FROM LITIGATION TO INNOVATION: A FIRM'S ABILITY TO LITIGATE AND ITS EXPANSION INTO NEW TECHNOLOGICAL DOMAINS

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Abstract

Prior research has highlighted the role that a firm's litigation ability plays in defending its existing intellectual property. Our study explores how the firm's litigation ability affects its decisions on technological expansion. Using law firm exit as a shock, we find that it is associated with a temporary decline in patenting output of the client firm, and this decline is disproportionately driven by patenting in technologies new to the firm rather than in its existing technologies. Further, we find that the negative effect is stronger if the client firm expands into technologies that are highly litigated, when its existing inventors cannot be easily redeployed into the new domain, when the inter-firm mobility is low in the domain, or when the required knowledge is highly specialized.

Keywords: Innovation, technological expansion, litigation, intellectual property, employee mobility.

Introduction

To introduce novel products or services, a firm often expands into technological domains that are new to it (Penrose, 1959; Markides and Williamson, 1994; Galunic and Rodan, 1998; Helfat and Raubitschek, 2000). Much of the extant work focuses on how, prior to the expansion, the firm needs existing knowledge that it can redeploy in the new domain (Ahuja and Katila 2001; Helfat and Eisenhardt, 2004; Levinthal and Wu, 2010; Sakhartov and Folta, 2014; Karim and Mitchel, 2000; Moeen, 2017). Further, this redeployment usually requires the firm to synergistically combine its existing knowledge with knowledge originating from the new domain (Galunic and Rodan, 1998; Helfat and Raubitschek, 2000; Miller, 2006; Kaiser, Kongsted, Laursen, and Ejsing, 2018). However, some of the new knowledge may not be possessed by the firm. Therefore, the expanding firm must also consider whether it can successfully acquire this knowledge in the new domain.

The complication is that the knowledge in question may be held by other firms that protect it with intellectual property (IP) safeguards such as patents and trade secrets (Somaya, 2003; Landes and Posner, 2003; Clarkson and Toh, 2010). To expand technologically, the focal firm runs the risk of IP infringement. When this threat is severe enough, the firm's ability to deal with it could influence its decision to expand in the first place. Yet, the literature has largely been silent on this antecedent. Meanwhile, a separate stream of the literature demonstrates the importance of IP litigation as a strategic lever in technological competition (Ziedonis, 2003; Agarwal, Ganco, Ziedonis, 2009; Tan, 2016). This research stream mainly examines the IP litigation in the context of protecting *existing* IP. The potential role that litigation plays in the firm's decision to expand into new domains, in anticipation of having to deal with IP issues, has not been studied. This leaves a gap in our understanding of a firm's technological expansion: *Does the firm's ability to litigate over IP affect its decision to expand into a new technological domain?*[1]

From a firm's perspective, beyond knowing that the ability to litigate matters, it is important to know the specific circumstances making litigation ability more relevant. A useful observation here

[1] 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).

is that the individual inventors serve as key conduits for the requisite knowledge (Grant, 1996; Almeida and Kogut, 1999; Phillips, 2002; Song, Almeida and Wu, 2003). For the firm to access the necessary knowledge, it may need to hire inventors from competitors in the new domain (Coff, 1997; Rosenkopf and Almeida, 2003; Agarwal, Echambadi, Franco and Sarkar, 2004; Kaiser et al., 2018). Battles over IP are frequently fought when employees move across firms.[2] Hence, whether the firm anticipates the need for litigation upon expanding into a new domain will likely depend on the nature of employees within this domain. This leads us to the question: *What role do inventors within the new domain play in the relationship between the firm's ability to litigate over IP and its technological expansion*?

We address these questions by bringing together the literatures on technological expansion and IP and examining the relationships between a temporary reduction in the firm's ability to litigate over IP, its decision to expand technologically, and the characteristics of inventors associated with the new technological domain. Our main proposition is that a firm's loss of ability to defend against IP infringement lawsuits will lower its likelihood of expanding into a new technological domain. Further, we propose that this main effect will be stronger (i.e., more negative) when competitors in the new domain are more aggressive in enforcing IP rights, when the firm is less able to redeploy its own existing inventors into this new domain, when the cross-firm mobility in the new domain is lower, or when the new domain requires inventors with more specialized expertise.

We empirically capture changes (reductions) in the focal firms' ability to litigate and defend against IP infringement suits by exploiting unrelated exits, from 2002-2010, of the focal firms' primary IP law firms.[3] It is typical for a firm to form long-lasting relationships with its primary law firm. 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 effective in giving counsel on issues of risk and procedures during IP

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[2] In practice, over 85% of federal trade secret lawsuits involve the firm's employees or business partners (Almeling, Snyder, Sapoznikow, Mcollum, and Weader 2010). Highlighting the strategic nature of employee-related litigation, scholars found that firms actively use litigation to dissuade their employees from exit (Agarwal et al., 2009; Starr, Ganco and Campbell, 2018), especially the employees who carry knowledge representing central components of value creation (Wezel, Cattani and Pennings, 2006; Campbell, Ganco, Franco, Agarwal, 2012).

[3] We qualitatively examined the reasons for the law firm exit and selected only those that are plausibly exogenous to their client firm characteristics.

litigations and disputes over trade secrets or patents. 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 cost rises and the sudden exit of its law firm will cause a temporary reduction in its IP litigation ability. Empirically, we find support for our theoretical predictions. We additionally find evidence that the firm's ability to litigate decreases shortly after the exit of its primary law firm. This helps to justify our use of the law firm exits as proxies for reductions in a focal firm's IP abilities. Further, we find that patent filings in existing classes decline much less, which is consistent with our theorizing that firms lacking the ability to defend against IP infringement are hesitant to expand technologically while maintaining their activity in their existing domains.

Our study makes several contributions. First, we add to the literature on technological growth and innovation by shifting the focus away from the more established notion that firms' existing fungible resources are prerequisites for technological expansions (Helfat and Raubitschek, 2000; Sakhartov and Folta, 2014). We shift the focus towards the less-explored antecedents surrounding a firm's access to knowledge in the new domain. Even if resource redeployability is necessary for synergistic value creation (Penrose, 1959; Levinthal and Wu, 2010), the firm may need to engage in recombination with new components to achieve the synergy (Ahuja and Katila, 2001).

Second, by bridging the technological growth and the IP literatures, we highlight an underappreciated role of IP strategy. The firm's litigation ability goes beyond what is portrayed in much of the IP literature – serving to protect the firm's existing IP (Somaya, 2003; Agarwal et al., 2009; Clarkson and Toh, 2010). Our insight that firms employ litigation in new settings where they have yet to acquire any IP adds a layer of nuance to our understanding of IP strategy and hints at more significant roles that litigation plays in influencing the firm's major strategic decisions such as technological growth. By fleshing out the 'insurance-like' property of litigation in shaping managerial behavior and strategies, 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 the mobility of inventors and human capital (Wezel et al., 2006; Song et al., 2003; Agarwal et al., 2004). Mobility represents a fundamental channel through which knowledge diffuses across firm boundaries (Almeida and Kogut, 1999; Phillips, 2002). Given that employees are free to move (Coff, 1997), firms must manage the challenges associated with preventing out-flows or encouraging in-flows of knowledge. Much of the human capital literature focuses on the out-flows by taking on the individuals or the source firms' (competitors') point of view (e.g., Campbell et al., 2012). Among the ones that tackle the in-flow perspective of the focal firm acquiring human capital (e.g., Rosenkopf and Almeida, 2003; Somaya, Williamson and Lorinkova, 2008), examination has focused on the firm performance rather than on the levers that firms may need to acquire the human capital with the relevant IP. Our study partakes in this conversation by stressing that the firm's litigation ability facilitates the acquisition of relevant knowledge.

