Corporate innovation linkages and firm boundaries

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Abstract

Innovation matters for firm boundaries. Companies are more likely to integrate with peers with connected innovation. In this paper, I study how follow-on innovation determines the degree of integration between firms. I construct a measure of relative innovation proximity between firms, based on patent citations. I find companies are more likely to acquire peers with closer follow-on innovation, rather than build strategic alliances with them or license/buy their patents. Furthermore, the measure of relative innovation proximity between firms reflects firms' bargaining power and not the size of the synergies. In M&A transactions, a bidder with closer follow-on innovation pays a greater premium and exhibits lower announcement returns. On the other hand, in strategic alliance, a firm with closer follow-on innovation experiences greater announcement returns. These results are consistent with a hold-up model in which companies bargain over the type and terms of the contract.

JEL codes: C70; G34; L24; O33.

Keywords: Bargaining power; Firm boundaries; Industrial Organization; Innovation; Patents.

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"The nature of the business is that the revenues are dependent on patent protections. That means at some point you face a decline in that revenue stream. The replacement has either got to come from your own labs or from outside."

— Drew Burch, head of healthcare M&A at Barclays

(*Financial Times*, 2012)

1 Introduction

How does innovation shape firm boundaries? In principle, firms can innovate in house, or in collaboration with other firms under a variety of strategies, including M&As, patent acquisition/licensing deals, and strategic alliances, or infringe on other firms' patents. Turnover in innovation is high – every year about 5% of active patents change owners. Economically, spending on innovation is significant. For example, Apple spent $16 billion on research and development in 2019. Along with in-house innovation, Apple obtained new knowledge through acquisitions (Intel's modem business), strategic alliances (IBM), and patent acquisition/licensing deals (Lighthouse AI).[1]

The firm's choice of innovation strategy depends on the costs and benefits of innovation ownership (Grossman and Hart (1986), Hart and Moore (1988, 1990)). Strategies that involve a lower degree of integration (e.g., licensing deals) are usually less costly, but the risks associated with the loss of competitive advantage are potentially high. Instead, a higher degree of integration typically reduces the holdup risks, but it requires heavy setup costs, and its coordination effectiveness is often dubious. The importance of innovation ownership is associated with inter-firm innovation linkages that reflect the spread and diffusion of innovation.

Inter-firm innovation linkages could affect firm boundaries in two ways. First, innovation linkages could create synergies that affect companies' willingness to integrate. Second, innovation linkages could give rise to holdup between firms, and thus relate to their bargaining power. Yet, the existing literature mainly focuses on analyzing organizational structures in isolation rather than examining the trade-offs between them. Analyzing the firms' choice of organizational structures is associated with at least two challenges. First, the choice depends on the firms' bargaining power, which is

[1] Apple to acquire the majority of Intel's smartphone modem business. *Apple's press release*. July 25, 2019; Is Apple Becoming The Next IBM? *Forbes*. July 1, 2019; Apple Acquires Lighthouse AI's Patent Portfolio in Possible Home Security Push. *Fortune*. March 5, 2019.

unobservable. Second, firms may operate strategically before the integration event. In this paper, I address these challenges and focus on the trade-off between organizational structures, by studying whether corporate innovation linkages explain M&As, licensing, and collaboration decisions and announcement returns.

To measure innovation proximity between firms, I use patent data that capture corporate innovation. Patents usually incorporate innovation from the patents they cite (Jaffe et al. (2000), Acemoglu et al. (2016)), so the original patent may block the follow-on innovation if bargaining failures prevent the efficient licensing of patented technologies between follow-on and original innovators. I construct a pairwise measure of firms' relative innovation proximity in three steps. First, I identify integration events such as M&As, strategic alliances, licensing deals, and patent-infringement lawsuits. For each event, I categorize firms into patent holder and patent seeker. The patent holder is the firm that owns the innovation of interest, and the patent seeker is the firm that seeks to obtain it. For example, in M&As, the patent holder is the target and the patent seeker is the bidder.[2] Second, for each firm-pair, I calculate patent-holder innovation proximity (how closely the patent holder's patents cite the patent seeker's patent portfolio) and patent-seeker innovation proximity (vice versa). Third, I calculate *patent-holder relative proximity*, by taking the difference between patent-holder and patent-seeker innovation proximities. *Patent-holder relative proximity* shows the extent to which the patent holder's patents depend more on the patent seeker's patents compared with the patent seeker's dependence on the patent holder's patents.

Overall, my results are consistent with the holdup theory. Closer follow-on innovation is associated with a greater dependence from peers, meaning the firm has weaker bargaining power. I find a larger patent-holder relative proximity is associated with a deeper degree of integration. Patent seekers are more likely to acquire peers with closer follow-on innovation than to enter strategic alliances or patent acquisition/licensing deals with them. On the other hand, patent seekers are more likely to license patents from peers with closely related original patents, or, alternatively, to infringe on their patents.

Next, I study whether corporate innovation linkages determine the integration gains, and their

[2]Likewise, in licensing deals, the patent holder is the assignor and the patent seeker is the assignee. In patent-infringement lawsuits, the patent holder is the plaintiff and the patent seeker is the infringer. To identify patent holders and seekers in strategic alliances, I use an approach similar to Robinson (2008). The patent seeker is the firm that operates in an industry different from the alliance industry, and the patent holder is the firm that operates in the same industry as the alliance.

split. By examining announcement returns of companies involved in the integration, I show patent-holder relative proximity has no impact on combined returns but only how the deal gains are split. In M&As with larger patent-holder relative proximity, the patent seeker (bidder) pays a smaller premium to the patent holder (target) and exhibits greater announcement returns. In particular, A one-standard-deviation increase in patent-holder relative proximity is associated with a $1.9 million smaller premium and 59.2 bps greater bidder announcement returns. The results also hold in relative dollar gains; a one-standard-deviation increase in patent-holder relative proximity, on average, leads to an additional $14.7 million loss for the patent holder.

In strategic alliances and licensing deals with larger patent-holder relative proximity, the patent seeker benefits more from the deal. In strategic alliances, a one-standard-deviation increase in patent-holder relative proximity translates into 41.5 bps lower patent-seeker announcement returns. Among licensing deals, the market reacts more positively when the patent holder licenses its patents to a peer with closely original innovation. This finding suggests the patent holder's follow-on innovation is valuable and that the patent seeker's position weakens. On the other hand, the market reacts less positively when the patent holder licenses its original patents, because it might create additional competition and the patent holder's competitive advantage might weaken. A one-standard-deviation increase in patent-holder relative proximity is associated with a 49 bps decrease in patent-seeker announcement returns and a 40.5 bps increase in patent-holder returns compared with their average returns.

In the post-deal period, I find no effect of corporate innovation linkages on the stock market performance for any integration type. This finding suggests all the gains associated with innovation connections are priced at the announcement date. I also do not find any evidence that patent-holder relative proximity explains the long-term profitability, which confirms my measure captures only the gains split.

I address two possible alternative explanations for my findings. First, the choice of corporate innovation strategy may also be correlated with industry concentration. Stronger competition may lead to more aggressive innovation strategies. I run several tests to check whether industry concentration also has an impact on my measure. I find no significant correlation between these two measures. Controlling for industry concentration, the results are almost identical to the baseline results. Second, companies located close to each other are more likely to integrate. To rule out the

possibility that patent-holder relative proximity simply captures geographic distance, I divide the sample by the median of geographic distance between firm headquarters. I find no difference in patent-holder relative proximity between two subsamples.

My results are robust to alternative measures of innovation. First, controlling for firms' innovation portfolio values (Hall et al. (2005), Kogan et al. (2017)), I find innovation connections to matter in the split of deal gains. Compared with the baseline results, the magnitude of the effect remains the same when I control for stock-market-weighted innovation output, whereas it increases by 26%, controlling for citation-weighted innovation output. Second, patents are not the only output of corporate research and development process. I identify other innovation measures (capital expenditure and the value of intangible capital (Ewens et al. (2020))) and control for them in my regressions; the magnitude of the effect of patent-holder relative proximity on the degree of integration remains unchanged.

I make three main contributions to the literature. First, my paper is related to the literature on innovation and corporate strategy. Innovation affects many aspects of corporate life. So far, the main focus of the literature has been to understand the optimal intensity and frequency of innovation (Aghion and Tirole (1994), Barker and Mueller (2002), Hall et al. (2010)) and whether to develop it in house or obtain it externally (Pisano (1990), David et al. (2000)). The innovation literature neglects the firm dynamics, whereas the corporate-strategy literature does not treat the organizational structure of R&D in detail. I connect these two strands of literature, by analyzing how the innovation proximity between firms affects their boundaries. I propose a new measure of the innovation proximity between firms based on patent citations. I show the asymmetry of innovation proximity between firms explains the degree of integration between firms.

Second, my paper contributes to the literature on firm boundaries. Theoretical studies construct incomplete contracting models that analyze how costs and benefits of asset ownership affect boundaries of the firm (Grossman and Hart (1986), Hart and Moore (1988, 1990), Fauli-Oller and Sandonis (2003), Anosova (2018)). Yet, most empirical studies mostly focus on individual organizational structures (M&As – Rhodes-Kropf and Robinson (2008), Phillips and Zhdanov (2013) and Hoberg and Phillips (2010, 2016); patent acquisition/licensing deals – Bowen (2016); collaboration/joint ventures – Gomes-Casseres et al. (2006), Lindsey (2008), Robinson (2008); patent infringement lawsuits – Reitzig and Wagner (2010); corporate ventures capital investments –

Ma (2020), customer-supplier relationship – Acemoglu et al. (2007), Cohen and Frazzini (2008)), Frésard et al. (2020). Adding to these studies, I focus on the firms' choice of integration strategies. I see the choice of integration as a continuum from no integration to full integration (Figure 1). I find that companies are more likely to acquire peers with closer follow-on innovation, and build strategic alliances with peers with original innovation or to buy/license their patents. To the best of my knowledge, my study is the first to empirically analyze how existing corporate innovation linkages affect the determinant of and the choice between M&A, strategic alliance, patent acquisition/licensing deal, and patent infringement.

