation. It advises the firm on various strategic IP matters, such as how to protect the firm's IP, the potential for the firm's products to infringe on rivals' IP, and the value and strength of a target's patent portfolio. IP law firms may also help the firm monitor the environment for potential infringement of the firm's IP. Patent prosecution involves creating and filing patent applications and interfacing with agents of the patent office throughout the application process. IP litigation involves representing the firm in disputes over trade secrets or patents.

A law firm that has a long relationship with a client not only can offer more effective advice, but also can perform work about five times more efficiently than another similar-quality law firm without a prior relationship. Similarly, it could take a new law firm 1 or 2 years of experience to become proficient in its client's technologies.[19] The high level of efficiency reduces billable hours and generates cost savings for the client. A strong relationship is particularly important when the client is sued, as the law firm with deep knowledge of the client's IP strategy can quickly and effectively advise the client on potential risks and how best to proceed. The primary IP law firm becomes central in the formulation and deployment of its client's IP strategy, and this relationship is difficult to replicate in the short run. This is because the relationship is valuable at the level of the organization and not only at the level of individual attorneys providing services to their clients.

Accordingly, with the exit of its primary IP law firm, the client's (focal firm's) ability to litigate is temporarily reduced. We empirically demonstrate this reduction in a later section. This externally driven reduction in the focal firm's ability to litigate allows us to isolate some of the unobserved firm attributes that correlate with absolute levels of litigation ability and with firm's diversification across technological domains. Table 1 lists the IP law firms that exited in our sample. We hand-picked these firms where their exits are plausibly exogenous to their client firm characteristics. All 11 law firms were successful prior to their exits and often appeared on lists of most prestigious or highest grossing law firms.[20] Importantly, the exits do not appear related to the quality of IP work that the law firms performed or the quality characteristics of their clients. Eight of the 11 law firms engaged in general practice. In all eight cases the dissolution or bankruptcy stemmed from issues unrelated to the IP practice, such as a slowdown in the economy or malpractice lawsuit in a non-IP department. Two of the IP boutiques failed because the dot-com crash caused an abrupt slowdown in their billable hours that coincided with their costly expansion plans. Both firms were successful in the years preceding the dotcom bust. The third IP boutique filed for bankruptcy after in-fighting within the firm led to the exit of several prominent partners (Slater, 2009). Overall, the most common driver was financial

[19]These estimates are from our informal interview with a patent attorney at a top IP law firm.

[20]Although we do not have yearly financial data for the exited law firms, we find that they appeared on various lists that correlate with success. Brobeck, Phleger & Harrison LLP was the 30th highest grossing law firm in the United States. in 1998 according to *American Lawyer* magazine. In 2001, profit-per-partner at Brobeck, Phleger, & Harrison LLP had climbed to over $1 million (Gross, 2003). Coudert Brothers was ranked by *American Lawyer* magazine as one of the 100 highest grossing law firms in 2004. Heller and Ehrman ranked second on the *American Lawyer* magazine's A-List of Law Firms in 2004. Morgan and Finnegan was ranked as the number two law firm used for IP litigation in a survey of IP officers at Fortune 100 companies published by the *IP Law and Business Journal*. Thelen LLP was the 70th largest law firm in the United States in 2007 according to the *National Law Journal* 2007 law firm ranking. WolfBlock LLP was the 149th largest law firm in the United States prior to its failure, according to the *National Law Journal* 2008 law firm ranking.

TABLE 1 Law firm exits used in the sample

Firm	Founding year	Failure year	Approximate number of lawyers in year of failure	Practice	Outcome	Cause	Source
Altheimer & Gray	1914	2003	300	General practice	Bankruptcy	High debt, poor financial management practices, and a slowdown in revenues caused by the economic slowdown.	Arndofer (2003)
Brobeck Phleger & Harrison	1926	2003	1,100	General practice	Bankruptcy	Brobeck allowed technology firms to pay in equity rather than in cash. When the dot-com bubble burst, the value of the equity fell and Brobeck failed to meet financial obligations.	Gross (2003), Wallack and Chiang (2003)
Coudert Brothers	1853	2006	650	General practice	Dissolution	The exit of partners on the international law practice caused a sharp drop in revenues.	Rosen (2007)
Heller Ehrman LLP	1890	2008	500	General practice	Dissolution	The firm paid all earnings out to partners at end of each year. The financial crises and economic slowdown caused revenues to fall and several major clients to file for bankruptcy. The resulting drop in revenue and the lack of a cash cushion or ability to borrow caused the firm to cease operations.	Abate and Ross (2008), Cutler (2016)
Jenkins & Gilchrist	1951	2007	600	General practice	Dissolution	The firm's tax law division was sued by IRS for malpractice. The large financial liability stemming from the malpractice suit caused the firm to cease operation.	Lat (2007), justice.gov
Lyon & Lyon	1919	2002	100+	Intellectual property	Bankruptcy	The dot-com bust caused the IP business to slow and for several clients to default on payments.	Kamping-Carder (2010), Garvey (2015)

TABLE 1 (Continued)

Firm	Founding year	Failure year	Approximate number of lawyers in year of failure	Practice	Outcome	Cause	Source
Pennie & Edmonds	1883	2003	n/a	Intellectual property	Dissolution	An abrupt loss of a top partner and slowdown in revenue during the dot-com bust.	Kamping-Carder (2010)
Morgan and Finnegan	1893	2009	n/a	Intellectual property	Bankruptcy	Major disputes among partners and a sharp drop in revenue stemming form the slowdown in the economy.	Slater (2009), Weiss (2009), Kamping-Carder (2010)
Testa, Hurwitz & Thibeault	1973	2005	400	General practice	Dissolution	Partners in top grossing practices (fund formation and private equity) abruptly left for another firm.	Meland (2005)
Thelen LLP	1924	2008	400	General practice	Dissolution	Rapid expansion in the firm's real estate practice in 2006–2008 stressed the firm's finances. The decline in real estate related business in 2008 caused the partners to dissolve the firm.	Ross (2008)
WolfBlock LLP	1903	2009	317	General practice	Dissolution	The sharp decline in the economy and in the real estate market caused revenues to fall dramatically.	Passarella (2009)
Altheimer & Gray	1914	2003	300	General practice	Bankruptcy	High debt, poor financial management practices, and a slowdown in revenues caused by the economic slowdown.	Arndofer (2003)

mismanagement while facing a slowdown in demand. The law firms continued to hire partners with expensive compensation packages in hopes of bringing in lucrative clients. While such a strategy was driving growth in munificent environments, it proved to be disastrous in times of market decline.

In our estimation, we use a variety of specifications including a difference-in-difference design which allows us to take advantage of the IP law firm exits that are not related to client firm quality while ensuring that our effects are not driven by general slowdown in the market environment. Consequently, the IP law firm exit is plausibly exogenous in our context.

2.5 | Data and variables

We use several data sources in our study. Data on law firm clients comes from Lex Machina's IP litigation database. We obtain U.S. patent lawsuits from Thomson Westlaw, patent data from the U.S. Patent and Trademark Office (USPTO) and Patent Dataverse, financial data from Compustat, and firm-patent assignee identifiers and technology subcategory aggregations from the National Bureau of Economic Research (NBER).

To create our sample, we obtain a list of client (focal) firms of the exiting law firms in the Lex Machina database. From this list, we retain only "active" clients, which we define as ones that used the law firm to file an IP lawsuit within 5 years of the law firm's failure date. We further constrain the set of clients to ones that used the law firm for more than half of their lawsuits during the 5-year period.[21] We then match these firms to Compustat and patent data, which results in 57 firms with full patent and financial information. To create a control sample for the difference-in-difference design, we select firms that have patented in the prior 5-years, have litigated a patent in the prior 5-years, and belong to the same four-digit SIC industry classification as one of the treated firms. We constrain the sample range to 1 year before the first law firm exit and 1 year after the last exit. This results in an unbalanced panel of 2,976 firm-year observations, comprised of 57 treated firms and 555 control firms, across the 2002–2010 period. We use this sample to test Hypothesis 1.