IP Litigation Ability and Expansion into Technological Domains New to the Firm

Innovation is a key driver of the growth and performance of modern firms (Rosenberg, 2004; Haltiwanger et al., 2018). In the process of introducing innovative products and services, a firm not only relies on its prior technological resources but often needs to master technologies that fall outside of its prior focus. In fact, innovation stems from synergistically recombining the firm's existing technological resources with technologies that are new to it (Galunic and Rodan, 1998; Helfat and Raubitschek, 2000). Prior research, focusing on the firm's existing resources, has extensively examined how these resources apply to the new domain – i.e., how fungible they are (e.g., Ahuja and Katila, 2001; Helfat and Eisenhardt, 2004; Levinthal and Wu, 2010; Sakhartov and Folta, 2014). This literature has identified significant heterogeneity in a firm's ability to redeploy such resources to technological domains that are new to the firm as driven by the nature of the resource fungibility. Equally important, though less emphasized thus far, is that when a firm expands into technological domains that are new to it, it frequently needs to access technological resources that are held by other firms. Such resources may be protected by intellectual property safeguards, including patents and trade secrets. Technological expansion is thus fraught with the risk of infringing upon the intellectual property held by firms that are already operating in the domain into which the focal firm expands.

As an example, consider Google's recent expansion into hardware devices such as cellphones, home automation and virtual reality. Expansion into these markets allowed Google to leverage its unique knowledge in Internet technologies but also required Google to develop or acquire resources necessary for the introduction of hardware-based products. While such resources may be novel to Google, there are many other firms already holding such resources. 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. Google had to either acquire or develop these resources internally. Eventually, Google hired 2,000 cellphone engineers from Chinese manufacturer HTC and, in 2016, acquired the US cellphone manufacturer Motorola for $12.9B.[4] As many industry experts agreed, the primary reason for acquiring Motorola was to obtain its patent portfolio as well as some of its talent such as hardware engineers and Motorola's president of hardware development. These resources provided a foundation for Google's ecosystem of hardware devices including Google Home and Google Assistant.[5]

As the example illustrates, technological expansion necessary for introducing new products or services is often associated with significant intellectual property hazards. Hence, the ability to access and manage IP in the technological domain new to the firm may be an important driver of the expansion itself. Interestingly, the existing work on IP protection is largely silent on this possible antecedent. While prior studies have found evidence consistent with a firm using IP strategies (e.g., aggressive enforcement of patents against potential infringement by former employees) to reduce knowledge outflows or employee exit (Agarwal et al., 2009; Ganco et al., 2011) or to deter competitive entry into its existing technological domain (Clarkson and Toh, 2010)[6], the focus has been on how a firm enforces its *existing* IP. It remains unclear whether the firm's ability to litigate over IP influences its decision to expand into new technological areas where it may not yet possess any IP to begin with.

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[4] https://www.theverge.com/2017/9/20/16340108/google-htc-smartphone-team-acquisition-announced, accessed on August 8, 2018.

[5] 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.

[6] 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).

Our key argument is that a firm needs its ability to litigate over IP *in place* when it expands into technological domains that are new to it (i.e., creating new IP in these domains). We define the 'litigation ability' as having means to both initiate an IP-related litigation and defend against IP-related lawsuits filed by other firms (i.e., be a plaintiff or defendant in a lawsuit, respectively).[7] 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). Having its IP litigation ability ready when expanding into a new technological domain is important for multiple reasons. The expansion may cause competitors to initiate lawsuits when they observe or anticipate the firm's moves, especially when the firm may not hold its own IP in the new domain yet. These competitors may use litigations against the firm because of genuine concerns over IP violations, or simply to impede the firm's expansion in the domain. As we discuss below, this mechanism is even more salient when the expanding firm is likely to try to hire employees away from the competitors already operating in the domain. There exists a variety of effective IP-related strategies that these competitors can potentially use against the former employees (Starr et al., 2017; Agarwal et al., 2009). Having the ability to litigate over IP prior to the expansion thus serves as 'insurance' that will become handy if the firm finds itself in a legal battle post-expansion. It will also serve to protect investments made through the acquisition or internal development, including the investments in human capital that are necessary to compete in the new domain. Lastly, due to the frequent countersuits, having the IP litigation ability may also serve as a deterrent against competitors considering legal actions.

In more detail, when the firm considers expanding into and creating new IP in a new technological domain, it compares the expected benefits of such an expansion relative to the expected costs. The level of benefits depends on factors such as market size, price, customer demand and competition in the new technological domain (i.e., factors affecting revenue realized post-expansion). Costs are driven by investments needed to realize the revenues. They include the acquisition or development of human capital or other assets that are necessary in the new domain (e.g., hardware

[7] 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.

engineers in the case of Google for their expansion into electronic devices). Costs also include potential royalties, settlement payments or other litigation expenses. If, post-expansion, 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.[8] The ability to litigate will be critical in protecting both revenues against an injunction and costs from additional payments.[9]

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

H1: A reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm expanding into a new (to the firm) technological area (i.e., generating new IP in this area).

As we maintain above, whether a firm expands technologically depends on its calculus associated with the expansion. An important variable in this calculus is the likelihood that the competitors will initiate an IP-related lawsuit. Prior research shows that there is substantial heterogeneity in IP litigiousness (i.e., how aggressively competitors enforce their IP) across and within industries (Cohen et al., 2000; Ziedonis, 2003). For instance, from 2004 to 2014, the number of patent lawsuits *exceeded* the number of patents issued in the "wearables," transdermal drug delivery and Internet of Things technologies, while only 2-10% of wireless power, biometrics, and microfluids patents were litigated over the same period (Malik and Balasubramanian, 2015).[10] Consequently, the baseline probability of the firm getting sued differs depending on which technological domain it enters. Competitors' litigiousness varies

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[8] Evidence suggests that losing IP cases can be very costly (Mani and Sancheti, 2016). The high costs stem from the possibility that the judgement 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 and Sancheti, 2016).

[9] Strong litigation ability may also deter competitors from *initiating* a lawsuit and potentially surrendering a larger market share to the expanding firm. While such a mechanism is plausible (Agarwal et al., 2009), the effects point in the same direction as our hypotheses, so we abstract away from it for parsimony reasons.