Third, the paper contributes to the literature on M&As. Combining firms' innovation could create synergies. One strand of the M&A literature studies whether innovation linkages favor the post-merger innovation output (Ahuja and Katila (2001), Bena and Li (2014), Sevilir and Tian (2012), Sears and Hoetker (2014), Seru (2014)). Another strand of the M&A literature claims bidders with weaker bargaining power have to pay a greater premium, which is associated with additional costs for the bidders, and so they observe lower announcement returns (Lambrecht (2004), Gorton et al. (2009), Edmans et al. (2012), Anosova (2018)). However, testing this claim empirically is difficult, because bargaining power is unobservable. Ahern (2012) proxies for bargaining power using relative industry dependence based on the input-output matrix. He finds greater bargaining power is associated with larger relative gains in the vertical mergers. In this paper, I analyze corporate innovation linkages and propose a measure of bargaining power based on patents citations; this measure can be computed for any firm-pair with at least one patent. To validate my measure of bargaining power, I find my measure drives M&A gains split as opposed to value creation.

The rest of the paper is organized as follows. Section 2 lays down theoretical predictions, describes the details of data collection, and defines the measure of firms' innovation proximity. Section 3 examines how a firms' relative proximity affects firm boundaries. Section 4 presents the empirical results on firms' integration performance. Section 5 discusses possible alternative explanations and presents robustness checks. The final section concludes the paper.

2 Theory and data

This section lays out theoretical predictions, discusses the empirical approach, and defines a new measure of innovation proximity between firms. It also presents the data sources used in the

empirical analysis.

2.1 Theoretical framework and empirical approach

Firms' choice of innovation strategy can be seen as a continuum from no integration to full integration (Figure 1). The likelihood of firms' integration increases with the synergy effects. In principle, having connected innovation portfolios between two companies may improve their market power through two channels: (1) Operating in the same market, the buyer has enough experience to integrate the target's innovation (Bena and Li (2014)); and (2) if in the pre-deal period the potential buyer already uses the target's innovation, after the deal, she obtains exclusive rights for the acquired patents. Instead merging two different innovation portfolios may lead to a wider scope of future innovation. For example, by acquiring OraPharma Inc., a specialty pharmaceutical company, Johnson&Johnson was able to enter the new professional products market of oral-health products and create new therapies in that field. Measuring synergy effects at the firm level is difficult. Yhe M&A literature identifies some driven synergy forces such as product-market relatedness (Hoberg and Phillips (2010, 2016)), technological proximity, and technological overlap (Bena and Li (2014)).

Firms' choice of integration is associated with incomplete contracts, sunk costs, and opportunistic behavior (Galetovic and Haber (2017)). Switching from one technology to the other is costly for firms because business equipment could have difficulty adopting to new technologies. Opportunistic behavior and incomplete contracts can create room for renegotiation and thus possible appropriation of quasi-rent (Klein et al. (1978)). These all lead to a patent hold-up problem that consists of the hold-up (quasi-rent appropriation) and the technology monopoly (extraction of excessive royalties or block of follow-on innovation).

The holdup problem can appear in several ways. First, patent holders can extract excessive royalties because they have monopolistic access to the technology. Second, the holdup problem can be exacerbated if a firm relies on the innovation patented by multiple holders, so all of the patent holders are willing to extract excessive patent royalties. Third, the holdup problem is amplified when patented innovation is "essential" to respect an industry standard.[3] Fourth, patent holders often can extract larger royalties ex-post rather than ex-ante. Therefore, claiming royalties once the infringement takes place is more beneficial for the company.

[3]Standard-essential patents are patents that claim an invention that must be used to comply with an industry standard.

Once companies evaluate their synergy effects, they have to agree on the degree of integration and the split of synergy gains. Firms with greater bargaining power extract a larger share of total synergy gains. The source of bargaining power can be the relative size that is associated with the level of uncertainty of the merger outcome (Moeller et al. (2004), Alexandridis et al. (2013)). However, Schneider and Spalt (2019) show "size" should not be considered a proxy measure, because the size measure provides the opposite effects for the bidder announcement returns, depending on the sample selection. Apart from the size measure, other firms' bargaining power includes market-to-book values (Rhodes-Kropf and Robinson (2008)), and relative industry dependence based on the input-output matrix (Ahern (2012)).

Firms' bargaining power depends on how closely patent seekers depend on patent holder's patent portfolio. Suppose firm A's innovation is built on firm B's innovation, whereas firm B's innovation is not built on firm A's innovation portfolio. Firm B can block the use of firm A's innovation, because the use of firm A' innovation in isolation infringes on firm B's intellectual property right. In this case, the following two strategies are more likely to take place: (1) Firm A licenses the innovation from firm B or (2) firm B acquires firm A. Infringement would be very costly for firm A because firm B can easily prove infringement in court. Strategic alliance usually take place when two parties are equal players and both gain from their partnership without the threat of infringement.

My theoretical prediction can thus be summarized as follows::

- The likelihood of firms' integration increases with synergy effects.
- Asymmetry of innovation proximity between firms captures their bargaining power.
- Firm pairs with large asymmetry between firms' innovation proximity are more likely to choose between the licensing and M&A organizational structures.
- Firm pairs with small asymmetry between firms' innovation proximity are more likely to build strategic alliances or infringe on patents within its pair.

2.2 Measuring innovation proximity

To construct a relative measure of innovation proximity between two companies, I proceed in three steps.

First, I identify the patent seeker and holder in each deal. I define the patent seeker as the firm that obtains the innovation from the deal, and the patent holder as the firm that owns the innovation. The patent seeker is the bidder in M&As, the assignee in licensing deals, and the infringer in patent-infringement lawsuits. The patent holder is the target in M&As, the assignor in licensing deals, and the plaintiff in patent-infringement lawsuits. In strategic alliances, firms usually have equal status, so identifying the patent holder and patent seeker is challenging. To overcome this challenge, I follow Robinson (2008) and argue a firm that operates in an industry different from the alliance's industry seeks the expertise of the other firm. I call the patent holder the firm that operates in the same industry as the alliance, and the patent seeker is the firm that operates in an industry different from the alliance industry.

Second, I construct the firms' innovation dependence from the patent-holder and patent-seeker perspectives. Using Kogan et al. (2017) data, I build the innovation portfolio of each over time. A firm's patent portfolio includes all of the firm's patents filed before the deal announcement.[4] Using patent citations, I build direct and indirect patent connections between the patent portfolios of the patent holder and the patent seeker. I use two notions of patent citations: direction and degree. A directed link (X, Y) means patent X cites patent Y, but patent Y does not cite patent X. In other words, patent X is directly (first-degree) connected to patent Y. In my analysis, I exploit both direct and indirect connections (each patent cites some patents that in turn cite other patents). For example, if patent Z cites patent X, we can say patent Z is second-degree connected to patent Y. Suppose the patent holder has K patents and the patent seeker has N patents. From the patent seeker's perspective, define:

$$\textit{Patent-seeker proximity} = \frac{1}{K}\sum_{k=1}^{K}(5 - \textit{Connection degree}_{k,N}), \tag{1}$$

where $\textit{Connection degree}_{k,N}$ is the closest degree of citation of the patent seeker's patent k to any patent assigned to the patent holder before the deal announcement. First-degree connections (direct citations) have a score of 1; second-, third-, and fourth-degree connections have a score of 2, 3, and 4, respectively. Higher-degree connections are assigned a score of 5.[5] From the patent holder's

[4] I consider all of the firm's patents filed not prior to 20 years before the deal announcement, which is the maximum duration of the patent protection. Patents filed and granted before June 8, 1995, have a protection period for a maximum of 17 years from the issued date. Patents filed before June 8, 1995, but not approved until after June 8, 1995, are valid for the greater of 20 years from the filing date or 17 years from the grant date.

[5] Fifth- and higher-degree patents are mostly expired because patent's protection lasts a maximum 20 years from

perspective, define:

$$Patent\text{-}holder \quad proximity = \frac{1}{N}\sum_{n=1}^{N}(5 - Connection \quad degree_{n,K}). \tag{2}$$

Third, I compute the patent-holder relative proximity as the difference between patent-holder proximity and patent-seeker proximity:

$$Patent\text{-}holder \quad relative \quad proximity = \frac{Patent\text{-}holder \quad proximity - Patent\text{-}seeker \quad proximity}{8} + 0.5, \tag{3}$$

Patent-holder relative proximity ranges from 0 (none of the patent holder's patents cite the patent seeker's patent portfolio, and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (vice versa). Patent-holder relative proximity equals 0.5 when the patent-holder and patent-seeker proximity measures are equal.

2.3 Data

I merge data from a number of sources.

I identify completed mergers and acquisitions, strategic alliances, patent acquisition/licensing deals, and patent-infringement lawsuits. I require firms involved in transactions to be US public companies whose stock return data are available on CRSP. Moreover, utilities (SIC codes $4000-4999$) and financial firms (SIC codes $6000-6999$) are excluded.

The sample of M&A transactions comes from the SDC Platinum database. Buybacks are excluded from the sample. I restrict the sample to M&A transactions in which the bidder acquires at least 51% of the target's shares.

The US Patent and Trademark Office (USPTO) Patent Assignment dataset is the source for patent acquisition and licensing deals. This database contains all patent assignments reported to the USPTO from 1980 to 2017. It provides information on the changes of patent ownership, security agreements, patent acquisitions, licensing, inventor-employee assignment, and so on. To retrieve patent-acquisition and licensing deals, I adapt the strategies of Serrano (2010), Bowen (2016), and Ma (2020). In the case of multiple transaction dates, I consider the patent-acquisition/licensing-deal

the filing date and the time lag between the citing patent and the cited patent is, on average, 5.5 years. So these patents could be publicly used and will not have any difference in terms of connectedness.

announcement date to be the first date when the companies register a transaction in the USPTO. Multiple filings between the same parties filed on the same day are considered a single transaction.

I use SDC Platinum to assemble a sample of strategic alliance deals that spans from 1975 to 2010. I restrict the sample to strategic alliances that involve only two parties that operate in different two-digit SIC code industry; one firm operates in the same industry as the alliance.[6] I also exclude strategic alliances between different subsidiaries of the same company.

The sources of patent-infringement data are the Stanford NPE litigation database and Patent litigation docket reports data (Marco et al. (2017)). They include all patent-infringement lawsuits filed in US courts from 1985 to 2015. Parties can settle the dispute both in and out of court.

Next, I calculate my measure of firms' relative innovation proximity using the US patent database collected by Kogan et al. (2017) and available on Professor Noah Stoffman's website. It contains information about patents issued by USPTO from 1926 to 2010. I require both parties of an agreement to have at least one issued patent before their integration announcement.

The final sample consists of 932 M&A transactions, 2,479 patent acquisition and licensing agreements, 2,166 patent-infringement lawsuits, and 1,922 strategic alliances that span over the period from 1975 to 2010. 1975 is the first year when a deal meets all the criteria described above and 2010 is the last year when the Kogan et al. (2017) patent dataset is available.