To test the other hypotheses, we extend the sample to the technology class level. To construct the sample, we use the same date range (2002–2010) and set of firms as before. For each firm-year, we define the potential set of new domains as all USPTO technology classes in which the firm has not filed for patents during the prior 5 years. To rule out extraneous domains into which the firm is unlikely to expand, we constrain the classes to ones that fall within an NBER technology subcategory (Hall, Jaffe, & Trajtenberg, 2001) in which the firm has patented in the prior 5 years. These 36 two-digit technological subcategories represent a higher-order aggregation of the 400 USPTO technology classes (on average, each subcategory is comprised of about 11 technology classes). Technologies are more similar within a subcategory than across subcategories. Based on our analysis of expansion in the 10 years prior to the beginning of our sample (1992–2001), we find that the firm has a 22 times higher unconditional likelihood of expanding into a technology class that falls within the technology subcategories it has patented in during the prior 5 years than it does into a technology class that falls outside these technology subcategories.[22]

[21]In our sample of firms whose primary law firm failed, we find that in the prior 5 years, these client firms used that law firm in 76% of their patent litigation cases at the average and 100% at the median.

[22]To derive this estimate, we use all firms in the USPTO data set during the 1992–2001 period and consider all technology classes the firm has not patented in during the prior 5 years, resulting in 522,288,766 total observations.

Therefore, the criterion eliminates domains that the firm is unlikely to expand into. In total, the unbalanced panel has 389,138 observations.

2.6 | Dependent variables

The main dependent variable, *New Domains*, proxies for the extent to which the firm expands into new technological domains. We define a domain as the USPTO three-digit technology primary class.[23] Each class contains similar types of inventions for an application (Hall et al., 2001). *New Domains* is the total number of classes, new to the firm, in which the firm files for patents in the year. We define a class as being new to the firm if the firm has not applied for patents in the class within the prior 5 years. Tests of the contingency hypotheses require a sample with a firm-year-technology class unit of analysis. For these tests, we create a binary version of the dependent variable (*New Domain*) that equals 1 if the firm i entered class j in year t and is 0 otherwise.

2.7 | Independent variables

We code the main independent variable, *Law Firm Exit,* as 1 if the firm's primary law firm failed during the year and 0 otherwise. Because the law firms exited at different points in the year, we map the date of failure to the nearest year. For instance, we code *Law Firm Exit* equal to 1 in 2004 and 0 in 2003 if the law firm failed in December 2003.

The first contingency variable, *Inventor Utilization*, captures the ease with which the firm can utilize its inventors who are active in other technology classes in developing innovations in the focal primary class j. For each nonfocal technology class k in which firm i had a patent filing within the past 5 years (where $k \neq j$), we identify all inventors (including inventors outside the focal firm) with at least three patents in the prior 10 years. Next, to get a sense of how likely inventors active in k have the knowledge to also invent in j, we trace how many of these inventors in class k have also patented in class j. Then we create a ratio by dividing this count of inventors by the total number of inventors in k. Finally, we take the average of these ratios across all technology classes k for firm i in year t.

The second contingency variable, *Inventor Mobility*, captures the extent to which inventors within a domain tend to move across firms. For each primary class j in year t, we identify all inventors with at least three patents over the prior 10 years that have patented in j.[24] Within

[23]See the USPTO website for details: https://www.uspto.gov/web/patents/classification/. We utilize primary classification for simplicity and clarity in the construction of the measures. In a later section, we performed a range of robustness analyses to examine the validity of this approach of using primary class in the measures.

[24]We restrict the pool of inventors to ones with at least three patents so that we might observe switching of firms, that is, the same inventor patenting for different firms across patents. Results are similar when we raise the threshold to five patents. This approach essentially places more emphasis on inventors that are productive and could potentially generate bias, i.e., more productive inventors are more likely to be observed moving. We thank an anonymous reviewer for pointing out this issue. The aggregate nature of our measure renders it less prone to this bias, relative to measuring mobility at the individual level. That notwithstanding, if the aggregate inventor productivity correlates with technological domains, the extent of undercounting mobility events may correlate with domains as well. This is a general limitation of using patents to measure mobility. We try to mitigate this issue by examining the distribution of inventor productivity and testing our propositions with a subsample that excludes domains with low levels of average inventor productivity. The robustness tests are described in a later section.

this list of inventors, we code an inventor as having switched if she had been listed in more than one firm across patent filings. *Inventor Mobility* counts the total number of inventors that switched during the period. In a later section, we alternatively use *Inventor Mobility Ratio*, calculated as *Inventor Mobility* divided by the total pool of inventors, and find largely robust results. We use the counts as our primary measure because it may be a better proxy for the available resources in the new domain and it seems less prone to noise associated with domains that have a small number of inventors.

We control for various firm and environmental factors in our models. To account for the firm's knowledge stock and innovativeness, we include the total number of patents the firm applied for (and were subsequently successfully granted) over the prior 5 years (*Patent Total 5-yr*). Firms with a broader scope of technologies may be more apt to enter new technological domains. To account for the firm's technological scope, we first trace the USPTO technology classes in which the firm files for patents during the prior 5 years. To factor in weights for investments across classes, we calculate a concentration ratio of the firm's patents across these classes.[25] We then calculate the variable *Scope* as one minus this ratio, so that higher values indicate wider technological scope. To control for a firm's research and development efforts, we measure *R&D* as total spending in millions of dollars. Larger and more profitable firms may be more capable of expanding into new technological domains. Therefore, we control for firm size using the natural log of firm revenues (*ln*(*Revenues*)) and firm profitability using earnings before interest and taxes divided by total revenues (*Operating Margin*).[26] Firms may experience difficulty expanding into domains that require inventors with specialized knowledge. To measure inventor specialization in a domain, for each inventor who patented in the primary class j in year t, we calculate the proportion of her total patents that are filed in class j prior to year t. *Inventor Specialization* for class j is then measured as the average of this proportion across all inventors that have filed for patents in class j in year t. Firms may be less likely to enter domains where incumbents are highly litigious. To account for this, we measure the extent to which nonfocal incumbent firms in the focal technology class j utilize IP lawsuits as a strategic mechanism. We consider a nonfocal firm as an incumbent in class j if it filed a successful patent application in the class during the prior 5 years. A nonfocal incumbent is coded as being "litigious" if it filed a higher than the firm-level average number patent lawsuits in the prior 5 years. We measure *Litigiousness* as the proportion of nonfocal incumbents in class j in year t that are "litigious." To capture unobserved industry and year-specific factors, we include dummies for the firm's four-digit SIC code and year dummies. To account for how the firm's current research areas can affect entry, we include dummies for the NBER technological subcategories in which the firm patented over the past 5 years (Hall et al., 2001).

3 | RESULTS

Table 2, Panel A, contains descriptive statistics and correlations for the firm-year sample used to test Hypothesis 1. Firms in the sample expand into about one new technological class a year (average *New Domains* of 1.21). The firms in the sample are innovative, spending $747 million

[25]The concentration ratio or Herfindahl–Hirschman Index is calculated for each five-year period as $\sum_{k=1}^{K}\left(\frac{\text{total patents for firm i in tech class k}}{\text{total patents for firm i}}\right)^2$. *Scope* is 1 minus this ratio.

[26]Revenue is in millions of U.S. dollars.

TABLE 2 Descriptive statistics and correlations

Panel A. Descriptive statistics for firm-year sample[a]

	Mean	*SD*	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) New Domain$_{it}$	1.21	2.52	0	23	1							
(2) IP Lawsuit$_{it}$	0.89	2.28	0	36	0.05	1						
(3) Law Firm Exit$_{it}$	0.01	0.12	0	1	−0.02	0.00	1					
(4) Patent Total (5-year)$_{it-1}$	645.61	1,713.31	1	20,199	0.46	0.17	0.03	1				
(5) Scope (5-year)$_{it-1}$	0.70	0.27	0	0.98	0.31	0.12	−0.01	0.29	1			
(6) R&D$_{it}$	747.96	1,573.26	0	12,183	0.20	0.44	0.03	0.50	0.25	1		
(7) ln(Revenue)$_{it}$	7.24	2.54	−6.21	12.24	0.33	0.28	0.03	0.41	0.52	0.57	1	
(8) Operating Margin$_{it}$	−1.12	36.29	−1,866	0.90	0.01	0.01	0.00	0.01	0.06	0.02	0.15	1

Panel B. Descriptive statistics for firm-year-technology class sample[b]