[10] http://www.iam-media.com/Magazine/Issue/72/Features/In-search-of-the-next-patent-war, accessed on August 8, 2018 (Malik and Balasubramanian, 2015)

across domains for a variety of reasons. For instance, some technologies are inherently harder to protect through patents and the associated patents are easier to invent around, in turn compelling competitors to file many related patents and create patent "thickets" (Sherry and Teece, 2015). Since the subject of each patent claim is harder to discern in these technologies, accusations of IP violations and mutual litigation are widespread. Heterogeneity in litigiousness across domains can also stem from differences in rates of innovation and imitation across firms. Competitors that are frequent targets of imitation may opt to aggressively defend their IP (Agarwal et al., 2009), driving up the litigiousness within a domain (e.g., Apple's smartphone designs were imitated by several manufacturers, which led to aggressive enforcement of IP by Apple). Further, certain technological domains may be dominated by non-practicing entities (i.e., patent 'trolls') that litigate extensively to expropriate profits from producers and service providers (i.e., practicing entities) (Steensma et al., 2016).

Accordingly, having IP litigation ability in place prior to the technological expansion will be particularly important when the firm is expanding into a domain that has highly litigious competitors. In other words, the negative effect of the reduction in litigation ability on the technological expansion (laid out as per hypothesis 1) will be amplified. This logic also implies that, when the litigation ability of the firm is reduced, its expansionary efforts may be redirected toward domains exhibiting lower litigiousness. Thus, we propose:

H2: The more litigious the competitors are in the focal technological area, the more that a reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm expanding into this area (i.e., generating new IP in this area).

In the prior hypotheses, we focused on establishing the basic relationship between litigation ability and expansion into technological domains that are new to the firm. In the following, we delve deeper into a mechanism that may serve as a key contingency.

The role of the focal firm's IP litigation ability is particularly salient when much of subsequent knowledge transfer will be occurring via inventor mobility. Employees, including inventors, are largely free to quit at will and often leave with knowledge that is highly valuable to their previous employers (Coff, 1999; Blyler and Coff, 2003). As they are poached by and join 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 (Blyler and Coff, 2003; Aime, Johnson, and Ridge, 2010; Kim, 2014). Consistent with this argument, researchers and legal scholars have identified employee mobility and poaching as key drivers of IP-related lawsuits (Freedman, 2000; Beckerman-Rodau, 2002; Stone, 2002; Bishara, 2006; Kim, 2014). The practical importance of employee mobility and poaching-based litigation is also reflected in the fact that such lawsuits often make news headlines (Girard, 2002; Neumeyer, 2013; Boher, 2016; Lobel, 2017).[11] Over 85 percent of Federal-level trade secret lawsuits and over 93 percent of state-level trade secret lawsuits involve former employees or business partners (Almeling et al., 2010; Almeling, Snyder, Sapoznikow, McCollum, and Weader, 2011; Elmore, 2016).[12] 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 inevitably will infringe (i.e., based on the inevitable disclosure doctrine [Barankay, Contigiani and Hsu, 2018]) on the patent in the course of the new employment.

As we discussed earlier, when a firm enters a new technological domain, it often needs to acquire technological knowledge that is new to the firm. A common way to acquire this knowledge is through the hiring of inventors from competitors already operating in the domain. As these competitors will likely use IP-related lawsuits to try to reduce or impede such mobility in order to prevent knowledge outflows (Agarwal et al., 2009; Ganco et al., 2011), the firm's ability to defend against mobility-based IP lawsuits becomes critical. Thus, considerations surrounding the firm's need for and ease of hiring inventors from competitors will serve as key contingencies in the firm's expansion decision. We posit that the role of litigation ability in driving the firm's technological expansion (hypothesis 1) will depend on the calculus surrounding the potential hiring of competitors' inventors within the domain. Depicting this calculus at a broad level: when this hiring is needed or difficult, the firm would essentially have to make a greater investment during its expansion, which reduces the expected net gains of expansion and accordingly the likelihood of its decision to expand

[11] Prominent examples include Borland International suing Microsoft in an attempt 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).
[12] Analysis of trade secret cases filed at the Federal level reveals that 37 percent also involve a simultaneous patent lawsuit (Elmore, 2016; Nemec, Sammi, and Flanz, 2018).

in the first place. More specifically, we posit that this calculus will depend on the following factors: a) the firm's ability to redeploy its own existing inventors into the new technological domain, b) the ease with which it can hire inventors from competitors in the new domain, and c) how specialized the inventors are within the new domain.

First, the firm can potentially minimize the costs and legal problems associated with trying to hire from competitors if it is able to redeploy its own existing inventors from its previous domains into the new domain in question. This mirrors the situation where much of the needed new technological knowledge to operate in this new domain can be fungibly transferred from knowledge residing within the firm's existing inventors and used in previous domains (Levinthal and Wu, 2010; Sakhartov and Folta, 2014). However, if the firm cannot redeploy its existing inventors (e.g., Google did not have many hardware engineers prior to its expansion into the device segments), the firm is then left with the options of either hiring inexperienced inventors and developing them, retraining their existing inventors to 'tool up' on technologies related to the new domain, or poaching experienced inventors from competitors within the new domain. These options are costly and may take a significant amount of time that will delay the firm's expansion. Investments associated with the technological expansion will be greater and the firm will have more resources at stake if it loses the battle in the new technological domain. It is in these higher stakes situations when the 'insurance-like' property of the ability to litigate over IP becomes especially valuable. This leads us to formulate the following contingency:

H3a: The less that the firm can redeploy inventors from its existing technological areas into the focal technological area, the more that a reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm expanding into this area (i.e., generating new IP in this area).

Second, an alternative to redeploying the firm's existing inventors is to hire inventors from competitors already operating in the focal technological domain. There is significant heterogeneity, across domains, in the ease with which this alternative may be accomplished. In some technological domains, it may be more common for inventors to be bound by non-compete agreements that prevent them from joining competitors (Starr, 2017), or they may hold knowledge that is less easily transferrable across organizations (Starr et al., 2018; Neal, 1995). Consistent with such a view, prior work has found significant heterogeneity in the propensity of individuals to switch organizations (Neffke and Henning, 2013; Neal, 1995). In situations when the firm cannot easily find and hire competitors' inventors that it needs in its technological expansion (and holding constant the ease of redeploying its existing inventors from other domains), it is then left with the costly option of having to develop the inventors internally, which, as mentioned earlier, requires non-trivial investments. This increases the firm's eventual 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, these workers were not readily available on the labor market. This led Google to spend $1.1 billion on the acquisition of 2,000 hardware engineers from HTC.[13] 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 chips) in the device market and being ready 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:

H3b: The lower the inter-firm mobility of inventors within the focal technological area, the more that a reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm expanding into this area (i.e., generating new IP in this area).

Third, the extent to which inventors within the focal domain are specialized technologically will also affect the role that IP litigation ability plays in the firm's decision to expand into the domain. By specialization we mean the extent to which the inventors within the domain only work in technologies related to this domain and not in others. For instance, if a firm wants to produce smartphones, it needs hardware engineers with experience in designing smartphones. Due to the depth and industry-specificity of technological knowledge (Neal, 1995), redeploying these engineers to other technologies

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

would mean a loss of a significant portion of their human capital. This cost effectively locks these engineers in the specialized technologies in which they accumulated expertise.