I also include several additional variables as controls (all retrieved from SDC Platinum). Firm size is proxied by the natural logarithm of market equity. To measure profitability, I include operating income, scaled by book value of assets. I also control for leverage (ratio of debt to assets), and Tobin's Q. In the M&A sample, I also control for the relative deal size (transaction value, scaled by the bidder's market equity), means of payment, and deal attitude.

3 Innovation and firm boundaries

I study how corporate innovation linkages determine companies' innovation strategy. I examine what firm-pairs are more likely to integrate and how innovation linkages affect the probability of signing an agreement. I consider four main strategies to obtain external innovation (Figure 1): M&As, strategic alliances, patent acquisition or licensing agreements, and patent infringement.

To estimate the likelihood of firms' integration, I first need to identify placebo firm pairs.

[6] Otherwise, I am not able to distinguish between patent seeker and patent holder in a deal.

Potentially, I can calculate the innovation proximity between any pair of 7,545 companies over time. However, some firm pairs are very unlikely to integrate; so considering all firms' pairs is not the best counterfactual to the actual interaction between firms, because they might create additional noise. Therefore, I run a matching procedure to identify comparable potential pairs. I require a company to meet the following criteria in order to be a potential pair:

1. Its market value is 70%-130% of the actual firm's market value two months before the transaction announcement;

2. The company has at least one patent issued before the transaction;

3. The company operates in the same Fama-French 12 industry as the actual company.

I identify the top 10 closest potential firms for each company involved in an actual transaction, using 10-nearest-neighbors matching with no replacement. Then, I construct firm pairs; for each transaction, I have 120 potential firm pairs and 1 actual pair.[7]

I study how the average firms' proximity affects the likelihood of firms' integration. Panel A of Table 3 shows that a one-standard-deviation increase in average firm proximity doubles the probability of firms' integration compared with the average integration probability. Panel B reports the estimates for each type of integration separately. I compare the coefficients of average firm proximity between different types. I do not find any statistical difference, so I can conclude the average firm proximity predicts the likelihood of firms' integration but not the degree of integration.

Next, I look at the asymmetry of firms' proximity measured by patent-holder relative proximity. I start by conducting a univariate analysis by comparing patent-holder relative proximity in different types of deals. Table 1 shows it equals 0.55 in M&As and it is statistically different from licensing agreements (*patent-holder relative proximity* = 0.46). Then, I regress the actual deal indicator on patent-holder relative proximity. I also control for characteristics of firms involved in the transaction, firms' industry, and year fixed effects. Standard errors are clustered by patent-holder × patent-seeker industries. The estimates reported in Panel A of Table 4 show companies are more likely to integrate with firms on which they depend more. A one-standard-deviation increase in patent-holder relative proximity leads to 11% (= $0.018 \times 0.08/1.335\%$) lower integration probability than the average integration probability.

[7] I sometimes cannot identify all 10 similar firms, so my final sample is 25% smaller.

Next, I examine the integration probability by each type separately. Panel B shows a one-standard-deviation increase in patent-holder relative proximity is associated with a 50% ($= 0.074 \times 0.066/0.986\%$) higher merger probability than the mean merger probability in the sample. Panels C and D show that a one-standard-deviation increase in patent-holder relative proximity leads to a 22% ($= 0.037 \times 0.090/1.486\%$) higher probability of strategic alliance than the average strategic-alliance probability. Panels D reports a one-standard-deviation increase in patent-holder relative proximity lowers the probability of a licensing deal by 38% compared with the average probability. The results suggest greater patent-holder relative proximity is associated with a higher degree of firms' integration.

As an alternative strategy, companies may decide to exploit new advances, by infringing on the patent holder's rights. In this case, the patent holder can file a patent-infringement litigation lawsuits. Panel E of Table 4 shows that infringers are more likely to face a lawsuit if their innovation closely cites plaintiff's patents (patent-holder relative proximity is lower). This finding confirms firms depend on the innovation they cite, which provides an economic intuition and validation of my measure as bargaining power.

The understanding of the trade-off between the strategies is essential because the choice of integration degree is endogenous. I run a multinomial logistic regression, examining the impact of patent-holder relative proximity on the degree of integration. I find that the patent seeker interacts more deeply with the patent holder when their patent-holder relative proximity is larger (Table 5). I calculate the margins from a multinomial logistic regression (Figure 2). The figure shows the likelihood of each integration type as a function of *patent-holder relative proximity*. When the patent holder depends less on the patent seeker, licensing deals and patent infringement are more likely to happen. On the other hand, when the patent holder closely depends on the patent seeker, they are more likely to enter a strategic alliance or to agree on a merger. In sum, the figure shows that as patent-holder relative proximity increases, the patent seeker integrates more deeply with the patent holder. I also examine the coefficients for comparisons among all pairs of outcomes. I calculate the odds ratio for each pair of the outcomes (Panel B of Table 5). I find the coefficients of all pairs are statistically different from each other.

4 Deal performance

4.1 Announcement returns

To measure the effect of the deal on the value of the parties involved in the deal, I estimate cumulative abnormal returns (CARs). The abnormal return is defined as the difference between stock return and value-weighted market return. I use a three-day [−1,+1] window for M&A and strategic alliance samples because the actual date of the deal announcement is known. I use a 21-day [−10,+10] window for licensing deals and patent-infringement lawsuits, because most of the transactions are not covered by the media and the exact date of when the market learns about the event is unclear. Combined returns are defined as value-weighted returns around the announcement date, where the weights are based on the companies' market value two months prior to the announcement date.

Table 1 summarizes the mean CARs of the firms and their combined returns. Column 1 of Panel A reports the mean CARs for the M&A sample. Average bidder and combined abnormal returns are −1.35% and 1.70%, respectively, and statistically different from zero at the 1% level. Panel C of Table 1 presents the CARs for patent licensing deals. The average assignee and combined abnormal returns are 0.33% and 0.44%, respectively. Panel E reports average returns for the infringer equal to 0.93 and combined returns equal to 0.78% in the patent infringement lawsuits.

I investigate how patent-holder relative proximity affects announcement returns, estimating

$$CAR_{ijk} = \alpha + \beta Patent\ holder\ relative\ proximity_{ijk} + \epsilon_{ijk}, \tag{4}$$

The dependent variable is CAR_{ijk}, firm i's cumulative abnormal returns in deal k that involves firms i and j. *Patent holder relative proximity* is the variable of interest. In all specifications, the standard errors are clustered by firm i × firm j Fama-French 12 industries. In specifications (2) and (3), I add year, firm i, and firm j fixed effects. Specification (3) also includes a vector of deal and firms' characteristics.

Table 6 reports the estimates of patent-seeker announcement returns. In M&As, a one-standard-deviation increase in patent-holder relative proximity is associated with a 59.2 bps (= 4.231% × 0.140) increase in bidder announcement returns (Panel A). This effect is a large relative to the mean of -135 bps. In Panel C, I examine assignee announcement returns. I find a one-standard-deviation increase in patent-holder relative proximity leads to 48.6 bps (= 3.078% × 0.161) lower assignee

returns.

Next, I study the patent-holder announcement returns (Table 7). I find no difference in percentage announcement returns for targets in M&As. On the contrary, in licensing deals, assignor returns are greater by 40.5 bps ($= 2.517\% \times 0.161$) with a one-standard-deviation increase in patent-holder relative proximity. The size of firms involved in the interaction may differ considerably, inferring the split of the gains from the cumulative percentage abnormal returns of two parties of the deal might be difficult. I follow Ahern (2012) to calculate the firms' gain split in relative dollar terms. I find that in M&As, a one-standard-deviation decrease in patent-holder relative proximity is associated with an additional \$14.7 million ($= 4.833\% \times 0.140 \times \$2,200$) gain for the target (Table 8). On the contrary, the assignor loses, on average, \$28.6 million ($= 0.34\% \times \$8,400$) with a one-standard-deviation decrease in patent-holder relative proximity. In the licensing sample, the effect is opposite that in the M&A sample. One explanation is that the market accounts for additional competition from the assignee side, because now the assignor cannot block the assignee's innovation based on the assignor technology.

The results are consistent with the firms' holdup, where a greater *patent-holder relative proximity* is associated with weaker bargaining power. I find that patent holders with independent innovation (lower *patent-holder relative proximity*) are more likely to license their patents rather than to sell their business. In M&As such patent holders are able to extract a greater premium and dollar announcement returns. Whereas, in licensing deals the market punishes patent holders that have independent patent portfolio and license their patents. By doing this, patent holders may lose their bargaining power and potentially create an additional competition in the supply market. That is the reason why the market reacts negatively to such licensing deals.

In theory, bargaining power has no impact on the total deal gains but only on their split. So to validate my measure, I regress *patent-holder relative proximity*, the variable of interest, on the combined returns. Table 9 shows no significant relationship between *patent-holder relative proximity* and the combined returns.

4.2 Premium

Next, I analyze merger premiums. I calculate the premium as the deal value, divided by the target market value two months before the M&A announcement, minus one.

Table 10 presents the estimates from the premium regressions. A one-standard-deviation decrease in patent-holder relative proximity is associated with a $1.9 million higher premium paid by the bidder. This has an impact on bidder returns that decrease by 43.9 percentage points compared with the average bidder announcement returns.

Due to data limitations, I cannot calculate a premium for strategic alliances, licensing deals, and patent-infringement lawsuits, because I do not observe licensing royalties and patent-infringement lawsuit costs.

4.3 Post-deal performance

Under the efficient-markets hypothesis, the market incorporates the news of deals immediately, and we should not observe abnormal returns in the long run.

To test this hypothesis, I analyze long-run returns using the calendar-time approach (Fama (1998)) with 4-factor models (Fama and French (1993) and Carhart (1997)) and the Fama and MacBeth (1973) approach. Table 11 reports the results based on the calendar time and Fama and MacBeth (1973) approach. In both approaches, I do not find any statistical difference between deals with *patent-holder relative proximity* < 0.5 and *patent-holder relative proximity* ≥ 0.5.

Next, I analyze the operating performance in the post-deal period. I find no evidence of the change in the operation performance, measured by ROA (Table 12), thus confirming that my measure of patent-holder relative proximity captures only the deal gains split and not synergy effects.

4.4 Alternative explanations

First, relative proximity and integration decisions might correlate with industry concentration. Larger firms usually have greater bargaining power. To check whether they indeed to, I examine the correlation between patent-holder relative proximity and industry concentration. I find the correlation is less than 5% in absolute values. I also control for firms' industry concentration in multivariate analysis. The coefficients of patent-holder relative proximity remain almost unchanged (Table 13).