	Mean	*SD*	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) New Domain$_{ijt}$	0.01	0.08	0	1	1										
(2) Law Firm Exit$_{it}$	0.01	0.12	0	1	0.00	1									
(3) Inventor Utilization$_{ijt-1}$ (%)	0.81	1.64	0	62.37	0.05	0.00	1								
(4) Inventor Mobility$_{jt-1}$	902.66	1,520.24	0	15,603	0.05	−0.01	0.66	1							
(5) Patent Total (5-yr)$_{it-1}$	1,097.16	2,118.59	1	20,199	0.06	0.03	−0.12	−0.09	1						
(6) Scope (5-yr)$_{it-1}$	0.83	0.15	0	0.98	0.03	0.01	−0.24	−0.11	0.29	1					
(7) R&D$_{it}$	1,167.22	1,856.66	0	12,183	0.02	0.02	−0.12	−0.09	0.48	0.20	1				
(8) ln(Revenue)$_{it}$	8.47	2.04	−6.21	12.24	0.03	0.04	−0.24	−0.16	0.43	0.49	0.62	1			
(9) Operating Margin$_{it}$	−0.04	10.80	−1,866	0.55	0.00	0.00	−0.03	−0.02	0.01	0.04	0.01	0.07	1		
(10) Litigiousness$_{jt-1}$ (%)	39.88	20.96	0	100	−0.01	0.00	−0.10	−0.15	0.00	0.01	0.00	0.01	0.00	1	
(11) Inventor Specialization$_{jt-1}$ (%)	56.55	11.83	3.33	90.51	−0.01	0.00	−0.03	−0.02	0.02	0.00	0.00	0.02	0.00	−0.06	1

[a]Sample size equals 2,976.
[b]Sample size equals 389,138.

on R&D and filing for about 130 successful patent applications per year on average. *Patent Total*, *Scope*, and *ln*(*Revenues*) have correlations with *New Domains* over 0.3, which suggests that larger more innovative firms are more likely to expand across domains. The correlations between *Law Firm Exit* and the dependent variables appear low due to the inclusion of control firms. When the sample is constrained to firms that experience a law firm exit, *Law Firm Exit* has negative correlations with *New Domains* (−0.11) and *IP Lawsuits* (−0.08).

3.1 | The effect of law firm exit on litigation

For our empirical design to be effective, *Law Firm Exit* must reduce the firm's litigation ability. In this section, we provide evidence that law firm exit affects the firm's litigation ability by demonstrating its effect on IP lawsuits filed by the firm in the year of exit. A resulting decline in lawsuit filings would suggest that the firm's litigation ability has been reduced.

Figure 1 plots the average number of IP lawsuits filed by firms that experienced a law firm exit. This number falls from 0.84 in the year prior to the exit to 0.51 in the year of the exit. The graph also corroborates anecdotal evidence suggesting that the length of the effect lasts approximately 1 year; the number of lawsuit filings returns to the pre-exit level (0.92) in the year following the exit.

To more closely examine the effect of law firm exits, we analyze the count of patent lawsuits the firm files per year (*IP Lawsuits*) through a set of regression analyses. We use a generalized

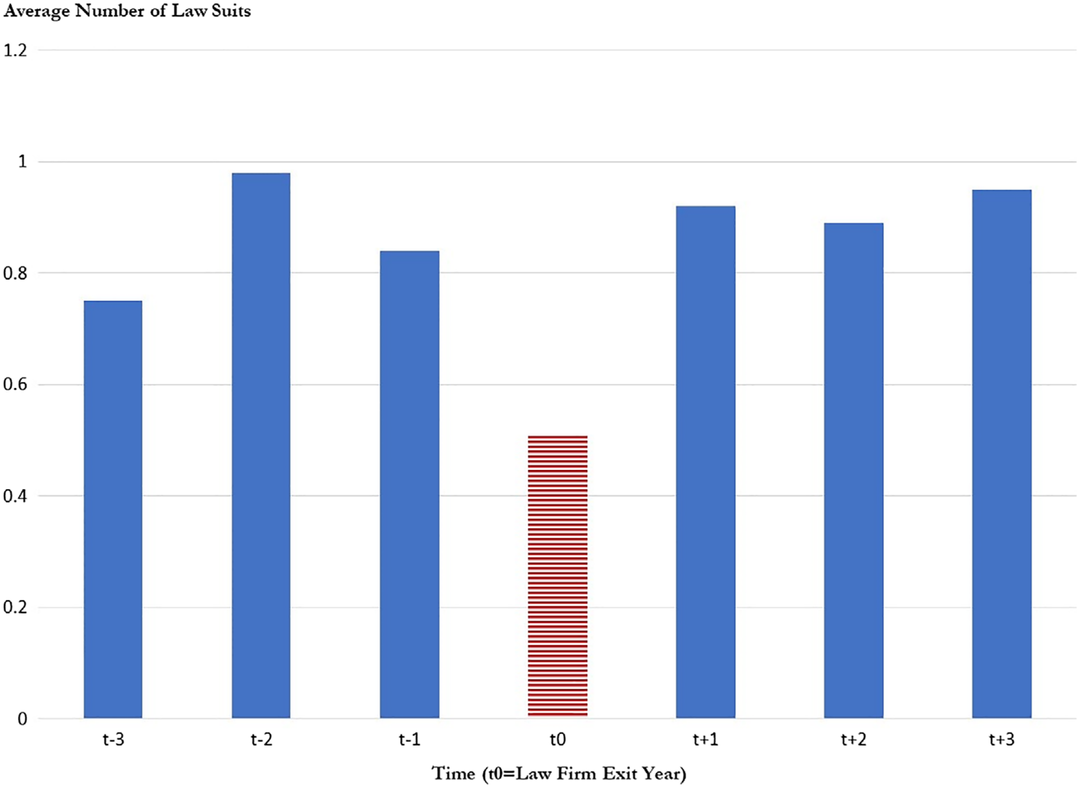

FIGURE 1 Effect of law firm exit on IP lawsuit filings. The figure plots the average number of IP lawsuits filed by client firms that experienced their law firm exiting. Law firm exits in time *t*0 [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Effect of law firm exit on IP lawsuits

Method	Model 1 Negative binomial	Model 2 Negative binomial	Model 3 Fixed effect Poisson
Law Firm Exit$_{it}$	−0.561	−0.562	−0.690
	(0.021)	(0.029)	(0.003)
Patent Total (5-yr)$_{it-1}$ (000)	−0.012	−0.024	−0.001
	(0.669)	(0.386)	(0.975)
Scope (5-yr)$_{it-1}$	0.194	0.143	0.712
	(0.525)	(0.644)	(0.132)
R&D$_{it}$ (000)	0.184	0.177	0.0690
	(0.000)	(0.000)	(0.082)
ln(Revenue)$_{it}$	0.071	0.079	0.150
	(0.098)	(0.067)	(0.401)
Operating Margin$_{it}$	0.122	0.125	0.021
	(0.036)	(0.029)	(0.789)
Treated Firm Dummy$_i$	0.392		
	(0.003)		
Technology subcategories entered (5-yr) dummies	Yes	Yes	Yes
Exiting law firm fixed effect	No	Yes	No
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	No
Observations	2,976	2,976	2,086
Log pseudolikelihood	−3,073	−3,060	−2,171

Note: Dependent variable: IP Lawsuits filed in a year. Treated Firm: indicates that the firm used a failed law firm. Exiting Law Firm FE: inclusion of 11 group dummies that indicate the firm used the failed law firm. Model 3 estimated by quasi-maximum likelihood. *p*-values calculated from robust standard errors that account for within firm clustering shown in parentheses.

difference-in-difference approach on the entire panel that allows for treatments (e.g., *Law Firm Exit*) that occur in different years to contribute to the identification of the treatment effect.[27] To do so, we account for the difference between the treatment and control group with a group indicator (*Treated Firm*) that takes the value of 1 if the firm uses a failed law firm (and zero otherwise). *Law Firm Exit* takes the value of 1 in the year of exit and zero otherwise. We account for time effects through our inclusion of year fixed effects, and we also include control variables. The coefficient on *Law Firm Exit* estimates the treatment effect of exit. We estimate the model using a negative binomial regression with robust errors clustered at the firm level. As shown in Table 3, Model 1, we find that *Law Firm Exit* reduces *IP Lawsuits* by about 56% (coefficient

[27]The procedure generalizes the basic two period difference-in-difference so that we can use the entire 2002–2010 panel. In subsequent models we attempt to suppress time-invariant unobserved heterogeneity by allowing for separate treatment group indicators based on the law firm or by including firm-level fixed effects.