Such specialization matters for several reasons. When the firm hires specialized inventors, it will be a clear indication to the competitors that the firm wants to expand into this domain. It thus heightens the competitors' awareness of the focal firm's expansion into the domain and raises the propensity of them initiating lawsuits against the firm. This propensity is further enhanced by the fact that the specialized inventors represent valuable resources given their relative rarity. Further, inventors with specialized skills may be more likely to be bound by non-competes (Starr et al., 2018). The violations of the terms of a non-compete contract may be easier to prove for specialized inventors.

Inventor specialization may also determine which competitors are the sources of new employees. When inventors are specialized, the firm may be more driven to hire from competitors already in the focal technological domain (e.g., experienced smartphone engineers can only be acquired from existing smartphone manufacturers). As other options become less feasible, the mechanisms underlying the prior hypotheses (H3a and H3b) become more accentuated. Greater specialization implies fewer generalists - fewer inventors who span multiple domains including the focal one. The option of redeploying the firm's existing inventors working in other technological areas declines in viability. Further, the depth of knowledge that comes with specialization increases the cost and time of internal development, which further raises the investment level of the firm should it choose this alternative. With redeployment and internal development becoming less attractive for more specialized inventors, the firm is pushed towards having to hire from competitors. At the same time, the competitors may provide strong retention incentives to keep their core human capital. These factors related to inventor specialization increase the costs associated with the firm's technological expansion.

Driven by a similar logic, specialized inventors working in the new domain are harder to redeploy back into other technologies, should the firm need to exit the domain (i.e., specialization raises exit cost). The firm may be forced to abandon the expansion if it loses a lawsuit, must pay large royalties or settlements and the continued operation in the domain is unprofitable, or if an injunction against it is granted to one of its competitors and the firm is forced to stop its operations in the domain. Its investments in specialized inventors will be less recoverable, which, in turn, affects the calculus pre-expansion by increasing its expected costs. In sum, inventor specialization in the new domain will drive the expected costs of technological expansion, thus increasing the importance of the firm's IP litigation ability as a defensive mechanism protecting the investments that are at stake. This leads us to our last contingency:

H3c: The more that operating in the focal technological area requires specialized inventors, the more that a reduction in a firm's ability to defend against IP infringement litigation will lower the likelihood of this firm expanding into this area (i.e., generating new IP in this area).

DATA & METHOD

Empirical Design: IP Law Firm Exits

We examine our propositions with the data from U.S. firms between 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 focal firms' primary IP law firm to capture changes (reductions) in the focal firms' ability to litigate, and trace resulting variations in their 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. Switching law firm is thus costly. 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.[14] Given the high level of specialization, often teams of IP

[14] Along with passing the legal bar in a state, U.S. patent attorneys must pass a United States Patent and Trademark Office (USPTO) exam 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 strong scientific and engineering backgrounds, which include either an undergraduate and/or graduate degree in a scientific or engineering discipline and discipline-specific work experience. For instance, 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.

attorneys are deployed to deliver services to their clients. Further, 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 still highly relevant. To the extent that the mobile IP attorneys cannot easily replicate all services of the 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.

According to our informal interviews with a patent attorney at a top IP law firm, 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. The high level of efficiency can reduce billable hours and generate significant cost savings for the client. Based on these interviews, it could take a new law firm one or two years of experience to become proficient in its client's technologies. 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 bypass some of the unobserved firm attributes that correlate with absolute levels of litigation ability and with firm's expansion 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.[15] 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 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.

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

[15] 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 U.S. 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 2nd 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 U.S. in 2007 according to the *National Law Journal* 2007 law firm ranking. WolfBlock LLP was the 149th largest law firm in the U.S. prior to its failure, according to the *National Law Journal* 2008 law firm ranking.

law firm to file an IP lawsuit within five years of the law firm's failure date. We further constrain the set of clients to ones that used the law firm for most of their lawsuits during the five-year period. 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, we select firms that have patented in the prior five-years, have litigated a patent in the prior five-years, and belong to the same four-digit SIC industry classification as one of the treated firms. We constrain the sample range to one year before the first law firm exit and one year after the last exit. This results in 2,976 firm-year observations 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 technology classes in which the firm has not filed for patents during the prior five years. To rule out extraneous domains into which the firm is unlikely to expand, we constrain the classes to ones that fall within a technology subcategory in which the firm has patented in the prior five years. In total, the unbalanced panel has 389,138 observations.

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 3-digit technology class.[16] 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 five 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 Domains*) that equals 1 if the firm *i* entered class *j* in year *t* and is 0 otherwise.

Independent Variables

[16] See the USPTO website for details: https://www.uspto.gov/web/patents/classification/

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, *Litigiousness*, measures the extent to which non-focal incumbent firms in the focal technology class *j* utilize IP lawsuits as a strategic mechanism. We consider a non-focal firm as an incumbent in class *j* if it filed a successful patent application in the class during the prior five years. A non-focal incumbent is coded as being 'litigious' if it filed a higher than the firm-level average number patent lawsuits in the prior five years. *Litigiousness* is measured as the proportion of non-focal incumbents in class *j* in year *t* that are 'litigious.'

The second contingency variable, *Inventor Redeployability,* captures the ease with which the firm can redeploy its inventors who are active in other technology classes to the focal class *j*. For each non-focal technology class *k* in which firm i had a patent filing within the past five years (where $k \neq j$), we identify all inventors (including inventors outside the focal firm) with at least three patents in the prior ten years. Next, to get a sense of how re-deployable inventors typically are from non-focal class *k* to focal class *j*, i.e. 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 third contingency variable, *Inventor Mobility,* captures the extent to which inventors within a domain tend to move across firms. For each class *j* in year *t*, we identify all inventors with at least three patents over the prior ten years that have patented in *j*.[17] Within this list of inventors, we code an inventor as having switched if she had been listed in more than one firm across patent filings.

[17] We restrict the pool of inventors to ones with at least three patents so that we might observe switching. The results are similar if we raise the threshold to five patents. Measuring mobility using patent data may induce bias as only more productive inventors are observed to move. In our analysis, we use the mobility of productive inventors as a proxy to gauge heterogeneity in mobility *across* technological domains. We do not intend to measure an average level of mobility within a domain or at the individual inventor level. Consequently, the concerns about the measurement bias should not apply to our empirical design.

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.

The fourth contingency variable, *Inventor Specialization*, measures the extent to which inventors within a technological domain are specializing in that domain. For each inventor who patented in class *j* in year *t,* we calculate the proportion of her total patents that are filed in class *j* prior to year *t*.[18] *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*.

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 five 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 five years. To factor in weights for investments across classes, we calculate a concentration ratio of the firm's patents across these classes.[19] 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[20] (*ln(Revenues)*) and firm profitability using earnings before interest and taxes divided by total revenues *(Operating Margin)*. 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

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[18] We use the historical data beginning in 1901.
[19] The concentration ratio or Herfindahl–Hirschman Index is calculated for each five-year period as
$\sum_{k=1}^{K}\left(\frac{total\ patents\ for\ firm\ i\ in\ tech\ class\ k}{total\ patents\ for\ firm\ i}\right)^2$. *Scope* is 1 minus this ratio.
[20] Revenue is in millions of U.S. dollars.

past five years (Hall et al. 2001). These 36 two-digit technological subcategories represent a higher order aggregation of the 400 USPTO technology classes.