Second, I rule out that patent-holder relative proximity captures geographic distance. Previous studies point out that geographic proximity increases merger likelihood (Uysal et al. (2008), Ozcan

(2015)). Connected innovation is more likely to be concentrated within the same state or even the same county (Jaffe et al. (1993), Audretsch and Feldman (1996)). I address this question by dividing the patent-holder relative proximity by the median of geographic proximity. I find no difference in means between the two subsamples (Table 14).

5 Robustness

First, patent proximity captures the average connectedness and depends on the number of patents the firms have. If a patent holder has a small patent portfolio, the probability that a patent seeker cites the patent holder patents is lower. Thus, the measure might be biased by the size of the patent portfolio. To address this possibility, I look at alternative variables that capture the value of innovation output. The first measure is the citation-weighted value of the patents (Hall et al. (2005)), a widely used proxy in the literature. After controlling for the absolute value of the patents, I find my innovation proximity measures still matter and become even more statistically significant (Table 15). The second measure, proposed by Kogan et al. (2017), is the value of the patents weighted by the stock market. Taking into account this measure, I find that my innovation measures survive. These results suggest the importance of looking at the innovation connections between the companies and not just their absolute innovation outputs.

Second, patents are not the only output of a firm's innovation process. For example, trade secrets and know-how could be an alternative to patents. I consider other types of innovation output, by controlling for capital expenditures and the change in intangible value, measured by Ewens et al. (2020). The magnitude of the effects of patent-holder relative proximity on the degree of firms' integration remains the same (Table 16).

Third, in my main analysis, I calculate patent-holder relative proximity using innovation portfolios that consist of up to 20-year-old patents, which is the maximum life of their patent. Older patents are closer to the expiration, so their value should be lower compared to the newly issued patents. In the M&A transaction, the bidder should value the new target's patents more. In the appendix, I run regressions considering only up to 7- (10- or 15-) year patents. I find the effect is always statistically significant and the magnitude of the effect is increasing when considering only more recent patents.

6 Conclusion

I analyze the impact of corporate innovation linkages on firm boundaries. First, I show companies integrate more deeply with peers with closely follow-on innovation. This finding suggests companies actually bargain over type, terms, and conditions of the agreements.

Second, I study market reaction around the deals. I find my bargaining-power measure facilitates how the gains are split, as opposed to driving the total performance. In M&As, patent seekers obtain lower returns in the deals with greater patent-holder relative proximity. This result holds both in percentage points and dollar value. On the other hand, patent seekers experience greater announcement returns when they are able to sign strategic alliance or license patents from peers with closely original patents (greater bargaining power).

I find that my measure of patent-holder relative proximity is consistent with the bargaining power hypothesis, where greater patent-holder relative proximity translates into weaker bargaining power. I use patent-holder relative proximity in the context of contracting to acquire external innovation. Potentially, the application can be extended to a more general case. Future research can focus on other corporate activities, such as customer-supplier relationships and asset purchases. Studying how a firm's bargaining power affects the litigation-lawsuit settlement outcome might be also promising.

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Figure 1: Continuum of transaction types and degree of firms' integration

The figure shows the transaction types with respect to the degree of firms' integration.

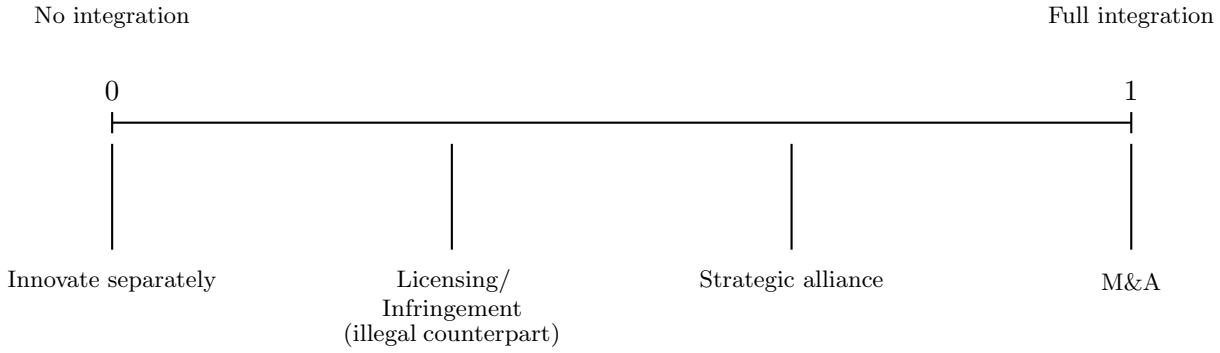

Figure 2: Probability of firms' integration, by type

The figure plots the probability of firms' integration (by type) with respect to Patent-holder relative proximity. The probabilities are calculated using multinomial logistic regression. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent-holder (-seeker) proximity measures the extent to which the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (all patent holder's patents do not cite patent seeker's patent portfolio and all patent seeker's patents directly cite patent holder's patent portfolio) to 1 (vice versa). Patent-holder relative proximity equals 0.5 when patent-holder and patent-seeker proximity measures are equal. In the graph, the probability of no integration is suppressed.

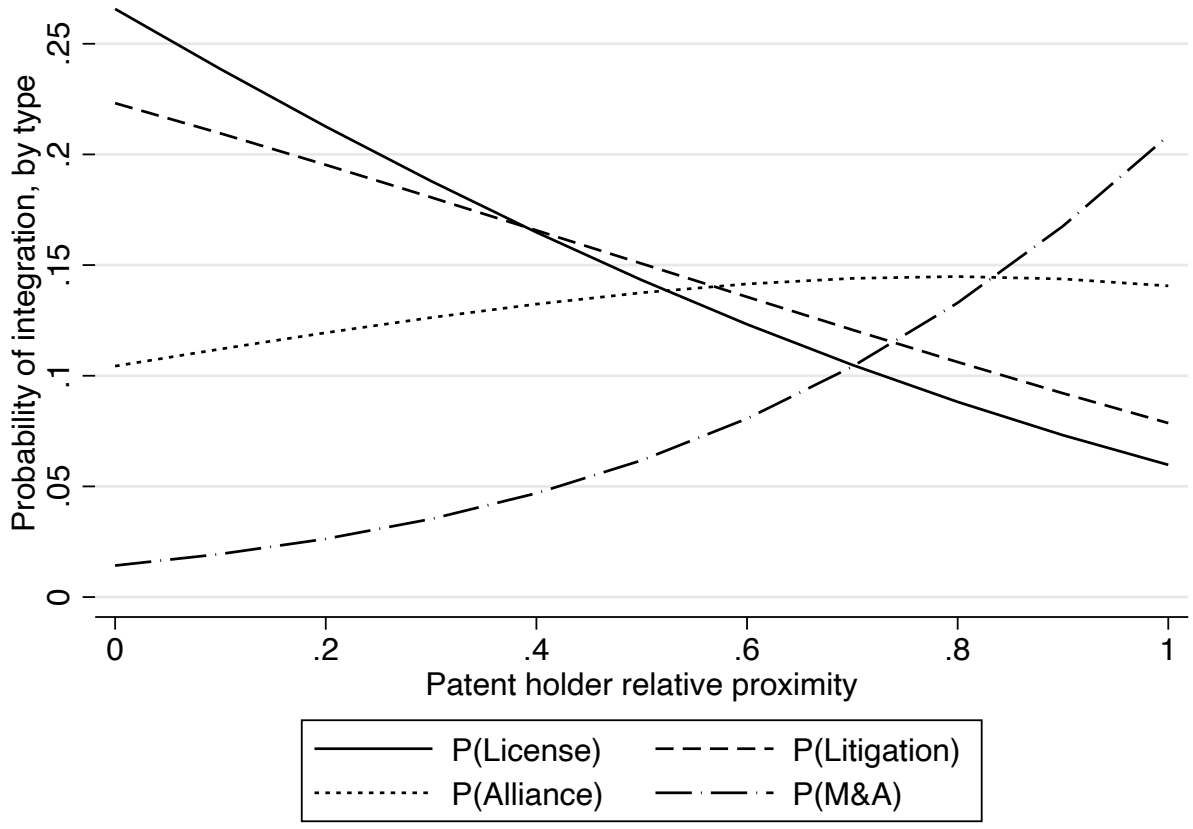

Table 1: Summary statistics

This table reports summary statistics of the sample based on the intersection of Thomson's One M&A dataset, SDC Platinum, USPTO patent-assignment dataset, Stanford NPE litigation database, Patent litigation docket reports data, Kogan et al. (2017), CRSP, and Compustat databases. The patent seeker is a firm that is willing to obtain the innovation, and the patent holder is a firm with such an innovation. All variables are defined in Table 17.

Panel A: Completed M&As

	Mean	St.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.557	0.140	0.000	0.500	0.500	0.610	1.000	932
Deal performance								
Patent-seeker CAR (%)	-1.350	7.162	-25.517	-4.393	-0.777	2.266	19.832	932
Patent-holder CAR (%)	25.601	30.073	-99.219	8.376	20.733	36.640	299.832	927
Combined CAR (%)	1.702	6.966	-18.600	-1.691	1.006	5.185	25.183	927
Δ$CAR	3.782	7.010	-26.005	-0.417	2.492	6.957	37.181	927
Premium	0.669	0.420	0.001	0.354	0.587	0.906	1.993	814
ROA, 1-year	0.123	0.118	-0.393	0.084	0.134	0.187	0.355	886
ROA, 2-year	0.120	0.123	-0.434	0.084	0.137	0.188	0.330	854
ROA, 3-year	0.120	0.118	-0.466	0.084	0.134	0.183	0.312	798
Patent-seeker (bidder) characteristics								
Patent-seeker market equity	7.635	2.183	2.721	5.952	7.542	9.179	12.175	932
Patent-seeker Tobin's Q	2.331	2.512	0.198	0.837	1.519	2.657	14.735	932
Patent-seeker leverage	0.138	0.143	0.000	0.017	0.110	0.203	0.968	932
Patent-seeker ROA	0.135	0.143	-0.529	0.095	0.154	0.211	0.395	927
Patent-holder (target) characteristics								
Patent-holder market equity	5.169	1.721	1.505	3.956	5.161	6.336	9.390	932
Patent-holder Tobin's Q	1.898	2.915	0.057	0.617	1.110	2.055	48.515	932
Patent-holder leverage	0.125	0.159	0.000	0.000	0.057	0.214	0.812	926
Patent-holder ROA	0.025	0.265	-1.253	-0.011	0.105	0.164	0.349	925
Deal characteristics								
Relative deal size	0.400	0.610	0.000	0.048	0.186	0.534	6.944	925
Same industry	0.746	0.436	0.000	0.000	1.000	1.000	1.000	932
Hostile	0.033	0.179	0.000	0.000	0.000	0.000	1.000	932
Cash	0.424	0.494	0.000	0.000	0.000	1.000	1.000	932
Alternative bargaining-power measures								
Patent-seeker CW patent output	2.880	2.285	0.000	0.330	2.867	4.780	7.765	932
Patent-holder CW patent output	1.413	1.516	0.000	0.000	1.075	2.523	5.631	932
Patent-seeker SM patent output	3.724	3.159	0.000	0.592	3.423	6.234	10.149	932
Patent-holder SM patent output	1.295	1.654	0.000	0.000	0.563	2.133	7.057	932