−0.561, $p = .021$). Next, we account for heterogeneity across exiting law firms by including group dummies at the law firm level instead of a single treated dummy.[28] We find similar results (Model 2: −0.562, $p = .029$).

To account for potential unobserved firm-level factors that could influence litigation rates, we also analyze the effect of *Law Firm Exit* on *IP Lawsuits* using a client firm-level quasi-maximum likelihood fixed effect Poisson model with robust standard errors (Wooldridge, 1999).[29] Inspecting our firm-level control variables, we find that all have enough variation to be included in the model.[30] Model 3 displays the results. We find a 69% decline ($p = .003$) in *IP Lawsuits* when the firm's law firm exits. When the magnitude of coefficient is large, it can be more accurate to calculate the incident rate ratio (exponential of the coefficient) rather than interpret the coefficient as a semi-elasticity. Doing so, we find that the incident rate ratio is 50% (e^{-69}) of what it would be if the law firm did not exit. Overall, our results suggest that *Law Firm Exit* substantially impacts the firm's litigation ability.

3.2 | The effect of law firm exit on expansion into new technological domains

In this section, we test our main hypothesis, which states that a reduction in the firm's ability to litigate will lower its likelihood of diversifying into new technological domains. Therefore, we expect a negative effect of *Law Firm Exit* on *New Domains*.

We begin our analysis using a generalized difference-in-difference approach using one group level dummy (*Treated Firm*). Using a negative binominal model with robust standard errors clustered at the firm level (Table 4, Model 1), we find a negative effect of *Law Firm Exit* (coefficient −0.424; $p = .059$). In Model 2, we account for heterogeneity across exiting law firms by including group dummies at the law firm level and find that *Law Firm Exit* reduces *New Entry Count* by approximately 56% (−0.56; $p = .013$). To account for unobserved time-invariant client firm-level heterogeneity related to technological expansion, we estimate Model 3 using fixed effect Poisson. We find *Law Firm Exit* reduces entry by about 50% (coefficient −0.495; $p = .008$). To rule out the possibility that the inclusion of control firms inflates our estimates, we rerun the analysis using only the treated firms (i.e., client firms that used a law firm that exits). Using a negative binomial regression model, we find a 63% drop in expansion ($p = .023$, see Model 3). Applying firm fixed effects in Model 4, we find a 57% drop ($p = .010$). Overall, our findings strongly support Hypothesis 1.

[28]We include 11 failed law firm dummies that take the value of 1 if the firm used the failed law firm and 0 otherwise. The omitted group effect is the control group.

[29]The model is robust to over or under dispersion. The robust standard errors allow us to draw an inference in the case of over or under dispersion and account for any within-firm clustering.

[30]For example, we observe a high within-firm coefficient of variation for *R&D* (60%), *Patent Total* (100%), and *Operating Margin* (2,542%). *Scope* has a small within-firm coefficient of variation (16%), but lies in [0, 1). The average within firm standard deviation of *Scope* is 0.11, which represents a meaningful change in scope. One issue is that within-firm correlation between *R&D* and *ln*(*Revenues*) is around 0.7. However, results are similar if we drop either variable. Multicollinearity does not appear to be an issue, as variance inflation factors are under 2 and the condition index is 10.

TABLE 4 Effect of law firm exit on new domains (test of Hypothesis 1)

	Model 1	Model 2	Model 3	Model 4	Model 5
Sample	**Full sample**	**Full sample**	**Full sample**	**Treated firms**	**Treated firms**
Method	**Negative binomial**	**Negative binomial**	**Fixed effect Poisson**	**Negative binomial**	**Fixed effect Poisson**
Law Firm $Exit_{it}$	−0.424	−0.562	−0.495	−0.631	−0.569
	(0.059)	(0.013)	(0.008)	(0.023)	(0.010)
Patent Total (5-yr)$_{it-1}$ (000)	−0.031	−0.033	0.0269	−0.187	−0.008
	(0.645)	(0.337)	(0.808)	(0.058)	(0.890)
Scope (5-yr)$_{it-1}$	0.927	0.971	−2.620	0.433	5.920
	(0.002)	(0.002)	(0.005)	(0.834)	(0.008)
$R\&D_{it}$ (000)	−0.073	−0.075	0.0994	0.339	2.164
	(0.097)	(0.107)	(0.156)	(0.109)	(0.000)
ln(Revenue)$_{it}$	0.135	0.133	−0.064	−0.085	−1.433
	(0.000)	(0.000)	(0.728)	(0.773)	(0.007)
Operating $Margin_{it}$	−0.001	−0.001	−0.005	1.524	−1.923
	(0.131)	(0.127)	(0.056)	(0.096)	(0.028)
Treated Firm $Dummy_i$	0.059				
	(0.604)				
Technology subcategories entered (5-yr) dummies	Yes	Yes	Yes	Yes	Yes
Exiting law firm fixed effect	No	Yes	No	No	No
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	No	Yes	No
Observations	2,976	2,976	2,201	325	260
Log pseudolikelihood	−2,957	−2,941	−1,826	−307	−193

Note: Dependent variable: New Domains. Treated Firm: indicates that the firm used a failed law firm. Exiting Law Firm FE: inclusion of 11 group dummies that indicate the firm used the failed law firm. Model 3 and Model 5 estimated by quasi-maximum likelihood. *p*-values calculated from robust standard errors that account for within firm clustering shown in parentheses.

3.2.1 | Robustness tests for Hypothesis 1

We also test Hypothesis 1 at the firm-year-technology class level so that we can include our contingency variables as controls. The binary dependent variable, *New Domain*, indicates if the firm enters the technology class. We estimate a conditional (firm fixed effect) logit model, and include all previous controls, the contingency variables, year fixed effects, and technology subcategory fixed effects. Calculating the semi-elasticity from the model, we find that *Law Firm Exit* decreases the likelihood of expansion by 37% ($p = .047$).

Although our conceptual explanation is about how the reduction of the firm's litigation ability holds the firm back from expanding into new domains, an alternative explanation could be that it is the firm's ability to file for patents that was disrupted, which could happen if the exiting law firm was instrumental in its patent filing process. This could cause us to confound a reduction in expansion with a more systemic reduction in patent filing. A complete stoppage in patent filings post law firm exits would leave us unable to distinguish our theoretical mechanisms from the more mechanical effect of a reduction in patent filings. To examine this alternative explanation, we model the effect of *Law Firm Exit* on *New Patents*. Rerunning the fixed effect Poisson model on the treated firm sample per Table 4, Model 5, we find that *Law Firm Exit* reduces new patent filings by 29.6% in the year ($p = .000$). Because the firm is still filing patents (the drop is not close to 100%), we can rule out a simple mechanical effect due to the firm being unable to file for patents without its law firm. A closer inspection reveals that much of this decline in new patent filings is accounted for by the firms not expanding into new domains. A highly active firm will on average file for about 15 patents when it expands into a new domain. The estimates from Table 4 suggest that a *Law Firm Exit* reduces the number of new domains each year by about one. Using the average filing rates for firms in the sample (86 per year), the estimated reduction in patents (29.6%), and the average patents upon expansion (15), we estimate that 58% of the decline in patenting in the year stems from the decline in new technological domains.

To provide further evidence, we also assess if *Law Firm Exit* affects patenting in domains in which the firm is currently active in during the five-years leading up to our sample period (e.g., 1996–2001). Using the sample of treated firms, their number patents in current domains as the dependent variable, the specifications per Table 4, Model 4 (generalized difference-in-difference design with heterogeneous law firm treatments via negative binomial) and Model 5 (fixed effect Poisson), we do not find economically relevant effect of *Law Firm Exit* on firm's patenting in its current domains (respectively, −0.03, $p = .85$; −0.06, $p = .39$). Thus, the effect of *Law Firm Exit* on the firm's decision to expand appears to be separate from the firm's decision to patent.[31]

3.3 | Test of contingency hypotheses

3.3.1 | Firm-year-technology class sample

In this section, we test the contingency hypotheses, which are based on attributes of technological domains into which the firm is at hazard of expanding, and hence need to be tested using the firm-year-technology class sample described earlier. On average, firms in the sample have 132 primary technology classes in their potential entry set.