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 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 a statistically significant (p-value < 0.05) correlation with *New Domains* (-0.11) and *IP Lawsuits* (-0.08).

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 is a viable shock to 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. The average number of lawsuits falls from 0.84 in the year prior to the shock to 0.51 in the year of the shock. The graph also corroborates anecdotal evidence that suggests that the length of the shock lasts approximately one year; the number of lawsuit filings returns to the pre-shock level (0.92) in the year following the shock.

To more closely examine the effect of law firm exit, we analyze the count of patent lawsuits the firm files per year (*IP Lawsuits*) through a set of regression analyses. We start with a simple generalized difference-in-difference approach in which we include a group dummy (*Treated Firm*) that takes the value of 1 if the firm uses a failed law firm (and zero otherwise), year fixed effects that account for the time effect, *Law Firm Exit*, and controls. 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 percent (coefficient -0.561, p-value 0.021). Next, we account for heterogeneity across exiting law firms by including a group dummies at the law firm level instead of a single treated dummy.[21] We find similar results (Model 2: -0.562, p-value 0.029).

Unobservable firm-level factors could influence litigation rates and undermine our ability to draw inferences from the difference-in-difference analysis. To address the issue, we analyze the effect of *Law Firm Exit* on *IP Lawsuits* using a firm-level Quasi-maximum Likelihood Fixed Effect Poisson model with robust standard errors (Wooldridge, 1999).[22] Inspecting our firm-level control variables, we find that all have enough variation to be included in the model.[23] We display the results in Model 3. We find a 69 percent decline (p-value 0.003) in *IP Lawsuits* when the firm's law firm exits. When the magnitude of the coefficient is large, it can be more accurate to calculate the incident rate ratio (the exponential of the coefficient) rather than interpret the coefficient as a semi-elasticity. Doing so, we find that the incident rate ratio is 50 percent (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.

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 expanding 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-

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21 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.

22 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.

23 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.

value 0.059). 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-value 0.013). To account for unobserved 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-value 0.008). To rule out the possibility that the inclusion of many control firms inflates our estimates, we rerun the analysis using only the treated firms (i.e. ones that used a failed law firm). Using a negative binomial regression model, we find a 63 percent drop in expansion (p-vale 0.023, see Model 3). Applying firm fixed effects in Model 4, we find a 57 percent drop (p-value 0.010). Overall, our findings strongly support Hypothesis 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* significantly decreases the likelihood of expansion by 37% (p-value 0.047).

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, rather than its ability to litigate, because the exiting law firm was instrumental in its patent prosecution process, and what we observed as reduced expansion into new domains were drops in patent filings. 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 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 4, we find that *Law Firm Exit* reduces new patent filings by 29.6% in the year (p-value 0.000). This suggests that there is not a simple mechanical effect in which patenting (thus our measure of expansions) falls to zero because the firm is 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 accounts. 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. Therefore, we estimate that at least half of the decline in patenting in the year stems from the decline in new technological domains.

Test of Contingency Hypotheses

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 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 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 percent). Although several variables have moderately high correlations (*Inventor Redeployability* 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.[24]

Testing contingency hypotheses in linear models typically involves interacting the main variable with the contingency variable and interpreting the coefficient on the interaction term. 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

[24] 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 particular variable is not a likely source of multicollinearity (Judge et al. 1985).

be easily deduced, nor can an odds-ratio be interpreted (Ai and 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)[25] of *Law Firm Exit* across the two models using Welch's *t*-test (Penner-Hahn and Shaver, 2005; Toh and Miller, 2017).

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 Hypothesis 2 by splitting the sample by low and high *Litigiousness* and comparing the average partial effect of *Law Firm Exit* across the two models. *Law Firm Exit* has no significant effect on the likelihood a firm will enter a domain when the incumbents are not litigious (Model 1: -0.0002, p-value 0.933), but a negative and significant effect when the incumbents are litigious (Model 2: -0.006, p-value 0.002). Although the effect size in Model 2 may seem small, the unconditional entry probability of expansion in the high *Inventor Specialization* sample is only 0.006. The result in Model 2 suggests that a *Law Firm Exit* reduces the likelihood by approximately 100 percent in the high *Litigiousness* subsample

To test Hypothesis 2, we compare the two APEs (high *Litigiousness* sample from Model 2 minus the low *Litigiousness* sample from Model 1) and find a negative and significant effect that supports Hypothesis 2 (-0.006, p-value 0.047). The result suggests that moving from low to high *Litigiousness* reduces the likelihood of the firm expanding into class *j* by 0.6 percentage points, which is sizable given the unconditional entry rate is only 0.6 percent.

To test Hypothesis 3a, we split the sample by high and low *Inventor Redeployability*. We find a significantly negative effect of *Law Firm Exit* in the low *Inventor Redeployability* subsample (Model 3: -0.006, p-value 0.004) and an insignificant effect in the high *Inventor Redeployability* subsample (Model 4: 0.003, p-value 0.465). This suggests that the less the firm can redeploy its existing inventors into a new

[25] 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 *k*th variable using the following formula: $\overline{f(x'\beta)}\,\beta_k$, where $f(.)$ denotes the logit probability density function.

domain, the more that a reduction in its litigation ability will decrease its likelihood of expanding into the domain. The cross-sample test provides formal support for Hypothesis 3a (0.009, p-value 0.037).

To test Hypothesis 3b, we split the sample by low and high *Inventor Mobility*. *Law Firm Exit* has a negative and significant effect in the low *Inventor Mobility* sample (Model 5: -0.007, p-value 0.006), but a positive and insignificant effect in the high *Inventor Mobility* sample (Model 6: 0.002, p-value 0.543). Comparing the APEs across the high and low samples, we find a positive and significant difference (0.009, p-value 0.035), which supports Hypothesis 3b.

We similarly test Hypothesis 3c. In the low *Inventor Specialization* sample, we find a positive and insignificant effect of *Law Firm Exit* on *New Domain* (Model 7: 0.001, p-value 0.717). In the high *Inventor Specialization* sample, we find a negative and significant effect of *Law Firm Exit* (Model 8: -0.006, p-value 0.024). We then compare the two APEs (high sample minus low sample) and find a negative and significant effect (-0.007, p-value 0.041), which supports Hypothesis 3c.

Fixed Effect Logit Models

Estimates from the previous pooled logit analysis may be inconsistent if unobservable firm-level factors drive both the firm's decision to expand and other firm-level decisions, such as R&D spending or choice of technological scope. To address this issue, 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, which we display in Table 6 (Kitazawa, 2012).[26]

In testing Hypothesis 2, we find an insignificant effect of *Law Firm Exit* when *Litigiousness* is low (Model 1: -0.154, p-value 0.524) and a significant negative effect when it is high (Model 2: -1.054, p-value 0.028). The effect size in Model 2 suggests that the likelihood of expanding into class *j* drops

[26]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) shows 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 percent. If the unconditional probability of success is 50 percent, then a 10 percent increase is equivalent to a 5 percentage point increase.

by about 100 percent when the firm's law firm exits. Comparing the differences in the semi-elasticities, we find weak statistical support for Hypothesis 2 (-0.900, p-value 0.08).