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Panel B: Potential M&As

	Mean	Sd.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.516	0.064	0.000	0.500	0.500	0.500	1.000	97,627
Patent-seeker (bidder) characteristics								
Patent-seeker market equity	7.217	1.965	2.985	5.758	7.140	8.530	11.903	97,489
Patent-seeker Tobin's Q	2.650	2.377	0.748	1.286	1.836	2.964	15.306	97,489
Patent-seeker leverage	0.178	0.163	0.000	0.027	0.156	0.272	0.779	97,627
Patent-seeker ROA	0.113	0.167	-0.774	0.080	0.140	0.200	0.370	97,200
Patent-holder (target) characteristics								
Patent-holder market equity	5.115	1.681	2.237	3.863	5.046	6.195	11.952	97,436
Patent-holder Tobin's Q	2.373	2.296	0.701	1.122	1.561	2.583	14.406	97,436
Patent-holder leverage	0.167	0.183	0.000	0.004	0.112	0.276	0.771	97,627
Patent-holder ROA	0.012	0.263	-0.987	-0.026	0.093	0.160	0.366	97,365
Deal characteristics								
Same industry	0.537	0.499	0.000	0.000	1.000	1.000	1.000	97,627

Panel C: Completed patent-acquisition/licensing deals

	Mean	St.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.463	0.161	0.000	0.380	0.500	0.518	1.000	2,479
Deal performance								
Patent-seeker CAR (%)	0.339	11.431	-36.707	-5.180	0.166	5.846	37.062	2,479
Patent-holder CAR (%)	0.702	10.680	-32.366	-4.521	0.482	5.440	36.785	2,479
Combined CAR (%)	0.439	8.151	-25.920	-3.784	0.342	4.508	25.401	2,471
Δ$CAR	0.004	7.463	-24.442	-3.987	0.228	3.918	22.225	2,471
Patent-seeker (assignee) characteristics								
Patent-seeker market equity	8.403	2.330	2.590	6.731	8.673	10.200	12.814	2,476
Patent-seeker Tobin's Q	2.126	1.550	0.755	1.168	1.601	2.405	9.356	2,476
Patent-seeker leverage	0.204	0.155	0.000	0.083	0.193	0.280	0.647	2,479
Patent-seeker ROA	0.113	0.133	-0.512	0.074	0.127	0.179	0.361	2,474
Patent-holder (assignor) characteristics								
Patent-holder market equity	8.473	2.608	2.364	6.637	8.820	10.526	12.894	2,474
Patent-holder Tobin's Q	1.812	1.122	0.709	1.169	1.420	2.028	7.506	2,474
Patent-holder leverage	0.238	0.158	0.000	0.132	0.217	0.313	0.674	2,479
Patent-holder ROA	0.094	0.143	-0.682	0.069	0.113	0.163	0.346	2,478
Deal characteristics								
Same industry	0.435	0.496	0.000	0.000	0.000	1.000	1.000	2,479

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Panel D: Potential patent-acquisition/licensing deals

	Mean	St.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.497	0.088	0.000	0.500	0.500	0.500	1.000	172,836
Patent-seeker (assignee) characteristics								
Patent-seeker market equity	7.360	2.122	2.985	5.828	7.285	8.953	11.903	172,684
Patent-seeker Tobin's Q	2.489	2.165	0.748	1.262	1.752	2.817	15.306	172,684
Patent-seeker leverage	0.182	0.169	0.000	0.021	0.161	0.283	0.779	172,836
Patent-seeker ROA	0.102	0.165	-0.774	0.069	0.128	0.186	0.370	172,139
Patent-holder (assignor) characteristics								
Patent-holder market equity	7.220	2.247	2.237	5.639	7.239	8.717	11.952	172,567
Patent-holder Tobin's Q	2.376	2.050	0.701	1.235	1.685	2.683	14.406	172,567
Patent-holder leverage	0.189	0.171	0.000	0.028	0.167	0.291	0.771	172,836
Patent-holder ROA	0.090	0.187	-0.987	0.065	0.124	0.181	0.366	172,032
Deal characteristics								
Same industry	0.439	0.496	0.000	0.000	0.000	1.000	1.000	172,836

Panel E: Filed patent-infringement lawsuits

	Mean	St.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.475	0.181	0.000	0.373	0.500	0.541	1.000	2,166
Lawsuit performance								
Patent-seeker CAR (%)	1.127	12.605	-37.744	-5.013	0.770	7.103	42.656	2,166
Patent-holder CAR (%)	0.903	12.221	-36.809	-5.332	0.704	6.446	41.179	2,166
Combined CAR (%)	0.925	9.293	-28.773	-3.771	0.763	5.563	29.785	2,166
Δ$CAR	-0.430	8.639	-33.111	-4.587	-0.149	4.005	25.158	2,166
Patent-seeker (infringer) characteristics								
Patent-seeker market equity	8.253	2.103	3.311	6.903	8.339	9.831	12.355	2,166
Patent-seeker Tobin's Q	2.747	2.069	0.845	1.454	2.100	3.196	13.492	2,166
Patent-seeker leverage	0.186	0.164	0.000	0.031	0.163	0.286	0.691	2,166
Patent-seeker ROA	0.123	0.139	-0.495	0.087	0.135	0.193	0.387	2,160
Patent-holder (plaintiff) characteristics								
Patent-holder market equity	8.435	2.376	2.751	6.667	8.524	10.573	12.285	2,166
Patent-holder Tobin's Q	2.713	1.870	0.803	1.464	2.069	3.249	10.883	2,166
Patent-holder leverage	0.175	0.153	0.000	0.044	0.157	0.255	0.789	2,166
Patent-holder ROA	0.124	0.143	-0.501	0.085	0.143	0.205	0.383	2,166
Deal characteristics								
Same industry	0.771	0.420	0.000	1.000	1.000	1.000	1.000	2,166

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Panel F: Potential patent-infringement lawsuits

	Mean	St.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.495	0.083	0.000	0.500	0.500	0.500	1.000	207,316
Patent-seeker (infringer) characteristics								
Patent-seeker market equity	7.669	2.010	2.985	6.219	7.755	9.086	11.903	207,130
Patent-seeker Tobin's Q	2.954	2.465	0.748	1.480	2.136	3.462	15.306	207,130
Patent-seeker leverage	0.177	0.175	0.000	0.012	0.144	0.283	0.779	207,316
Patent-seeker ROA	0.089	0.188	-0.774	0.060	0.128	0.191	0.370	206,738
Patent-holder (plaintiff) characteristics								
Patent-holder market equity	7.786	2.144	2.237	6.284	7.954	9.253	11.952	207,184
Patent-holder Tobin's Q	2.905	2.377	0.701	1.470	2.137	3.302	14.406	207,184
Patent-holder leverage	0.182	0.173	0.000	0.021	0.156	0.280	0.771	207,316
Patent-holder ROA	0.095	0.193	-0.987	0.067	0.135	0.195	0.366	206,691
Deal characteristics								
Same industry	0.612	0.487	0.000	0.000	1.000	1.000	1.000	207,316

Panel G: Completed strategic alliances

	Mean	St.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.517	0.160	0.000	0.473	0.500	0.556	1.000	1,922
Strategic alliance performance								
Patent-seeker CAR (%)	2.680	21.322	-53.128	-9.600	1.692	13.238	72.965	1,922
Patent-holder CAR (%)	4.412	24.755	-61.859	-9.169	2.924	16.011	82.859	1,922
Combined CAR (%)	3.055	16.757	-44.592	-6.418	2.631	11.530	55.560	1,919
Δ$CAR	0.465	15.250	-40.207	-8.529	-0.009	9.098	46.335	1,919
Patent-seeker characteristics								
Patent-seeker market equity	8.368	2.374	2.661	6.621	8.756	10.266	12.037	1,921
Patent-seeker Tobin's Q	2.894	2.807	0.827	1.310	1.876	3.226	16.138	1,921
Patent-seeker leverage	0.167	0.149	0.000	0.030	0.145	0.265	0.646	1,922
Patent-seeker ROA	0.101	0.181	-0.648	0.074	0.135	0.193	0.418	1,920
Patent-holder characteristics								
Patent-holder market equity	7.815	2.312	2.479	6.058	7.946	9.742	11.628	1,920
Patent-holder Tobin's Q	3.619	3.352	0.782	1.516	2.383	4.209	18.461	1,920
Patent-holder leverage	0.137	0.151	0.000	0.002	0.098	0.222	0.729	1,922
Patent-holder ROA	0.106	0.205	-0.856	0.064	0.139	0.224	0.418	1,920
Deal characteristics								
Same industry	0.724	0.447	0.000	0.000	1.000	1.000	1.000	1,922

Panel H: Potential strategic alliances

	Mean	St.dev.	Min	p25	Median	p75	Max	N
Patent-holder relative proximity	0.497	0.085	0.000	0.500	0.500	0.500	1.000	129,286
Patent-seeker characteristics								
Patent-seeker market equity	7.286	2.274	2.661	5.471	7.393	9.021	12.037	129,043
Patent-seeker Tobin's Q	3.044	2.818	0.827	1.379	2.006	3.472	16.138	129,043
Patent-seeker leverage	0.158	0.157	0.000	0.013	0.122	0.254	0.646	129,286
Patent-seeker ROA	0.108	0.183	-0.648	0.074	0.142	0.204	0.418	128,798
Patent-holder characteristics								
Patent-holder market equity	6.894	2.101	2.479	5.378	6.865	8.410	11.628	129,088
Patent-holder Tobin's Q	3.036	2.892	0.782	1.374	2.029	3.487	18.461	129,088
Patent-holder leverage	0.149	0.162	0.000	0.006	0.103	0.241	0.729	129,286
Patent-holder ROA	0.099	0.197	-0.856	0.066	0.135	0.202	0.418	128,586
Deal characteristics								
Same industry	0.536	0.499	0.000	0.000	1.000	1.000	1.000	129,286

Table 2: Firm's innovation strategies, by year

This table reports the number of M&As, strategic alliances, licensing deals, and patent litigation lawsuits, by year.