To perform the analysis, we use the binary dependent variable *New Domain*, which equals 1 if a firm i expands into the technology primary class j in year t and is 0 otherwise. We include the same controls as in the prior analysis, as well as industry and year fixed effects. To account for unobserved technological factors that could render expansion into a domain difficult, we include fixed effects for the NBER technological subcategories.

Table 2, Panel 2, displays the descriptive statistics for the firm-year-technology class sample. The unconditional mean rate of expansion is low, at 0.007 (i.e., 0.7%). Although several

[31]Even after losing its primary law firm, the firm should still be able to process more standard patent applications because such tasks can be handled by in-house IP lawyers, who likely have expertise and experience in such areas. Firms may also use in-house lawyers to sketch the positioning of a patent (e.g., what strategic claims does it make, etc.) then engage with any outside IP lawyer or patent agent (i.e., anyone, including non-lawyers that have passed the USPTO's bar exam) to write the formal drafts and help prosecute the patent.

variables have moderately high correlations (*Inventor Utilization* and *Inventor Mobility* 0.66; *ln* (*Revenues*) and *R&D* 0.62), multicollinearity does not appear to be problematic, as the condition index is 23 and all variance inflation factors are under 2.2.[32]

Testing contingency hypotheses in linear models typically involves interacting the main and contingency variables and interpreting the interaction term's coefficient. However, in a logit model, the marginal effect of the interaction variables does not equal the marginal effect of the interaction term, the sign and statistical significance of the actual interaction effect cannot be easily deduced, or can an odds-ratio be interpreted (Ai & Norton, 2003). To overcome these problems, we test the hypotheses using a segmented sample approach, splitting the sample at the mean of the contingency variable and comparing the average partial effect (APE) of *Law Firm Exit* across the two models using Welch's *t* test (Penner-Hahn & Shaver, 2005; Toh & Miller, 2017).[33] In subsequent robustness checks, we use the more conventional approach of having interaction terms in the models and also plot these interaction effects, and find similar results. We report these tests in the Supporting information.

3.3.2 | Pooled logit models

In Table 5, we display the results of pooled logit models that include industry, year, and technology subcategory fixed effects. We test our contingency hypotheses by splitting the sample into a low segment and high segment based on the contingency's mean and then comparing the APEs of *Law Firm Exit* across the two models using Welch's *t* test.

In the low *Inventor Utilization* segment (Model 1), we find a negative APE (−0.006, p = .004). In the high *Inventor Utilization* segment (Model 1), we find a positive APE (0.003, p = .465). To test Hypothesis 2a, we compare the two APEs (high *Inventor Utilization* sample from Model 2 minus the low *Inventor Utilization* sample from Model 1) and find a positive and effect that supports Hypothesis 2a (0.009, p = .037). The result suggests that moving from a scenario in which the firm is more able to utilize its inventors in the new domain (e.g., high *Inventor Utilization*) to a scenario in which the firm is less able to utilize its inventors in the new domain (e.g., low *Inventor Utilization*) reduces the likelihood of the firm expanding into the domain by 0.9 percentage points, which is sizable given the unconditional entry rate is only 0.6%.

To test Hypothesis 2b, we split the sample by low and high *Inventor Mobility*. *Law Firm Exit* has a negative effect in the low *Inventor Mobility* sample (Model 3: −0.007, p = .006), but a weak positive effect in the high *Inventor Mobility* sample (Model 4: 0.002, p = .543). Comparing the APE in the high subsample to the APE in the low sample, we find an economically meaningful difference (0.009, p = .035), which supports Hypothesis 2b.

[32]We calculate the condition index as the square root of the maximum divided minimum Eigen value from the independent variable matrix. A condition index under 30 suggests that there is little to no multicollinearity. A variance inflation factor under 5 suggests that a variable is not a likely source of multicollinearity (Judge, Griffths, Hill, Lutkepohl, & Lee, 1985).

[33]In a logit model, the marginal effect of a variable is a function of the other variables in the model. To interpret the economic magnitude of the effect, we calculate the average partial effect for the kth variable using the following formula: $f(\bar{x}'\beta)\,\beta_k$, where $f(.)$ denotes the logit probability density function.

TABLE 5 Contingency hypothesis tests: pooled logit models

Sample	Model 1 Low inventor utilization	Model 2 High inventor utilization	Model 3 Low inventor mobility	Model 4 High inventor mobility
Law Firm Exit$_{it}$	−0.006	0.003	−0.007	0.002
	(0.004)	(0.465)	(0.006)	(0.543)
High Sample Estimate − Low Sample Estimate Welch's t test (p-value)	*0.009*		*0.009*	
	(0.037)		*(0.035)*	
Inventor Utilization$_{ijt-1}$ (%)	0.022	0.003	0.004	0.003
	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility$_{jt-1}$ (000)	−0.005	−0.001	0.008	−0.0004
	(0.000)	(0.000)	(0.000)	(0.048)
Patent Total (5-yr)$_{it-1}$ (000)	0.001	0.002	0.001	0.002
	(0.000)	(0.000)	(0.006)	(0.000)
Scope (5-yr)$_{it-1}$	0.022	0.049	0.018	0.048
	(0.000)	(0.000)	(0.000)	(0.000)
R&D$_{it}$ (000)	0.000	−0.003	−0.001	−0.002
	(0.138)	(0.000)	(0.062)	(0.004)
Ln(Revenue)$_{it}$	0.002	0.007	0.002	0.005
	(0.001)	(0.000)	(0.000)	(0.000)
Operating Margin$_{it}$	0.004	0.000	0.005	0.000
	(0.096)	(0.000)	(0.072)	(0.000)
Litigiousness$_{jt-1}$ (%)	0.000	−0.0002	0.0000	−0.0002
	(0.202)	(0.002)	(0.514)	(0.001)
Inventor Specialization$_{jt-1}$ (%)	0.000	0.0000	0.0000	0.0001
	(0.281)	(0.692)	(0.239)	(0.721)
Year fixed effect	Yes	Yes	Yes	Yes
Technology subcategory fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Observations	254,413	87,465	241,069	103,085

Note: Dependent variable is New Domain (0/1). Average partial effects shown. *p*-values calculated from robust standard errors that account for within firm clustering shown in parentheses.

3.3.3 | Fixed effect logit models

Per earlier tests of the main effect, we also use estimation that accounts for unobserved client firm-level factors potentially driving both the firm's decision to expand and other firm-level decisions, such as R&D spending or choice of technological scope. We rerun the analysis using fixed-effect logit models (i.e., conditional logit models) with the fixed effect at the firm level. To interpret the effect size, we estimate the semi-elasticities (Kitazawa, 2012), which we display in Table 6.[34]

We test Hypotheses 2a and 2b in similar fashion as before, but instead compare the differences in the semi-elasticities. We find a negative effect of *Law Firm Exit* on the likelihood of entry in the low *Inventor Redeployability* (Model 1) and the low *Inventor Mobility* (Model 3) subsamples. In both cases our estimate of the semi-elasticities for *Law Firm Exit* fall near or under −1, which suggests that the likelihood of expansion essentially drops to zero when the firm's law firm exits. Turning to our cross-sample t tests, we find strong support for Hypothesis 2a (p = .024) and Hypothesis 2b (p = .02). Overall, evidence presented in Table 6 supports our predictions.

3.3.4 | Robustness tests

In this section, we report the results of robustness checks of our contingency hypotheses. First, we investigate the sensitivity of our *Inventor Mobility* measure. *Inventor Mobility* measures the number of inventors that switched firms within the technology class over the past 10 years. However, this count variable could correlate with the size of the domain, and larger domains could have more inventors and are easier or more attractive for the firm to expand into, which could potentially explain our results.[35] To overcome this issue, we rerun the fixed-effect logit models using the *Inventor Mobility Ratio*, which scales the *Inventor Mobility* by the total number of inventors in the domain. We report the results in Table 7. We find a large negative effect of *Law Firm Exit* in the low *Inventor Mobility Ratio* subsample (semi-elasticity −202.6%, p = .048) and a smaller negative effect in the high *Inventor Mobility Ratio* subsample (semi-elasticity −22.7%, p = .224). Comparing the estimates, we find support for Hypothesis 2b using *Inventor Mobility Ratio* at the 10% level (p = .095). The rest of the findings are like the ones in Table 6.