We test Hypotheses 3a-3c in similar fashion. We find a negative and statistically significant effect of *Law Firm Exit* on the likelihood of entry in the low *Inventor Redeployability* (Model 3)*,* the low *Inventor Mobility* (Model 5), and the high *Inventor Specialization* (Model 8) subsamples. In all three 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 3a (p-value 0.024), Hypothesis 3b (p-value 0.02), and Hypothesis 3c (p-value 0.05). Overall, evidence presented in Table 6 supports our predictions.

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.[27] 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 strong and significantly negative effect of *Law Firm Exit* in the low *Inventor Mobility Ratio* subsample (semi-elasticity -206 percent, p-value 0.048) and a negative and insignificant effect in the high *Inventor Mobility Ratio* subsample (semi-elasticity -22.7 percent, p-value 0.224). Comparing the estimates, we find support for Hypothesis 3b using *Inventor Mobility Ratio* at the 10 percent level (p-value 0.095). The rest of the findings are like the ones in Table 6.

Second, 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 firm and year

[27] 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.

fixed effects because the shock only affects some industries in a given year. To address such unobserved factors that vary across time and across industry, we retest our contingency hypotheses using a conditional logit model with industry-year fixed effects. We report the results in Table 8. The magnitude of the contingency effects are like those in Table 7. We find support at the 5 percent level for all four contingency hypotheses.

Additional Analyses

In this section, we provide additional analysis of Hypothesis 1. In earlier tests, 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 overall technological scope of the firm. A firm that makes a large change in its technological scope may be more exposed than a firm that expands into a domain by filing only one single patent. 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.[28] Since 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 average partial effect, we find *Law Firm Exit* reduces scope by -0.01 (p-value 0.011). The results support Hypothesis 1.

Litigation ability may be more relevant in determining expansion for some firms than others. In earlier tests, by including only a dummy variable indicating a reduction in litigation ability, we may underestimate the influence that litigation ability has on firms' expansion decisions. To address the concern, 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.

[28] 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.

Estimating the control function via Generalized Method of Moments (Wooldridge, 2010) we find a negative and significant effect of the residual (-1.53, p-value 0.023) and a positive and significant effect of *IP Lawsuits* (1.63, p-value 0.025, 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.

We assume that law firm exits are exogenous in respect to client firm performance. To rule out the possibility that client firm performance drove law firm exit, we use the sample of client firms and regress an indicator variable of their law firm exit on year dummies, and several important client firm performance and innovation measures—*ln(Revenues)*, *Operating Margin*, *R&D*, *Patent Total 5-yr*, and *Scope*. Using a (firm) fixed effect logit we find no statistically significant effect for any variable. Contrary to the expectation that client firm performance drove law firm exit, we find positive coefficients for *ln(Revenues)*, *Operating Margin*, and *R&D*.

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-fixed Poisson effect 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 0.40 as compared to our estimated coefficient of *Law Firm Exit* of -0.569 and p-value of 0.01. Our estimated effect of *Law Firm Exit* is more negative than approximately 98 percent of the simulated placebo estimates. These results are consistent with hypothesis 1.

Discussion

We set out to investigate the effect of a firm's IP litigation ability on the technological expansion 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 expand 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 accessing the new knowledge. Specifically, we propose that the effect of litigation ability on the decision to expand will be stronger when the expansion will lead to encountering litigious competitors, when it is harder for the firm to redeploy its existing inventors into the new technological domain, when the domain has fewer mobile inventors, or when the technological domain requires specialized 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 access new knowledge as it expands technologically, we are doing more than just adding another antecedent to the firm's technological expansion and growth (Penrose, 1959; Levinthal and Wu, 2010). 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 fungible resources that it can apply and embed within new products in a new technological space (Helfat and Raubitschek, 2000; Sakhartov and Folta, 2014). Such resources often drive the value creation in technological expansion and constitute a theoretical basis for firm growth and scope. While not challenging this established notion, we highlight the challenges associated with the synergistic value creation in the new domain. The firm often needs to engage in recombination between the existing and new knowledge to achieve the synergies (Galunic and Rodan, 1998; Ahuja and Katila, 2001). The barriers to access of the new knowledge then constitute pertinent constraints in the firm's 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 growth and innovation.

Second, this study attempts to bridge the IP literature and the theory of firms' technological growth. The IP literature has laid out the antecedents, dynamics 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 (Somaya, 2003; Agarwal et al., 2009; Clarkson and Toh, 2010). 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, but could serve a more significant purpose in the firm's major strategic decisions such as those related to technological growth. Further, 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, the contingencies that we identified further research on inventor mobility and human capital (Wezel et al., 2006; Song et al., 2003; Agarwal et al., 2004). 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 and 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 (Coff, 1997; Campbell et al., 2012). We focus on the mirror perspective of the IP management challenges associated with the inflows. Further, the past studies that studied the inflows by adopting the perspective of a firm acquiring human capital (e.g., Rosenkopf and Almeida, 2003; Somaya et al., 2008; Agrawal et al., 2010) 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.

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 identification strategy.

First, the available data does 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.

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 one 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 shocks at the state level (e.g., Younge, Tong and Fleming, 2015). Our shock occurs close to the phenomenon under study – i.e., the IP law firm exits directly affect the litigation ability of treated firms. When the shocks are more distant from the examined phenomenon, the potential for confounding increases. However, it would be useful to examine the effects of changes in the IP litigation ability using different empirical strategies.

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. Since 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.

Conclusion

When companies expand technologically, they often need to acquire resources that are 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 expand 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 intellectual property and employee mobility.

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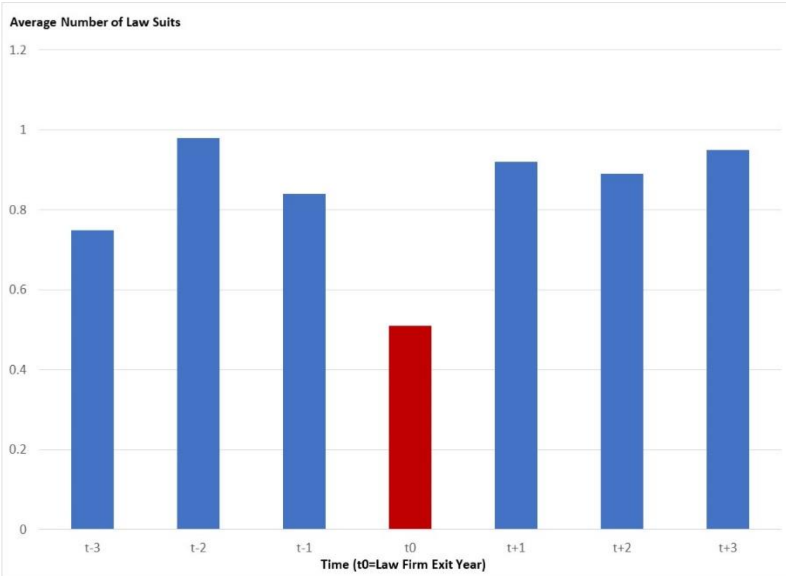
Table 1 Law firm exits used in the sample

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 *et al.*, 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 payed 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 *et al.*, 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-Cader, 2010; Garvy, 2015
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

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 *t0*.

