ESSAYS ON INTELLECTUAL PROPERTY LITIGATION

by

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ABSTRACT

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Essays on intellectual property litigation

Dissertation directed by Professor Jeffrey J. Reuer, Guggenheim Endowed Chair, Professor of Strategy, Entrepreneurship, and Operations

The last couple of decades have witnessed an increase in the number of patent litigations, especially in industries in which patents are a key source of competitive advantage. In my dissertation I examine how patent litigation between firms can influence outcomes at the firm level and at the individual level. In my first essay, I propose that patent litigation conveys negative information about start-ups to incumbent firms. Additionally, I propose that it also undermines the value of signals such as venture capital and alliance network prominence on the formation of alliances in the future. We suggest that these signals aid in the broadcast of the negative information which adversely impacts their prospects of forming alliances. In my second essay, we examine the impact of patent litigation on inventors. Specifically, we propose that such litigation impacts inventor's mobility between firms, in addition to the collaborative relationships they form with inventors within the organization. We suggest that patent litigation, increases the costs associated with their reputation and costs associated with hiring. Additionally, due to an increase in search costs to find collaborators, an increase in costs of collaboration due to reputational concerns of the sued inventors, and the opportunity cost they have to endure to fight litigation, inventors can find it challenging to form relationships that help promote innovation within the firm. Finally, in my third essay, I compare the inclusion of exclusivity provisions in volitional licensing agreements and those that are signed as a result of settlement of patent litigation between parties. Specifically, we suggest that licensing agreements signed post settlement are less likely to include exclusivity provisions due to an increase in the transactional hazards between the parties. Evidence from our data suggest that while exclusivity is used as a contractual safeguard to protect licensee investments in complementary assets especially when there is uncertainty in the technology, this relationship is adversely impacted in the deals signed post settlement. Finally, we also examine the inclusion of exclusivity provisions in settlement contracts signed between parties that relied on relational governance mechanisms such as past licensing relationships. We suggest that it is hard to rebuild the trust that parties once had over repeated interactions with each other, which adversely impacts their choice to grant a partner exclusive access to technologies.

Keywords: Alliance formation, Venture capital firm prominence, Alliance network prominence, Inventor mobility, Inventor collaboration, Exclusive license, Settlement, Transactional hazards, Patent litigation

DEDICATION

This dissertation is dedicated to my family. First, to my parents. You were my earliest teachers from whom I draw much of my perseverance. The sheer amount of hard work and sacrifice that you put into making sure I got the best education in my formative years, as well as consistently creating an environment that ensured that I could focus on my education laid the foundation which helped me get to where I am today. My achievements are because of you. Second, to my sister, Bhavya, my counsellor for life. You always knew how to get me to talk for hours on end which helped me express my thoughts better. Without the technical support you provided in some parts of this dissertation, I would have taken much longer to finish. While I don’t always let you know it, I am incredibly lucky to have you not only as a sister, but as my best friend.

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CHAPTER I

INTRODUCTION

Firms in high-technology industries are engaged in the creation of knowledge which is stored as patented and unpatented intellectual property. To prevent the unauthorized use of their valuable technology by rivals, incumbent firms choose to enforce and protect their intellectual property (IP) using patent litigation. Patent litigation is an exercise that involves substantial private and social costs. For example, litigation curbs firm's innovation and growth, affects venture capital firm investments, and results in a decrease in firm's market value. In this dissertation, I develop new theory and evidence to examine how patent litigation between firms can influence outcomes at the firm level and at the individual level. Specifically, in my first essay I investigate the impact of unresolved patent litigation on collaboration prospects for start-ups. In my second essay, I examine the impact of unresolved lawsuits on their prospects of moving between firms as well as collaboration opportunities within the firm. Finally, in my third essay I look at the one outcome of patent litigation, settlement between parties, and examine its impact on the governance and design choices made by firms. Across three studies, I find evidence that litigation creates a cloud of uncertainty impacting firms and individuals in unexpected ways. These findings have important implications for alliances and signaling theory, for inventor collaboration and mobility, and for interorganizational governance and contract design.

In this introduction, I first provide a brief summary of my three essays concerning the filing and resolution of patent lawsuits and their impact on firm and inventor level outcomes. Next, I preview the arguments and evidence from each of these essays. Finally, I outline my contribution to the various streams of research in strategy and entrepreneurship.

Collaboration under the shadow of litigation

The last couple of decades have witnessed an increase in the number of patent litigations, especially in industries in which patents are a key source of competitive advantage. While most extant research examines how patent litigation affects start-ups' investments in innovation or their ability to raise external financing, it neglects how litigation may also affect their ability to form collaborative relationships with incumbent firms, one of the key avenues of technology development and commercialization. This paper investigates the impact of expensive patent litigation on alliance formation in resource-constrained start-ups. It also examines the implications of litigation on the signals that these start-ups utilize to obtain external resources. Specifically, we suggest that patent litigation conveys negative information about the start-ups to incumbent firms, and patent litigation also undermines the value of signals such as venture capital and alliance network prominence on the formation of alliances in the future. Evidence on these effects of patent litigation are provided from start-ups in the biopharmaceuticals industry.