Second, we test an alternative measure of *Inventor Utilization*. In our original measure, we take the average utilization across all domains in which the firm is active, without regard to how many inventors it possesses in a domain. For firms with unbalanced inventor allocation across domains, the current calculation could provide less precise measurement. As an alternative, we recalculate the measure using an inventor-weighted average. Rerunning the test for H2a, we find very similar results (e.g., using logit model from Table 5, p = .000, and fixed effect logit from Table 6, p = .025).

Third, we investigate the sensitivity of our results to industry-year variability as there could be specific factors within an industry in a year affecting our results. For example, unobserved labor market shocks could correlate with our contingency variable, but not be suppressed by

[34]The average semi-elasticity of $\frac{\partial ln \Pr[y_{it}=1|x_{it},\alpha_i]}{\partial x_{it}} = \beta\frac{1}{1+\exp[\beta x_{it}+\alpha_i]}$ is a function of the fixed effect α, which has been conditioned out of the model (Chamberlain, 1980). However, Kitazawa (2012) demonstrates that the semi-elasticity can be consistently estimated without α using the following formula: $E[semi-elasticity] = \beta(1-E[y_{it}])$, where $E[y_{it}]) = \bar{y} = \frac{1}{nT}\sum_{i=1}^{n}\sum_{t=1}^{T} y_{it}$. The semi-elasticity in the conditional logit model can be interpreted as the percentage change in the probability of success (in our case entry into a new domain) for a one-unit change in the independent variable. For example, a semi-elasticity of 0.1 suggests that for a one-unit change in the independent, the probability of success increases by 10%. If the unconditional probability of success is 50%, then a 10% increase is equivalent to a 5-percentage point increase.

[35]However, if *Inventor Mobility* only captured the size of the technological domain, it would be unclear why *Law Firm Exit* would vary across the low and high subsamples.

TABLE 6 Contingency hypothesis tests: firm-level fixed effect logit models

Sample	Model 1 Low inventor utilization	Model 2 High inventor utilization	Model 3 Low inventor mobility	Model 4 High inventor mobility
Law Firm Exit$_{it}$	−1.370	−0.083	−1.355	−0.026
	(0.009)	(0.730)	(0.009)	(0.913)
High Sample Estimate − Low Sample Estimate Welch's t test (p-value)	*1.290*		*1.329*	
	(0.024)		*(0.020)*	
Inventor Utilization$_{ijt-1}$ (%)	4.913	0.321	1.829	0.381
	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility$_{jt-1}$ (000)	−1.154	−0.149	0.956	−0.114
	(0.000)	(0.000)	(0.000)	(0.000)
Patent Total (5-yr)$_{it-1}$ (000)	0.079	0.082	0.060	0.100
	(0.105)	(0.190)	(0.230)	(0.086)
Scope (5-yr)$_{it-1}$	−5.666	−0.745	−2.165	−0.465
	(0.029)	(0.465)	(0.307)	(0.652)
R&D$_{it}$ (000)	0.092	0.110	0.086	0.191
	(0.305)	(0.151)	(0.333)	(0.012)
Ln(Revenue)$_{it}$	0.426	−0.237	0.256	−0.328
	(0.142)	(0.183)	(0.369)	(0.070)
Operating Margin$_{it}$	0.177	0.004	0.902	0.007
	(0.801)	(0.572)	(0.217)	(0.319)
Litigiousness$_{jt-1}$ (%)	0.002	−0.014	0.001	−0.017
	(0.346)	(0.003)	(0.669)	(0.000)
Inventor Specialization$_{jt-1}$ (%)	−0.003	−0.001	−0.004	0.003
	(0.348)	(0.845)	(0.306)	(0.380)
Year fixed effect	Yes	Yes	Yes	Yes
Technology subcategory fixed effect	Yes	Yes	Yes	Yes
Observations	205,776	75,535	202,226	88,394
Pseudo R^2	0.16	0.14	0.16	0.13
Number of firms	155	294	177	289

Note: Dependent variable is New Domain (0/1). Semi-elasticities shown. *p*-values calculated from robust standard errors that account for within firm clustering shown in parentheses.

firm and year fixed effects because the shock only affects some industries. To address this, we retest our contingency hypotheses using a conditional logit model with industry-year fixed effects. We report the results in Table 8. The magnitudes of the contingency effects are like those in Table 7. We find support for both contingency hypotheses.

Fourth, the propensity for the firm to enter a domain may depend on domain-specific factors, such as the financial opportunity, the typical wage rate for inventors, the financial performance of incumbents, and so on. To more precisely account for these potential confounding factors, we take two approaches. One, we account time invariant factors that relate to the

TABLE 7 Contingency hypothesis tests: firm-level fixed effect logit models using inventor mobility ratio

Sample	Model 1 Low inventor utilization	Model 2 High inventor utilization	Model 3 Low inventor mobility	Model 4 High inventor mobility
Law Firm $Exit_{it}$	−1.371	0.082	−2.026	−0.277
	(0.009)	(0.732)	(0.048)	(0.224)
High Sample Estimate − Low Sample Estimate Welch's t test (p-value)	*1.453*		*1.756*	
	(0.011)		*(0.095)*	
Inventor $Utilization_{ijt-1}$ (%)	3.326	0.247	0.480	0.371
	(0.000)	(0.000)	(0.000)	(0.000)
Inventor $Mobility_{jt-1}$ (000)	0.010	−0.004	−0.008	−0.013
	(0.003)	(0.588)	(0.000)	(0.025)
Patent Total $(5\text{-yr})_{it-1}$ (000)	0.081	0.076	0.056	0.059
	(0.098)	(0.225)	(0.397)	(0.241)
Scope $(5\text{-yr})_{it-1}$	−5.762	−1.160	−1.598	−1.541
	(0.027)	(0.250)	(0.378)	(0.187)
$R\&D_{it}$ (000)	0.096	0.108	0.175	0.160
	(0.285)	(0.160)	(0.189)	(0.015)
$\ln(Revenue)_{it}$	0.414	−0.228	−0.129	−0.234
	(0.155)	(0.195)	(0.717)	(0.180)
Operating $Margin_{it}$	0.207	0.002	−0.201	0.007
	(0.770)	(0.744)	(0.813)	(0.311)
$Litigiousness_{jt-1}$ (%)	0.003	−0.003	0.002	−0.011
	(0.105)	(0.561)	(0.559)	(0.000)
Inventor $Specialization_{jt-1}$ (%)	0.000	−0.001	−0.008	−0.004
	(0.943)	(0.807)	(0.218)	(0.209)
Year fixed effect	Yes	Yes	Yes	Yes
Technology subcategory fixed effect	Yes	Yes	Yes	Yes
Observations	205,776	75,535	136,064	167,421
Number of firms	150	294	155	287

Note: Dependent variable is New Domain (0/1). Semi-elasticities shown. *p*-values calculated from robust standard errors that account for within firm clustering shown in parentheses.

interaction of the domain and the firm (e.g., a stable prevailing wage rate for inventors and a stable willingness to pay for talent), using firm–technological domain fixed effects.[36] We find robust results for all hypotheses (see Table 9). Two, to account for how value of a technological

[36]To assess if we have enough variation within-technological domain over time across all three contingency variables to properly identify the effects, we provide two sets of statistics. To assess the variation within firm-technological domain, we provide the within firm-technological domain coefficient of variation for each contingency: *Inventor Utilization* (135%) and *Inventor Mobility* (33%). To allow the reader to assess the relative variation within firm-technological domain as compared to between them, we provide the within firm-technological domain standard deviation divided by the between firm-technological domain standard deviation for *Inventor Utilization* (0.55) and *Inventor Mobility* (0.15). Variation is notably less within firm-technological domains than between them.