Table 2 Descriptive statistics and correlations

Panel A. Descriptive Statistics for Firm-Year Sample

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

Sample size equal to 2,976

Panel B. Descriptive Statistics for Firm-Year-Technology Class Sample

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

Sample size equals 389,138.

Table 3 Effect of law firm exit on IP lawsuits

	(1)	(2)	(3)
Method:	Negative Binomial	Negative Binomial	Fixed Effect Poisson
Law Firm Exit$_t$	-0.561	-0.562	-0.690
	(0.021)	(0.029)	(0.003)
Patent Total (5-yr)$_{t-1}$ (000)	-0.012	-0.024	-0.001
	(0.669)	(0.386)	(0.975)
Scope (5-yr)$_{t-1}$	0.194	0.143	0.712
	(0.525)	(0.644)	(0.132)
R&D$_t$ (000)	0.184	0.177	0.0690
	(0.000)	(0.000)	(0.082)
ln(Revenue)$_t$	0.071	0.079	0.150
	(0.098)	(0.067)	(0.401)
Operating Margin$_t$	0.122	0.125	0.021
	(0.036)	(0.029)	(0.789)
Treated Firm Dummy	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

Dependent variable: IP Lawsuits filed in a year. Treated Firm: the firm that 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.

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

	(1)	(2)	(3)	(4)	(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$_t$	-0.424	-0.562	-0.495	-0.631	-0.569
	(0.059)	(0.013)	(0.008)	(0.023)	(0.010)
Patent Total (5-yr)$_{t-1}$ (000)	-0.031	-0.033	0.0269	-0.187	-0.008
	(0.645)	(0.337)	(0.808)	(0.058)	(0.890)
Scope (5-yr)$_{t-1}$	0.927	0.971	-2.620	0.433	5.920
	(0.002)	(0.002)	(0.005)	(0.834)	(0.008)
R&D$_t$ (000)	-0.073	-0.075	0.0994	0.339	2.164
	(0.097)	(0.107)	(0.156)	(0.109)	(0.000)
ln(Revenue)$_t$	0.135	0.133	-0.064	-0.085	-1.433
	(0.000)	(0.000)	(0.728)	(0.773)	(0.007)
Operating Margin$_t$	-0.001	-0.001	-0.005	1.524	-1.923
	(0.131)	(0.127)	(0.056)	(0.096)	(0.028)
Treated Firm Dummy	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

Dependent variable: New Domains. Treated Firm: the firm that 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.

Table 5 Contingency hypothesis tests: Pooled logit models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample:	Low Litigiousness	High Litigiousness	Low Inventor Redeployability	High Inventor Redeployability	Low Inventor Mobility	High Inventor Mobility	Low Inventor Specialization	High Inventor Specialization
Law Firm Exit$_t$	-0.0002	-0.006	-0.006	0.003	-0.007	0.002	0.001	-0.006
	(0.933)	(0.002)	(0.004)	(0.465)	(0.006)	(0.543)	(0.717)	(0.024)
High Sample Estimate - Low Sample Estimate Welch's t-test (p-value)	*-0.006*		*0.009*		*0.009*		*-0.007*	
	(0.047)		*(0.037)*		*(0.035)*		*(0.041)*	
Litigiousness$_{t-1}$ (%)	0.000	-0.0001	0.000	-0.0002	0.0000	-0.0002	-0.00004	-0.00002
	(0.000)	(0.000)	(0.202)	(0.002)	(0.514)	(0.001)	(0.003)	(0.127)
Inventor Redeployability$_{t-1}$ (%)	0.002	0.002	0.022	0.003	0.004	0.003	0.003	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility$_{t-1}$ (000)	0.001	0.002	-0.005	-0.001	0.008	-0.0004	0.0002	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.048)	(0.267)	(0.000)
Inventor Specialization$_{t-1}$ (%)	0.000	0.000	0.000	0.0000	0.0000	0.0001	0.0003	-0.0002
	(0.451)	(0.533)	(0.281)	(0.692)	(0.239)	(0.721)	(0.000)	(0.000)
Patent Total (5-yr)$_{t-1}$ (000)	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.001
	(0.001)	(0.007)	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.016)
Scope (5-yr)$_{t-1}$	0.031	0.020	0.022	0.049	0.018	0.048	0.030	0.022
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R&D$_t$ (000)	-0.002	-0.001	0.000	-0.003	-0.001	-0.002	-0.002	-0.001
	(0.001)	(0.157)	(0.138)	(0.000)	(0.062)	(0.004)	(0.000)	(0.166)
ln(Revenue)$_t$	0.003	0.003	0.002	0.007	0.002	0.005	0.003	0.002
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Operating Margin$_t$	0.000	0.000	0.004	0.000	0.005	0.000	-0.00003	0.000
	(0.674)	(0.000)	(0.096)	(0.000)	(0.072)	(0.000)	(0.000)	(0.948)
Year Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Technology Subcategory Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Industry Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Observations	188,242	159,286	254,413	87,465	241,069	103,085	163,645	182,706
Pseudo R-Square	0.16	0.18	0.20	0.15	0.19	0.14	0.18	0.14

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.

Table 6 Contingency hypothesis tests: Firm-level fixed effect logit models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample:	Low Litigiousness	High Litigiousness	Low Inventor Redeployability	High Inventor Redeployability	Low Inventor Mobility	High Inventor Mobility	Low Inventor Specialization	High Inventor Specialization
Law Firm Exit$_t$	-0.154	-1.054	-1.370	-0.083	-1.355	-0.026	-0.043	-0.982
	(0.524)	(0.028)	(0.009)	(0.730)	(0.009)	(0.913)	(0.861)	(0.017)
High Sample Estimate - Low Sample Estimate Welch's t-test (p-value)	*-0.900*		*1.290*		*1.329*		*-0.939*	
	(0.080)		*(0.024)*		*(0.020)*		*(0.050)*	
Litigiousness$_{t-1}$ (%)	0.044	-0.019	0.002	-0.014	0.001	-0.017	-0.005	-0.002
	(0.000)	(0.000)	(0.346)	(0.003)	(0.669)	(0.000)	(0.010)	(0.306)
Inventor Redeployability$_{t-1}$ (%)	0.427	0.761	4.913	0.321	1.829	0.381	0.530	0.500
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility$_{t-1}$ (000)	-0.041	0.206	-1.154	-0.149	0.956	-0.114	-0.095	-0.002
	(0.016)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.955)
Inventor Specialization$_{t-1}$ (%)	-0.001	0.003	-0.003	-0.001	-0.004	0.003	0.032	-0.034
	(0.647)	(0.493)	(0.348)	(0.845)	(0.306)	(0.380)	(0.000)	(0.000)
Patent Total (5-yr)$_{t-1}$ (000)	0.026	0.119	0.079	0.082	0.060	0.100	0.163	-0.025
	(0.610)	(0.035)	(0.105)	(0.190)	(0.230)	(0.086)	(0.004)	(0.618)
Scope (5-yr)$_{t-1}$	-1.021	-4.525	-5.666	-0.745	-2.165	-0.465	-0.772	-3.027
	(0.355)	(0.028)	(0.029)	(0.465)	(0.307)	(0.652)	(0.573)	(0.035)
R&D$_t$ (000)	0.137	0.094	0.092	0.110	0.086	0.191	0.077	0.183
	(0.079)	(0.260)	(0.305)	(0.151)	(0.333)	(0.012)	(0.341)	(0.027)
ln(Revenue)$_t$	-0.342	0.447	0.426	-0.237	0.256	-0.328	-0.081	-0.184
	(0.063)	(0.125)	(0.142)	(0.183)	(0.369)	(0.070)	(0.691)	(0.452)
Operating Margin$_t$	-0.148	-0.017	0.177	0.004	0.902	0.007	-0.219	-0.191
	(0.389)	(0.672)	(0.801)	(0.572)	(0.217)	(0.319)	(0.622)	(0.205)
Year Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Technology Subcategory Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Observations	167,468	128,878	205,776	75,535	202,226	88,394	146,583	161,003
Pseudo R-Square	0.16	0.17	0.16	0.14	0.16	0.13	0.19	0.14

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.