Year	License (1)	Lawsuit (2)	Alliance (3)	M&A (4)
1975	2	0	0	0
1978	0	0	0	4
1979	0	0	0	2
1980	9	0	0	6
1981	29	0	0	16
1982	26	0	0	11
1983	41	0	0	13
1984	25	0	0	12
1985	28	1	0	25
1986	33	1	12	31
1987	33	1	15	21
1988	36	2	12	20
1989	26	7	36	25
1990	43	28	41	10
1991	27	34	94	9
1992	31	45	119	12
1993	43	54	117	12
1994	70	47	162	29
1995	67	49	146	41
1996	52	49	117	34
1997	81	71	169	53
1998	94	95	156	70
1999	91	61	150	62
2000	90	125	99	55
2001	140	169	65	49
2002	191	162	73	30
2003	187	202	63	34
2004	182	189	48	32
2005	134	135	67	44
2006	148	105	58	40
2007	143	123	30	34
2008	168	166	38	36
2009	110	127	22	33
2010	99	118	13	27
Total	2479	2166	1922	932

Table 3: Prediction of firms' integration, using average firm proximity

The table reports the estimates of a linear probability model:

$$\mathbb{1}\{integration_{ijt}\} = \alpha + \beta Average\ firm\ proximity_{ijt} + \epsilon_{ijt},$$

where $\mathbb{1}\{integration_{ijt}\}$ equals 1 when the integration between firms i (patent holder) and j (patent seeker) is announced at time t, and 0 when the integration does not take place. In specification (4) of Panel A, the table reports the estimates of a logistic regression. *Average firm proximity* is the average of patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures the extent to which the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Potential interactions are identified thought a matching procedure requiring (1) their market value is 70%-130% of the actual firms' market value two months before the interaction, (2) they have at least one patent issued before the interaction, and (3) they operate in the same industry as the actual firms. I identify the top 10 potential firms for each actual firm that respects criteria (1)-(3) above and create all possible pairs among potential firms. t-statistics, reported in parentheses, are based on standard errors clustered around firm i × firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: Predicting firm integration

	LPM (1)	LPM (2)	LPM (3)	Logit (4)
Average firm proximity	0.223***	0.229***	0.207***	6.885***
	(10.39)	(10.25)	(9.64)	(11.99)
Controls	N	N	Y	Y
Year FE	N	Y	Y	Y
Industry FE	N	Y	Y	Y
N	545,560	545,560	540,514	540,514
R^2	0.018	0.019	0.020	0.093

Panel B: Predicting integration, by type

	M&A (1)	Alliance (2)	License (3)	Infringement (4)
Average firms' proximity (synergy)	0.220***	0.173***	0.209***	0.225***
	(7.74)	(19.73)	(5.89)	(7.50)
Controls	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
N	92,614	122,886	157,323	167,691
R^2	0.015	0.020	0.027	0.023

Table 4: Prediction of firms' integration, using Patent-holder relative proximity

In specifications (1)–(3), the table reports the estimates of a linear probability model:

$$\mathbb{1}\{integration_{ijt}\} = \alpha + \beta Patent - holder\ relative\ proximity_{ijt} + \epsilon_{ijt}$$

where $\mathbb{1}\{integration_{ijt}\}$ equals 1 when the integration between firms i (patent holder) and j (patent seeker) is announced at time t, and 0 when the integration does not take place. In specification (4), the table reports the estimates of a logistic regression. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. Potential interactions are identified thought a matching procedure requiring: (1) their market value is 70%-130% of the actual firms' market value two months before the interaction; (2) they have at least one patent issued before the interaction; (3) they operate in the same industry as the actual firms. I identify the top 10 potential firms for each actual firm that respect criteria (1)-(3) above and create all possible pairs among potential firms. t-statistics, reported in parentheses, are based on standard errors clustered around firm i × firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: Predicting firm interaction

	LPM (1)	LPM (2)	LPM (3)	Logit (4)
Patent-holder relative proximity	-0.016	-0.016	-0.018**	-0.828***
	(-1.42)	(-1.50)	(-1.99)	(-2.61)
Controls	N	N	Y	Y
Year FE	N	Y	Y	Y
Industry FE	N	Y	Y	Y
N	550,366	550,366	545,268	545,268
R^2	0.000	0.001	0.008	0.055

Panel B: Predicting M&A transactions

	LPM (1)	LPM (2)	LPM (3)	Logit (4)
Patent-holder relative proximity	0.075***	0.077***	0.074***	4.282***
	(4.15)	(4.15)	(3.99)	(5.87)
Controls	N	N	Y	Y
Year FE	N	Y	Y	Y
Industry FE	N	Y	Y	Y
N	93,550	93,550	92,680	92,680
R^2	0.003	0.003	0.005	0.042

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Panel C: Predicting strategic alliances

	LPM (1)	LPM (2)	LPM (3)	Logit (4)
Patent-holder relative proximity	0.040**	0.039***	0.037***	0.968***
	(2.60)	(2.68)	(2.88)	(3.70)
Controls	N	N	Y	Y
Year FE	N	Y	Y	Y
Industry FE	N	Y	Y	Y
N	124,334	124,334	122,886	122,886
R^2	0.001	0.003	0.013	0.084

Panel D: Predicting licensing transactions

	LPM (1)	LPM (2)	LPM (3)	Logit (4)
Patent-holder relative proximity	-0.063***	-0.063***	-0.059***	-2.195***
	(-2.72)	(-3.15)	(-3.36)	(-3.56)
Controls	N	N	Y	Y
Year FE	N	Y	Y	Y
Industry FE	N	Y	Y	Y
N	161,955	161,955	160,469	160,469
R^2	0.002	0.005	0.016	0.103

Panel E: Predicting patent infringement lawsuits

	LPM (1)	LPM (2)	LPM (3)	Logit (4)
Patent-holder relative proximity	-0.030***	-0.030***	-0.031***	-1.699***
	(-3.64)	(-3.65)	(-4.58)	(-4.39)
Controls	N	N	Y	Y
Year FE	N	Y	Y	Y
Industry FE	N	Y	Y	Y
N	170,527	170,527	169,233	169,233
R^2	0.001	0.001	0.007	0.049

Table 5: Prediction of firm's degree of integration, using multinomial logistic regression

In specifications (1)–(2) of Panel A, the table reports the estimates of multinomial logistic regression:

$$Degree\ of\ Integration_{ijt} = \alpha + \beta Patent - holder\ relative\ proximity_{ijt} + \epsilon_{ijt}$$

where $Degree\ of\ Integration_{ijt}$ equals 1 if there is no integration between firms i and j, two in case of licensing agreement, three in case of patent infringement lawsuit, four in case of strategic alliance, and five in case of merge and acquisition. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm i $\times$ firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: multinomial logistic regression on firms' integration types

Dependent variable		Mlogit (1)	Mlogit (2)	Mlogit (3)
1 (No integration)	Patent-holder relative proximity		(Base outcome)	
2 (License)	Patent-holder relative proximity	-4.380***	-4.610***	-2.189***
		(-4.08)	(-4.37)	(-3.07)
3 (Infringement)	Patent-holder relative proximity	-3.044***	-2.868***	-1.290***
		(-4.14)	(-4.41)	(-3.48)
4 (Strategic alliance)	Patent-holder relative proximity	2.172***	1.813***	0.854**
		(2.84)	(2.63)	(2.18)
5 (M&A)	Patent-holder relative proximity	5.098***	5.418***	4.454***
		(7.12)	(6.53)	(8.26)
	Controls	N	N	Y
	Industry FE	N	Y	Y
	N	550,366	550,366	545,268
	pseudo R^2	0.010	0.032	0.083

Panel B: Factor change in the odds of "integration degree"

			b	z	$P>\|z\|$	e^b	$e^b StdX$
No Integration	vs	License	2.1805	10.385	0.000	8.851	1.209
No Integration	vs	Infringement	1.2831	6.021	0.000	3.608	1.118
Infringement	vs	License	0.8974	3.015	0.003	2.453	1.081
Strategic alliance	vs	No Integration	0.8628	3.935	0.000	2.37	1.078
Strategic alliance	vs	License	3.0433	10.058	0.000	20.975	1.304
Strategic alliance	vs	Infringement	2.1459	7.042	0.000	8.55	1.206
M&A	vs	No Integration	4.4504	13.073	0.000	85.659	1.474
M&A	vs	License	6.6309	16.592	0.000	758.17	1.782
M&A	vs	Infringement	5.7335	14.29	0.000	309.046	1.648
M&A	vs	Strategic alliance	3.5876	8.878	0.000	36.146	1.367

Table 6: Patent seeker announcement returns

In Panel A (B) the table reports the estimates of:

$$CAR_{jk} = \alpha + \beta Patent - holder\ relative\ proximity_{ijk} + \epsilon_{ijk}$$

where CAR_{jk} is the three-day $[-1, +1]$ window patent seeker percentage abnormal returns around the M&A (strategic alliance) announcement date. In Panel C (Panel D) CAR_{jk} is the $[-10, +10]$ window assignee (infringer) percentage abnormal returns around the licensing signed date (patent infringement lawsuit filing date). Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm i × firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: M&A deals (Bidder side)

	(1)	(2)	(3)
Patent-holder relative proximity	5.218***	5.905***	4.231**
	(4.14)	(5.16)	(2.42)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	932	932	907
R^2	0.010	0.084	0.142

Panel B: Strategic alliances (Patent seeker side)

	(1)	(2)	(3)
Patent-holder relative proximity	-4.453***	-4.856***	-2.596**
	(-6.82)	(-9.23)	(-2.32)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	1922	1922	1915
R^2	0.014	0.032	0.069

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Panel C: Licensing deals (Assignee side)

	(1)	(2)	(3)
Patent-holder relative proximity	-2.188	-2.872**	-3.078**
	(-1.50)	(-2.40)	(-2.27)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2,479	2,478	2,464
R^2	0.001	0.031	0.038

Panel D: Patent infringement lawsuits (Infringer side)

	(1)	(2)	(3)
Patent-holder relative proximity	-0.002	-0.003	-0.000
	(-0.12)	(-0.27)	(-0.02)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2166	2163	2157
R^2	0.000	0.031	0.041