TABLE 8 Contingency hypothesis tests: industry-year fixed effect logit models

Sample	Model 1 Low inventor utilization	Model 2 High inventor utilization	Model 3 Low inventor mobility	Model 4 High inventor mobility
Law Firm Exit$_{it}$	−1.522	0.076	−1.557	0.087
	(0.003)	(0.716)	(0.002)	(0.420)
High Sample Estimate − Low Sample Estimate Welch's t test (p-value)	*1.596*		*1.64*	
	(0.003)		*(0.002)*	
Inventor Utilization$_{ijt-1}$ (%)	4.27	−0.142	0.549	0.164
	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility$_{jt-1}$ (000)	−0.670	−0.039	2.080	−0.013
	(0.000)	(0.009)	(0.000)	(0.395)
Patent Total (5-yr)$_{it-1}$ (000)	0.390	0.292	0.367	0.257
	(0.000)	(0.000)	(0.000)	(0.000)
Scope (5-yr)$_{it-1}$	6.729	3.217	5.08	3,643
	(0.000)	(0.000)	(0.000)	(0.000)
R&D$_{it}$ (000)	−0.191	−0.269	−0.212	−0.248
	(0.000)	(0.000)	(0.000)	(0.000)
ln(Revenue)$_{it}$	0.38	0.173	0.064	0.173
	(0.479)	(0.000)	(0.204)	(0.000)
Operating Margin$_{it}$	1.21	−0.002	1.354	−0.002
	(0.003)	(0.087)	(0.001)	(0.082)
Litigiousness$_{jt-1}$ (%)	0.002	−0.031	0.0001	−0.018
	(0.280)	(0.000)	(0.656)	(0.000)
Inventor Specialization$_{jt-1}$ (%)	0.001	−0.021	−0.003	−0.038
	(0.717)	(0.000)	(0.347)	(0.000)
Technology subcategory fixed effect	Yes	Yes	Yes	Yes
Observations	274,236	93,460	261,078	109,398
Pseudo R^2	0.12	0.09	0.1	0.09
Number of industry-year groups	68	82	70	83

Note: Dependent variable is New Domain (0/1). Semi-elasticities shown. p-values calculated from robust standard errors that account for within industry-year clustering shown in parentheses.

domain may change over time, we include two time varying measures that should correlate with changes in value or opportunity: the number of patent applications in the technological domain in the year and the number of firms filing for such applications. To account for incumbent performance, as it may affect inventor mobility, we include incumbents' average operating margin and average earnings per share. Rerunning the firm-level fixed effect logit model with these four additional control variables and conducting the split-sample test of the hypotheses, we find very similar differences in the semi-elasticities and similar p-values for the tests: H2a-*Inventor Utilization* $p = .023$ and H2b-*Inventor Mobility* $p = .018$.

TABLE 9 Contingency hypothesis tests: firm-technological domain level fixed effect logit models

SAMPLE	Model 1 Low inventor utilization	Model 2 High inventor utilization	Model 3 Low inventor mobility	Model 4 High inventor mobility
Law Firm Exit_{it}	−1.269	0.437	−1.264	0.423
	(0.012)	(0.041)	(0.012)	(0.046)
High Sample Estimate − Low Sample Estimate Welch's t test (p-value)	*1.71*		*1.69*	
	(0.002)		*(0.002)*	
Inventor $\text{Utilization}_{ijt-1}$ (%)	5.303	0194	0.992	0.216
	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility_{jt-1} (000)	−1.339	0.049	−0.655	0.033
	(0.003)	(0.560)	(0.410)	(0.964)
Patent Total $(5\text{-yr})_{it-1}$ (000)	0.092	0.159	0.083	0.138
	(0.000)	(0.000)	(0.000)	(0.000)
Scope $(5\text{-yr})_{it-1}$	6.366	3.175	5.597	3.510
	(0.000)	(0.000)	(0.000)	(0.000)
$\text{R\&D}_{it}$ (000)	−0.089	−0.130	−0.102	−0.113
	(0.000)	(0.000)	(0.000)	(0.000)
$\ln(\text{Revenue})_{it}$	0.446	0.315	0.464	0.276
	(0.000)	(0.000)	(0.000)	(0.000)
Operating Margin_{it}	1.485	−0.003	1.415	−0.003
	(0.000)	(0.060)	(0.000)	(0.037)
$\text{Litigiousness}_{jt-1}$ (%)	−0.005	−0.012	−0.008	0.014
	(0.107)	(0.238)	(0.013)	(0.205)
Inventor $\text{Specialization}_{jt-1}$ (%)	0.037	−0.103	0.024	−0.088
	(0.015)	(0.004)	(0.100)	(0.015)
Year fixed effect	Yes	Yes	Yes	Yes
Observations	151,106	73,034	146,834	87,355
Pseudo R^2	0.20	0.16	0.17	0.14
Number of industry-year groups	552	609	502	559

Note: Dependent variable is New Domain (0/1). Semi-elasticities shown. *p*-values calculated from robust standard errors that account for within firm-technological domain clustering shown in parentheses.

3.4 | Additional analyses

In this section, we provide additional analyses to address concerns related to firm heterogeneity and law firm exit. In addition, we briefly summarize our analyses of potential confounding factors and measurement issues as well as the results of another contingency effect that underscores our main proposition; a full treatment can be found in the Supporting information.

3.4.1 | Firm and domain specific factors

In earlier tests of the main effect, we measure the number of new domains the firm expands into as our dependent variable. However, the extent to which such expansion would require new inventors and expose the firm to legal backlash could depend on how it affects the firm's overall technological scope. A firm that makes a larger change in its scope may be more exposed. To test the sensitivity of findings to this issue, we measure how much the firm's technological scope increases in a year. Because we are only interested in whether scope increases, the dependent variable is calculated as: $DV = Scope_{t} - Scope_{t-1}$ if >0 and 0 otherwise.[37] As the dependent variable is bound between 0 and 1, we use a fractional logit model and include all controls, year, technology subcategory, and industry fixed effects. Calculating the APE, we find *Law Firm Exit* reduces scope by −0.01 (p-value .011). The results support H1.

Litigation ability may be more relevant in determining expansion for some firms than others. To explore the heterogeneity in the effect of litigation ability, we use *IP Lawsuits* to estimate the relationship between litigation ability and *New Domains*. We deploy a Poisson control function model and use *Law Firm Exit* as an instrument. In the first stage, we model *IP Lawsuits* as a function of *Law Firm Exit* and our controls from Table 3 Model 1. We find a negative and significant effect of *Law Firm Exit*. We then use the residual from model as an additional variable in the second stage *New Domains* equation, which includes all the prior controls. Estimating the control function via generalized method of moments (Wooldridge, 2010), we find a negative effect of the residual (−1.53, p = .023) and a positive effect of *IP Lawsuits* (1.63, p = .025, marginal effect = 4.45). Interpreting *IP Lawsuits* as a rough proxy for litigation ability, we find a positive relationship between litigation ability and expansion into new domains. Therefore, a disruption in this ability will reduce expansion, supporting our prediction.

3.4.2 | Law firm exit

To further stress test the suitability of law firm exits as an identification tool we conduct a Monte Carlo simulation-based falsification test. Using the sample of treated firms (i.e., ones that used a failed law firm), we randomly assign a law firm exit for each firm in a year that the true exit did not occur. We then run a firm-level fixed effect Poisson regression of *New Domains* on this "placebo exit" and all controls (per Table 4 Model 5). We repeat this process 10,000 times. Per Hypothesis 1, we should observe a more negative effect of *Law Firm Exit* than for the placebo effect. For the "placebo exit" we find an average coefficient of 0.044 and average p-value of .40 as compared to our estimated coefficient of *Law Firm Exit* in Table 4 Model 5 of −0.569 (p = .01). Our estimated effect of *Law Firm Exit* is more negative than approximately 98% of the simulated placebo estimates. These results help provide confidence in our H1 test results.

[37]Using the raw change could capture a firm that is shrinking its scope. Our theory suggests firms will be less likely to expand into new technological domains without litigation ability, not that the lack of litigation ability will cause the firm to exit existing domains.

3.4.3 | Additional analyses contained in the Supporting information

In the Supporting information, we conduct the following analyses which we summarize here. First, we account for firms' strategic use of litigation ability and find robust results. Second, find no evidence to support that client firm performance could potentially drive law firm exit and thus confound our results. Third, we provide evidence that the likelihood that competitors will initiate an IP-related lawsuit amplifies the main proposition. Fourth, we provide an in-depth analysis of measurement issues that stem from using patent data to calculate firm scope.

4 | DISCUSSION

We set out to investigate the effect of a firm's IP litigation ability on the technological diversification into a new domain. Our key finding is that a firm's ability to litigate and defend against potential lawsuits contributes to its decision to diversify into new technological domains and generate IP in the new area. The salience of litigation ability as a consideration for expansion is especially pronounced when the firm faces difficulties in acquiring the knowledge embodied in human capital that is necessary to enter the new domain. Specifically, we propose that the effect of litigation ability on the decision to expand will be stronger when it is harder for the firm to utilize its existing inventors in the new technological domain and when the domain has fewer mobile inventors. Using the exit of focal firms' primary law firms as an empirical setting allowing us to trace reduction in firms' litigation abilities, we find evidence consistent with our hypotheses.