Table 7 Contingency hypothesis tests: Firm-level fixed effect logit models using Inventor Redeployability Ratio

Sample:	(1) Low Litigiousness	(2) High Litigiousness	(3) Low Inventor Redeployability Ratio	(4) High Inventor Redeployability Ratio	(5) Low Inventor Mobility	(6) High Inventor Mobility	(7) Low Inventor Specialization	(8) High Inventor Specialization
Law Firm Exit$_t$	-0.154	-1.037	-1.371	0.082	-2.026	-0.277	-0.037	-0.982
	(0.526)	(0.030)	(0.009)	(0.732)	(0.048)	(0.224)	(0.884)	(0.017)
High Sample Estimate - Low Sample Estimate Welch's t-test (p-value)	*-0.890*		*1.453*		*1.756*		*-0.945*	
	(0.091)		*(0.011)*		*(0.095)*		*(0.049)*	
Litigiousness$_{t-1}$ (%)	0.043	-0.021	0.003	-0.003	0.002	-0.011	-0.003	-0.003
	(0.000)	(0.000)	(0.105)	(0.561)	(0.559)	(0.000)	(0.102)	(0.189)
Inventor Redeployability$_{t-1}$ (%)	0.392	0.854	3.326	0.247	0.480	0.371	0.452	0.489
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility Ratio$_{t-1}$ (%)	0.012	0.011	0.010	-0.004	-0.008	-0.013	0.005	0.018
	(0.006)	(0.014)	(0.003)	(0.588)	(0.000)	(0.025)	(0.140)	(0.000)
Inventor Specialization$_{t-1}$ (%)	0.002	0.006	0.000	-0.001	-0.008	-0.004	0.029	-0.031
	(0.595)	(0.190)	(0.943)	(0.807)	(0.218)	(0.209)	(0.000)	(0.000)
Patent Total (5-yr)$_{t-1}$ (000)	0.027	0.120	0.081	0.076	0.056	0.059	0.165	-0.025
	(0.598)	(0.034)	(0.098)	(0.225)	(0.397)	(0.241)	(0.004)	(0.612)
Scope (5-yr)$_{t-1}$	-1.201	-4.541	-5.762	-1.160	-1.598	-1.541	-1.073	-3.045
	(0.273)	(0.031)	(0.027)	(0.250)	(0.378)	(0.187)	(0.431)	(0.035)
R&D$_t$ (000)	0.136	0.095	0.096	0.108	0.175	0.160	0.076	0.182
	(0.081)	(0.254)	(0.285)	(0.160)	(0.189)	(0.015)	(0.347)	(0.028)
ln(Revenue)$_t$	-0.344	0.421	0.414	-0.228	-0.129	-0.234	-0.079	-0.183
	(0.061)	(0.150)	(0.155)	(0.195)	(0.717)	(0.180)	(0.698)	(0.453)
Operating Margin$_t$	-0.139	-0.017	0.207	0.002	-0.201	0.007	-0.198	-0.187
	(0.419)	(0.676)	(0.770)	(0.744)	(0.813)	(0.311)	(0.655)	(0.213)
Year Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Technology Subcategory Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Observations	167,723	128,878	205,776	75,535	136,064	167,421	146,583	161,003

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.

Table 8 Contingency hypothesis tests: Industry-Year fixed effect logit models

Sample:	(1) Low Litigiousness	(2) High Litigiousness	(3) Low Inventor Redeployability	(4) High Inventor Redeployability	(5) Low Inventor Mobility	(6) High Inventor Mobility	(7) Low Inventor Specialization	(8) High Inventor Specialization
Law Firm Exit$_t$	-0.109	-1.100	-1.522	0.076	-1.557	0.087	0.000	-1.013
	(0.607)	(0.015)	(0.003)	(0.716)	(0.002)	(0.420)	(0.999)	(0.008)
High Sample Estimate - Low Sample Estimate Welch's t-test (p-value)	*-0.991*		*1.596*		*1.64*		*-1.012*	
	(0.046)		*(0.003)*		*(0.002)*		*(0.021)*	
Litigiousness$_{t-1}$ (%)	0.043	-0.022	0.002	-0.031	0.0001	-0.018	-0.004	-0.004
	(0.000)	(0.000)	(0.280)	(0.000)	(0.656)	(0.000)	(0.007)	(0.041)
Inventor Redeployability$_{t-1}$ (%)	0.163	0.238	4.27	-0.142	0.549	0.164	0.231	0.147
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Mobility$_{t-1}$ (000)	0.109	0.528	-0.670	-0.039	2.080	-0.013	0.113	0.182
	(0.000)	(0.000)	(0.000)	(0.009)	(0.000)	(0.395)	(0.000)	(0.000)
Inventor Specialization$_{t-1}$ (%)	-0.008	0.000	0.001	-0.021	-0.003	-0.038	0.029	-0.041
	(0.004)	(0.931)	(0.717)	(0.000)	(0.347)	(0.000)	(0.000)	(0.000)
Patent Total (5-yr)$_{t-1}$ (000)	0.026	0.368	0.390	0.292	0.367	0.257	0.287	0.302
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Scope (5-yr)$_{t-1}$	3.835	4.295	6.729	3.217	5.08	3,643	4.413	3.870
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R&D$_t$ (000)	-0.276	-0.179	-0.191	-0.269	-0.212	-0.248	-0.286	-0.189
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(Revenue)$_t$	0.130	0.154	0.38	0.173	0.064	0.173	0.187	0.067
	(0.000)	(0.001)	(0.479)	(0.000)	(0.204)	(0.000)	(0.000)	(0.081)
Operating Margin$_t$	0.121	-0.006	1.21	-0.002	1.354	-0.002	-0.002	0.089
	(0.255)	(0.004)	(0.003)	(0.087)	(0.001)	(0.082)	(0.030)	(0.408)
Technology Subcategory Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Observations	197,986	175,580	274,236	93,460	261,078	109,398	174,882	198,169
Pseudo R-Square	0.12	0.12	0.12	0,09	0.1	0.09	0.15	0.1

Dependent variable is New Domain (0/1). Models include fixed effects at the industry-year level. Semi-elasticities shown. P-values calculated from robust standard errors that account for within firm clustering shown in parentheses.