Table 7: Patent holder announcement returns

In Panel A (B) the table reports the estimates of:

$$CAR_{ik} = \alpha + \beta Patent - holder\ relative\ proximity_{ijk} + \epsilon_{ijk}$$

where CAR_{ik} is the three-day $[-1, +1]$ window patent holder percentage abnormal returns around the M&A (strategic alliance) announcement date. In Panel C (Panel D) CAR_{ik} is the $[-10, +10]$ window assignor (plaintiff) percentage abnormal returns around the licensing signed date (patent infringement lawsuit filing date). Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm i × firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: M&A deals (Target side)

	(1)	(2)	(3)
Patent-holder relative proximity	25.071***	19.374***	-2.650
	(5.16)	(5.19)	(-0.34)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
Observations	927	927	906
R^2	0.018	0.097	0.192

Panel B: Strategic alliances (Patent holder side)

	(1)	(2)	(3)
Patent-holder relative proximity	2.309***	2.716***	-1.330**
	(3.75)	(3.45)	(-2.21)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	1922	1922	1915
R^2	0.003	0.027	0.074

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Panel C: Licensing deals (Assignor side)

	(1)	(2)	(3)
Patent-holder relative proximity	3.806***	3.037**	2.517**
	(3.56)	(2.50)	(2.01)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2,479	2,478	2,464
R^2	0.003	0.030	0.034

Panel D: Patent infringement lawsuits (Plaintiff side)

	(1)	(2)	(3)
Patent-holder relative proximity	0.003	0.007	0.025
	(0.12)	(0.27)	(0.74)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2166	2163	2157
R^2	0.000	0.035	0.042

Table 8: Patent holder relative dollar gains

The table reports the estimates of:

$$\Delta\$CAR_{ijk} = \alpha + Patent - holder\ relative\ proximity_{ijk} + \epsilon_{ijk}$$

where the dependent variable is $\Delta\$CAR_{ijk}$ defined as the difference between dollar value of patent holder announcement returns and patent seeker announcement returns, scaled by the sum of patent holder and Patent-seeker market equity two months prior to the announcement of interaction k. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm i × firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: M&A deals

	(1)	(2)	(3)
Patent-holder relative proximity	-9.438***	- 9.495***	-4.833**
	(-6.35)	(-7.12)	(-2.54)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
Observations	927	927	906
R^2	0.039	0.105	0.176

Panel B: Strategic alliances

	(1)	(2)	(3)
Patent-holder relative proximity	-0.679***	-0.817***	-0.873***
	(-3.29)	(-5.46)	(-2.67)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	1909	1909	1905
R^2	0.001	0.010	0.020

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Panel C: Licensing deals

	(1)	(2)	(3)
Patent-holder relative proximity	1.060	0.821	2.119**
	(1.00)	(0.86)	(2.32)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2,471	2,470	2,464
R^2	0.001	0.022	0.027

Panel D: Patent infringement lawsuits

	(1)	(2)	(3)
Patent-holder relative proximity	1.485**	1.774**	1.796
	(2.07)	(2.32)	(1.58)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2166	2163	2157
R^2	0.001	0.023	0.033

Table 9: Combined announcement returns

Panel A (B) reports the estimates of

$$CAR_{ijk} = \alpha + \beta Patent - holder\ relative\ proximity_{ijk} + \epsilon_{ijk}$$

where CAR_{ijk} is the three-day [−1, +1] window combined cumulative abnormal percentage returns (CARs) around M&A (strategic alliance) announcement date. In Panels C and D CAR_{ijk} is calculated over the [−10, +10] day window. The weights are based on the companies' market value two months prior to interaction announcement. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm $i \times$ firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: M&A deals

	(1)	(2)	(3)
Patent-holder relative proximity	-1.740*	-1.048	1.365
	(-1.87)	(-1.05)	(0.96)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
Observations	927	927	906
R^2	0.001	0.080	0.181

Panel B: Strategic alliances

	(1)	(2)	(3)
Patent-holder relative proximity	-0.002	-0.001	0.001
	(-0.90)	(-0.55)	(0.23)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	1919	1919	1915
R^2	0.000	0.020	0.025

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Panel C: Licensing deals

	(1)	(2)	(3)
Patent-holder relative proximity	0.905	0.157	-0.183
	(1.21)	(0.21)	(-0.21)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2,471	2,470	2,464
R^2	0.000	0.033	0.041

Panel D: Patent infringement lawsuits

	(1)	(2)	(3)
Patent-holder relative proximity	0.002	0.003	0.013
	(0.12)	(0.30)	(0.88)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
N	2166	2163	2157
R^2	0.000	0.037	0.045

Table 10: Premiums

The table reports the estimates of:

$$Premium_{ijk} = \alpha + \beta Patent - holder\ relative\ proximity_{ijk} + \epsilon_{ijk}$$

where *Premium* is the value of the merger transaction, scaled by the target's market value 43 trading days prior to the M&A announcement, minus 1 (Officer (2003)). Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm $i \times$ firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: M&A deals

	(1)	(2)	(3)
Patent-holder relative proximity	-1.053***	-0.899***	-0.068*
	(-12.76)	(-17.00)	(-1.81)
Controls	N	N	Y
Year FE	N	Y	Y
Industry FE	N	Y	Y
Observations	925	925	907
R^2	0.082	0.166	0.932

Table 11: Long-term returns

The table reports the estimates of the patent seeker average monthly abnormal returns using Fama-French (1993) 3-factor model and Fama-Macbeth regression. Monthly abnormal returns are based on the daily average of abnormal returns over 1 (2 or 3) years (depending on the specification) followed the deal announcement date. The market return is the value-weighted return. Panel A (C) estimates are based on three portfolios. The first portfolio consists of the full sample of the M&A (licensing) deals. The second (third) one includes all the M&A (licensing) deals with Patent-holder relative proximity less (greater or equal) than 0.5. Panels C and D use Fama-French approach. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on robust errors. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: M&A deals. Calendar-time approach

	1 year	2 years	3 years
	(1)	(2)	(3)
Full sample	0.224	0.192	0.181
	(1.39)	(1.33)	(1.26)
M&As with low Patent-holder relative proximity	0.368*	0.225	0.209
	(1.82)	(1.40)	(1.27)
M&As with high Patent-holder relative proximity	0.135	0.176	0.172
	(0.73)	(1.04)	(1.08)
Wald test	0.39	0.83	0.87

Panel B: M&A deals. Fama-MacBeth regression

	1 year	2 years	3 years
	(1)	(2)	(3)
Patent-holder relative proximity	0.757	0.573	0.072
	(1.45)	(1.08)	(0.14)
Controls	Y	Y	Y
Year FE	Y	Y	Y
Industry FE	Y	Y	Y
Observations	10,560	20,757	30,496
R^2	0.027	0.025	0.023

(continued on next page)

(Continued)

Panel C: Licensing deals. Calendar-time approach

	1 year (1)	2 years (2)	3 years (3)
Full sample	0.366***	0.331***	0.340***
	(2.90)	(2.94)	(3.18)
License with low Patent-holder relative proximity	0.462***	0.453***	0.411***
	(2.72)	(3.09)	(2.94)
License with high Patent-holder relative proximity	0.289***	0.228*	0.281***
	(2.14)	(1.94)	(2.60)
Wald test	0.51	0.32	0.54

Panel D: Licensing deals. Fama-MacBeth regression

	1 year (1)	2 years (2)	3 years (3)
Patent-holder relative proximity	-0.188	-0.774	-0.319
	(-0.20)	(-1.18)	(-0.59)
Controls	Y	Y	Y
Year FE	Y	Y	Y
Industry FE	Y	Y	Y
N	14,102	27,730	39,934
R^2	0.076	0.073	0.072

Table 12: Post-deal operating performance

The table reports the estimates of the post-deal operating performance, ROA. Firm portfolios include all patents, that are filed before the M&A (licensing) announcement and issued not prior that 20 years to the merger announcement, depending on the specification. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm $i \times$ firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: M&A deals

	1 year	2 years	3 years
	(1)	(2)	(3)
Patent-holder relative proximity	-0.008	0.009	-0.016
	(-0.57)	(0.86)	(-0.91)
Controls	Y	Y	Y
Year FE	Y	Y	Y
Industry FE	Y	Y	Y
N	863	831	777
R^2	0.682	0.598	0.542

Panel B: Licensing deals

	1 year	2 years	3 years
	(1)	(2)	(3)
Patent-holder relative proximity	-0.002	-0.010	-0.016
	(-0.16)	(-0.93)	(-1.50)
Controls	Y	Y	Y
Year FE	Y	Y	Y
Industry FE	Y	Y	Y
N	2280	2187	2098
R^2	0.631	0.601	0.554

Table 13: Prediction of firms' degree of integration. Controlling for industry competition

The table reports the estimates of multinomial logistic regression:

$$Degree\ of\ Interaction_{ijt} = \alpha + \beta Patent - holder\ relative\ proximity_{ijt} + \epsilon_{ijt}$$

where $Degree\ of\ Interaction_{ijt}$ equals 1 if there is no integration between firms i and j, 2 in case of licensing agreement, 3 in case of patent infringement lawsuit, 4 in case of strategic alliance, and 5 in case of merge and acquisition. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent-holder (-seeker) proximity measures the extent to which the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. In specification (1) I report baseline results, while in specification (2) I control for market concentration in patent holder and patent seeker industries. I define industry according to 48 Fama-French industry classification. t-statistics, reported in parentheses, are based on standard errors clustered around firm $i \times$ firm j industries (12 Fama-French industry). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

	(1)	(2)
1 (No integration)	Baseline	
2 (License)		
Patent-holder relative proximity	-2.181***	-2.081***
	(-3.06)	(-2.93)
Patent holder's industry HHI		0.089
		(0.11)
Patent seeker's industry HHI		3.560***
		(3.07)
3 (Infringement)		
Patent-holder relative proximity	-1.283***	-1.279***
	(-3.45)	(-3.49)
Patent holder's industry HHI		0.874
		(1.26)
Patent seeker's industry HHI		0.167
		(0.19)
4 (Strategic alliance)		
Patent-holder relative proximity	0.863**	0.754**
	(2.20)	(2.24)
Patent holder's industry HHI		4.191***
		(2.85)
Patent seeker's industry HHI		4.002***
		(3.54)
5 (M&A)		
Patent-holder relative proximity	4.450***	4.448***
	(8.23)	(8.29)
Patent holder's industry HHI		0.291
		(0.28)
Patent seeker's industry HHI		-0.075
		(-0.11)
N	540,514	540,514