These findings have various implications for both the existing literature and managerial practice. First, by focusing on litigation ability as a resource allowing the firm to acquire new knowledge as it expands technologically, we are doing more than just adding another antecedent to the firm's technological diversification literature (Levinthal & Wu, 2010; Penrose, 1959). Rather, we shift the attention away from the traditional discussion about the fungibility and redeployability of the firm's existing resources. It is well established that a firm needs to have resources that it can apply and embed within new products in a new technological space (Helfat & Raubitschek, 2000; Sakhartov & Folta, 2014). Such resources often drive the value creation in technological expansion and constitute a theoretical basis for firm growth and scope. While not contradicting this established notion, we highlight the challenges associated with the synergistic value creation in the new domain. The firms often need to engage in recombination between the existing and new knowledge to achieve the synergies (Ahuja & Katila, 2001; Galunic & Rodan, 1998). The barriers to acquisition of the new knowledge then constitute pertinent constraints in the firms' Penrosian growth. The understanding of the barriers of such growth is theoretically important. Our study thus refines our understanding of the less-explored antecedents in the context of the literature on technological diversification and innovation.

Second, this study bridges the IP literature and the technological diversification literature. The IP literature has laid out the antecedents and effects of litigation. Scholars have examined when and why firms engage in IP-related litigations, what the litigations entail, and what effects they have on the plaintiffs, defendants and other firms (Agarwal et al., 2009; Clarkson & Toh, 2010; Somaya, 2003). The central focus of this work has been on how the litigations serve to protect the firm's *existing IP*. This focus is not surprising, as litigation is typically conceptualized as resulting from disagreements over existing technological assets protected by IP safeguards. The firm needs to first own IP before others can infringe on it, which induces the firm to sue. As we show, the merits of the firm's ability to litigate go beyond this portrayal. The litigation plays a role in what the firm has yet to own or access from competitors. Identifying the role of IP litigation in the creation of future IP adds nuance to our understanding of IP strategy in ways that have not been sufficiently explicated. Our findings imply that litigation does not only occupy a derivative position, as a resource that is activated only after the firm has acquired IP. It could serve a more significant purpose in the firm's major strategic decisions such as those related to technological expansion. Furthermore, by fleshing out the insurance-like property of litigation ability in shaping managerial behavior, we are responding to the call to better comprehend the role of IP in strategy (Somaya, 2012).

Third, our focus on human capital as a key conduit of knowledge acquisition advances research on inventor mobility and human capital (Agarwal et al., 2004; Song et al., 2003; Wezel et al., 2006). It is well established that inventors and other knowledge workers are crucial repositories of firm knowledge, and their mobility represents a critical channel through which knowledge diffuses across firm boundaries (Almeida & Kogut, 1999; Phillips, 2002). Mobility of employees carrying valuable knowledge leads to many strategic challenges. The firms would like to encourage the inflow of knowledge while reducing the outflow and expropriation of knowledge and employee exit. Much of the related literature on knowledge spillovers has focused on the outflows, taking on the perspective of firms managing their IP expropriation challenges (Campbell et al., 2012; Coff, 1997). We focus on the mirror perspective of the IP management challenges associated with the inflows. Furthermore, the past studies that studied the inflows by adopting the perspective of a firm acquiring human capital (Agarwal, Audretsch, & Sarkar, 2010; Rosenkopf & Almeida, 2003; Somaya et al., 2008) examined the effects of inflows such as the diffusion of acquired knowledge or performance implications of acquiring inventors. Our study thus provides a complementary perspective by drawing our attention to the antecedents and contingencies related to knowledge inflows. As we maintain, the examination of the antecedents is deserving of attention. The process of acquiring human capital is abound in legal complications, especially when the firm is expanding in new territories marked by competitors' IP. Our study partakes in this conversation by stressing that the firm's litigation ability facilitates the acquisition of new human capital.

4.1 | Limitations and future research

The contributions notwithstanding, our study has multiple limitations that present opportunities for future research. Most of the limitations are driven by the available data. To address issues related to selection and unobserved heterogeneity (i.e., unobserved quality differences across firms likely correlate with both the IP litigation ability and technological decisions), we relied on a specific empirical strategy.

First, the available data do not provide information on the fine-grained innovative inputs and product decisions. Instead, we utilize the generation of new IP (i.e., patent filings) to gauge the extent and direction of innovative activity. While such an approach is consistent with prior research, it is possible that patent filings and innovative strategies diverge when firms lose legal representation. The firms may delay patenting in the new technological domain when their IP law firm exits while still investing in the R&D in the new area. Even in this extreme case, our theoretical insights should remain. Delaying the protection of IP in the new area lowers returns on the R&D investments (especially in technologically dynamic environments), which decreases the incentives of the focal firm to expand and introduce new products. However, future studies may generate novel insights by disentangling the effect of litigation on R&D investments, patenting and product decisions. Furthermore, we utilized patent records to trace mobility of inventors to test one of our hypotheses. Such approach may undercount mobility events of less productive inventors. Future studies may complement our analysis with data that utilize more comprehensive coverage of mobility (Campbell et al., 2012).

Second, given our empirical approach, we can only observe the short-term effect of changes in the IP litigation ability. As we show, the exit of a primary law firm creates a disruption in the ability to litigate of about 1 year. While losing a year can be critical in many dynamic contexts, examining long term effects of litigation ability may yield new findings. Our empirical approach also complements prior work that examined the effects of legislative changes at the state level affecting litigation ability of firms (e.g., Yonge, Tong, & Fleming, 2015). In our context, IP law firm exit occurs close to the phenomenon under study—that is, the IP law firm exits directly affect the litigation ability of treated firms. This design improves the ability to trace the effects of litigation ability and examine contingencies. It would be useful for future research to explicitly examine the tradeoffs of studying the IP litigation ability at different levels.

Third, our approach provides the effect of a decrease in the IP litigation ability. While there is no a priori reason to believe that the directionality of the change matters theoretically, this is a conjecture that may need to be validated empirically. Future research that identifies the effect of increases in the IP litigation ability would thus be welcome.

Fourth, IP litigation ability is likely complex and driven by a variety of underlying factors. Our study focuses on the litigation ability as determined by the external relationship with a law firm. Although other drivers of litigation ability should lead to similar effects in our theorized predictions, being able to examine other determinants of litigation ability may lead to novel findings. For instance, it is possible that the relationship with an external IP law firm, as we model it, is particularly important when firms expand technologically into new domains.

Lastly, we studied the effects of litigation ability in the context of large public firms. The litigation ability may play a different and potentially more pronounced role for small entrepreneurial firms. As small firms are at a natural disadvantage when fighting large litigants, the ability to litigate effectively is a critical resource. At the same time, smaller firms may need to acquire fewer new employees when expanding and, thus, their human capital strategies may stay "under the radar" of large competitors. Consequently, the human capital contingencies that we propose may matter less for small firms. Future research that compares how litigation operates in small versus large firms will be important and will help to position our results in a broader context.

5 | CONCLUSION

When companies diversify technologically, they often need to acquire resources that are embodied in human capital and protected by IP of competitors. We examined the role of IP litigation ability in facilitating the technological expansions. Our key insight is that firms need IP litigation ability *before* they diversify technologically. Because employees represent a critical channel through which the new knowledge is acquired, their characteristics play a critical role in how important it is to have the litigation ability in place prior to the expansion. Thus, while prior research highlights the role of IP litigation as a strategic resource in protecting the *existing* IP, we show that it plays an equally important role in generating future IP. In doing so, we hope to stimulate further discussion in the areas of innovation, protection of IP, and employee mobility.

ACKNOWLEDGEMENTS

All authors contributed equally to the manuscript. We appreciate helpful comments from seminar participants at the Copenhagen Business School, McGill University, Seoul National University's Business School, Syracuse University's Whitman School of Management, University of Utah, University of Wisconsin-Madison, and the 2019 Wharton Technology and Innovation Conference.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Ganco M, Miller CD, Toh PK. From litigation to innovation: Firms' ability to litigate and technological diversification through human capital. *Strat Mgmt J*. 2020;41:2436–2473. https://doi.org/10.1002/smj.3203