Table 14: Geography

The table reports sample splits of patent-holder relative proximity by geographic distance. Geographic distance is the geodetic distance between firms' headquarters. I divide the sample by the median of geographic distance. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent holder (seeker) proximity measures to what extent the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (indicating that all of the patent holder's patents do not cite the patent seeker's patent portfolio and all of the patent seeker's patents directly cite the patent holder's patent portfolio) to 1 (the opposite). Patent-holder relative proximity equals 0.5 when the patent holder and seeker proximity measures are equal. t-statistics, reported in parentheses, are based on standard errors clustered around firm i $\times$ firm j Fama-French 12 industries. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

	High (1)	Low (2)	t-stat (3)
Patent-holder relative proximity			
Full sample	0.503	0.503	-0.47
Completed deals	0.516	0.516	0.02
Potential deals	0.503	0.503	-0.56

Table 15: Bidder announcement returns using alternative measures

The table reports the estimates of bidder cumulative abnormal percentage returns (CARs) using alternative measures of bargaining power. *SM innovation output* is the logarithm of the firm's innovation output that weighs patents using stock market reaction (Kogan et al. (2017)). *CW innovation output* is the logarithm of the citation-weighted patent portfolio of the firm. Both SM and CW innovation outputs are measured one year before the M&A announcement and are taken from Kogan et al. (2017) dataset. t-statistics, reported in parentheses, are based on standard errors clustered around bidder × target industry (12 Fama-French industry). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

	(1)	(2)	(3)	(4)
Patent-holder relative proximity	4.231**	4.358**	5.332***	4.477**
	(2.42)	(2.13)	(3.09)	(2.62)
Bidder SM innovation output		-0.180		0.411
		(-1.24)		(1.00)
Target SM innovation output		-0.230		-0.613***
		(-1.44)		(-4.81)
Bidder CW innovation output			-0.336***	-0.706*
			(-2.89)	(-1.87)
Target CW innovation output			-0.067	0.437**
			(-0.38)	(2.50)
Controls	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
N	907	907	907	907
R^2	0.142	0.146	0.147	0.152

Table 16: Prediction of firms' degree of integration. Controlling for other types of intangibles

The table reports the estimates of multinomial logistic regression:

$$Degree\ of\ Interaction_{ijt} = \alpha + \beta Patent - holder\ relative\ proximity_{ijt} + \epsilon_{ijt}$$

where $Degree\ of\ Interaction_{ijt}$ equals 1 if there is no integration between firms i and j, 2 in case of licensing agreement, 3 in case of patent infringement lawsuit, 4 in case of strategic alliance, and 5 in case of merge and acquisition. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent-holder (-seeker) proximity measures the extent to which the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. In specification (1) I report baseline results, while in specifications (2), (3) and (4) I control for CAPEX or/and change in knowledge value calculated by Ewens et al. (2020). t-statistics, reported in parentheses, are based on standard errors clustered around firm i × firm j industries (12 Fama-French industry). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

Panel A: multinomial logistic regressions

	(1)	(2)	(3)	(4)
1 (No integration)	Baseline			
2 (License)				
Patent-holder relative proximity	-2.181***	-2.315***	-2.102***	-2.219***
	(-3.06)	(-3.28)	(-3.59)	(-3.74)
Patent seeker's CAPEX		4.201***		3.704***
		(4.10)		(3.65)
Patent holder's CAPEX		3.401***		2.879***
		(5.17)		(3.78)
Patent seeker's knowledge capital			0.278***	0.262***
			(2.76)	(2.63)
Patent holder's knowledge capital			0.301***	0.275***
			(4.05)	(3.82)
3 (Infringement)				
Patent-holder relative proximity	-1.283***	-1.234***	-1.101***	-1.042***
	(-3.45)	(-3.41)	(-3.30)	(-3.19)
Patent seeker's CAPEX		1.413**		0.871*
		(2.22)		(1.82)
Patent holder's CAPEX		-0.268		-0.929
		(-0.36)		(-1.24)
Patent seeker's knowledge capital			0.181***	0.176***
			(3.55)	(3.56)
Patent holder's knowledge capital			0.154**	0.155**
			(2.14)	(2.09)
4 (Strategic alliance)				
Patent-holder relative proximity	0.863**	0.771**	0.665**	0.596**
	(2.20)	(2.25)	(2.53)	(2.33)
Patent seeker's CAPEX		5.294***		4.763***
		(13.85)		(9.57)
Patent holder's CAPEX		5.589***		5.177***
		(12.58)		(7.48)
Patent seeker's knowledge capital			0.417**	0.380**
			(2.22)	(2.11)
Patent holder's knowledge capital			0.460***	0.443***
			(5.56)	(5.91)

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5 (M&A)				
Patent-holder relative proximity	4.450***	4.437***	4.331***	4.306***
	(8.23)	(7.45)	(7.41)	(6.66)
Patent seeker's CAPEX		-4.397***		-4.560***
		(-5.17)		(-4.81)
Patent holder's CAPEX		1.525***		1.169*
		(2.76)		(1.69)
Patent seeker's knowledge capital			0.022	0.026
			(0.97)	(1.10)
Patent holder's knowledge capital			0.076**	0.089**
			(2.48)	(2.45)
N	540514	530338	469301	460407

Panel B: Factor change in the odds of "integration degree"

			b	z	$P>\|z\|$	e^b	e^bStdX
No Integration	vs	License	2.219	10.615	0.000	9.200	1.225
No Integration	vs	Infringement	1.043	4.861	0.000	2.836	1.100
Infringement	vs	License	1.177	3.952	0.000	3.244	1.114
Strategic alliance	vs	No Integration	0.596	2.731	0.006	1.815	1.056
Strategic alliance	vs	License	2.815	9.360	0.000	16.695	1.294
Strategic alliance	vs	Infringement	1.638	5.376	0.000	5.147	1.162
M&A	vs	No Integration	4.306	11.846	0.000	74.123	1.483
M&A	vs	License	6.525	15.573	0.000	681.909	1.817
M&A	vs	Infringement	5.348	12.686	0.000	210.231	1.632
M&A	vs	Strategic alliance	3.710	8.768	0.000	40.845	1.404

Table 17: Variable definitions

Variable	Definition
Key variable of interest	
Patent-holder relative proximity	Difference between patent-holder proximity and patent-seeker proximity, where patent-holder (-seeker) proximity measures the extent to which the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (all patent holder's patents do not cite patent seeker's patent portfolio and all patent seeker's patents directly cite patent holder's patent portfolio) to 1 (vice versa). Patent-holder relative proximity equals 0.5 when patent-holder and patent-seeker proximity measures are equal. Sources: CRSP, Kogan et al. (2017), Thomson One.
Deal performance	
Firm i's CAR (%)	Cumulative abnormal percentage return of firm i around the deal announcement date. Three-day window [−1,+1] is used for M&As and strategic alliances; 21-day window [−10,+10] is used for license and patent infringement lawsuits. Source: CRSP.
Combined CAR (%)	Cumulative abnormal percentage return of value-weighted portfolio around the interaction announcement date. The weights are based on the companies' market value two months prior to the interaction announcement. Source: CRSP.
$\Delta\$CAR$	The difference between patent holder \$CAR and patent seeker \$CAR, scaled by the sum of patent holder and patent seeker market equities two months before the deal announcement (Ahern (2012)). \$CAR is the three-day dollar abnormal return for M&As and strategic alliances, and the 21-day dollar abnormal returns for licensing deals and patent infringement lawsuits. Market return is the value weighted market return. Source: CRSP.
Premium	Transaction value, scaled by the Patent-holder market equity of 43 trading days prior to interaction announcement, minus 1 (Officer (2003)). Sources: CRSP, Thomson One.
Firm Characteristics	
Market equity	Natural logarithm of firm's market value in millions two months prior to the deal announcement date. Source: CRSP.
Tobin's Q	Market value over book value of assets. Source: Compustat.
Leverage	Book value of debt over book value of assets. Source: Compustat.
ROA	Operating income before depreciation, normalized by book value of assets. Source: Compustat.
Interaction characteristics	
Relative deal size	Deal value, scaled by the Patent-seeker market equity. Sources: CRSP, Thomson One.
Same industry	Equal 1 if both firms are from the same industry, and 0, otherwise. Industry is defined according 12 Fama-French industry classification. Source: Thomson One.
Attitude	Equal 1 when there is a hostile takeover, and 0, otherwise. Source: Thomson One.
Cash	Equal 1 if cash is the term of payment that the patent seeker uses, and 0, otherwise. Source: Thomson One.
Alternative measures	
SM innovation output	Natural logarithm of the sum of 1 and the total dollar value of innovation produced by the firm in year t, based on the stock market. Source: Kogan et al. (2017).
CW innovation output	Natural logarithm of the firm's citation weighted patent value. Source: Kogan et al. (2017).
Geographic distance	Geodetic distance between the headquarters of two firms. Source: Compustat.

A Matching names to PERMNO

USPTO Assignment dataset, Stanford NPE litigation database and Patent litigation docket reports data do not have any firm identifier. So I build an algorithm that standardizes firm names and matches them to PERMNO.

First, I apply strategies of Serrano (2010), Bowen (2016) and Ma (2020) to identify patent acquisition and licensing agreements in USPTO Assignment dataset. Then I process for all licensing and litigation databases in the following order:

1. I eliminate most common misspellings. For example, I find 96 different versions of misspelling of word "corporation".

2. I build an algorithm to standardize most common words like Corporation (CORP), International (INTL), Pharmaceutical (PHARMA) etc.

3. I eliminate entity indicators such as "LLC", "CORP", "INC" etc.

4. I download CRSP database and identify all firm names with PERMNO. I standardize them using (1)-(3)

5. I match firm's names of USPTO Assignment dataset, NPE litigation database and Patent litigation docket reports data to standardized names from CRSP database

6. I eliminate if both parties of transactions have the same PERMNO

B Additional plots

Figure B.1: Probability of firms' integration, by type and patent seeker industry

The figure plots the probability of firms' integration (by type and patent seeker industry) with respect to Patent-holder relative proximity. The probabilities are calculated using multinomial logistic regression. Patent-holder relative proximity is the difference between patent-holder proximity and patent-seeker proximity, where patent-holder (-seeker) proximity measures the extent to which the patent holder's (seeker's) patents cite the patent seeker's (holder's) patent portfolio. Patent-holder relative proximity ranges from 0 (all patent holder's patents do not cite patent seeker's patent portfolio and all patent seeker's patents directly cite patent holder's patent portfolio) to 1 (vice versa). Patent-holder relative proximity equals 0.5 when patent-holder and patent-seeker proximity measures are equal. In the graph the probability of no integration is suppressed.