Inventor disruption in the wake of patent litigation

Prior research on inventor collaboration and their mobility has emphasized how disruptive events such as technological acquisitions or the death of collaborators can impact inventors. However, the impact of adverse events like patent litigation has largely been ignored. It is likely that being in a firm that is embroiled in litigation imposes substantial reputational and opportunity costs to the inventor and affects knowledge creation activities. We fill this gap by first examining the impact of patent litigation on inventors' mobility between firms. We suggest that the prospects of sued inventors to move to rival firms are damaged as subsequent inventions are scrutinized for possible use of litigated technology. Additionally, we examine the impact of formation of collaborative relationships between sued inventors and inventors that they are collaborating with for the first time, as well as the collaborative relationships between sued inventors and inventors that were known to the sued inventor prior to the litigation. Specifically, we suggest that patent litigation increases the cost of collaboration with sued inventors and heterogeneously impacts the formation of subsequent relationships with new and previous collaborators within the firm.

Starting off on the wrong foot: The formation of licensing agreements in the shadow of the court

Prior research on contract design and interorganizational governance has emphasized how the grant of exclusive licenses help reduce transactional hazards between parties. While these licensing deals are typically negotiated and signed on their own volition, the literature is scant on the inclusion of exclusivity provisions when parties are forced to negotiate and come to an agreement. We fill this gap by comparing the inclusion of exclusivity in volitional licensing agreements and those that are signed as a result of settlement of patent litigation between parties. It is likely that negotiations between both parties for a licensing agreement post settlement happen in an environment of mistrust caused by their involvement in a patent lawsuit. We suggest that licensing agreements signed post settlement are less likely to include exclusivity provisions due to an increase in transactional hazards between the parties. Additionally, evidence from our data suggest that while exclusivity is used as a contractual safeguard to protect licensee investments in complementary assets especially when there is uncertainty in the technology, this relationship is adversely impacted in the deals signed post settlement. Finally, we also examine the inclusion of exclusivity provisions in settlement contracts signed between parties that relied on relational governance mechanisms such as past licensing relationships. We suggest that it is hard to rebuild the trust that parties once had over repeated interactions with each other, which adversely impacts their choice to grant a partner exclusive access to technologies. Evidence on these comparisons between contracts are provided from licensing deals in the biopharmaceuticals industry.

Evidence from the three essays

In the first essay, we study the impact of litigation on alliance formation. Specifically, patent litigation can lead to an increase in the uncertainty surrounding a startup even in the presence of credible, positive signals and thereby reduce the value of such signals. We suggest that litigation sends negative information about the startup to potential partners and can spoil a startup's prospects for forming alliances. Additionally, we find that due to the visibility enhancing effects of affiliating with prominent venture capital firms and developing prominent positions in alliance networks, this negative information travels more broadly and further damages the alliance prospects of the new venture. Hence, the paper not only considers how patent litigation shapes alliance formation as a key component of their growth and development, but it also considers how patent litigation might have a bearing on the robustness of widely-known signals employed by startups to obtain external resources. We develop and test our hypothesis on a sample of venture capital backed US startups that were formed in the year 2000 or later in the biopharmaceutical industry. Venture capitalists largely focus their investments on information technology and biopharmaceutical industries and play a significant role in providing private financing to startup firms in these sectors. Thus, more firms in this industry are VC backed. Additionally, new ventures in this industry rely extensively upon alliances to develop and commercialize their technological ideas and innovations. Further, the biopharmaceutical industry is also well documented in literature as one which encourages significant patenting activity, and thus consequently firms in these industries are also prone to patent litigations. Our empirical findings using negative binomial regressions furnish evidence consistent with our theory. To account for the quality of firms that are impacted by patent litigation as opposed to those that are not, we construct a matched sample using coarsened exact matching procedure, by matching on the founding year of the startup, its location, the industry subgroup it belongs to, and the round of funding it has undergone. Our results are robust in this matched sample as well.

In the second essay, we study the impact of patent litigation on their ability to move between firms as well as their collaboration with other inventors within the firm, two activities that help in the creation of knowledge. We suggest patent litigation increases some of the costs of hiring litigated inventors, which can impede their movement between firms. Specifically, we find that patent litigation adversely impacts their likelihood of moving between firms. Additionally, we suggest that patent litigation can impact some of the costs of collaborating with the sued inventors, thus they can impact the creation of collaborative ties between litigated inventors and other inventors from the litigated firm. On the one hand, we show that litigated inventors have difficulties forming collaborative ties with colleagues they have never worked with prior to the litigation. On the other hand, we show that for colleagues with whom they had collaborated with prior to the litigation, we find a positive effect. In this multi-industry study, we test our hypothesis on a sample of inventors that started to apply for patents in the year 2000 or later. We focus on the first litigation case where these inventors were brought to court as defendants. We implemented a difference-in-differences research design and use linear probability models which furnish evidence consistent with our theory. We created a control group that consists of inventors who were active in the USPTO database during the period of the focal inventor's litigation case and had been active in the USPTO database for the same number of years as the litigated inventor. We matched each litigated (treated) inventor to five control inventors. We additionally test for alternate explanations for our findings and find no evidence for the same.

In the third essay, we seek to understand how volitional licensing agreements differ from agreements signed as a result of settlement between parties. We test these differences in the choice to grant exclusive licenses. We suggest that licensing agreements post settlement are less likely to include exclusivity provisions when compared to volitional licensing agreements due to the transactional hazards in dealing with a licensee that the licensor does not trust. Additionally, we argue that the transactional hazards faced by licensees, from the inherent uncertainty present in early stage technologies which drive them towards seeking exclusive deals (Somaya et. al., 2011), are further exacerbated when negotiating for an exclusive license consequent to settling their litigation. Specifically, we find that in licensing agreements that include early stage technologies, the likelihood of being granted an exclusive license are dampened in deals signed post settlement Finally, we also suggest that the licensing agreements signed post settlement increase the uncertainty in dealing with partners with whom the licensors had a prior relationship, due to the breakdown of trust between them. We find partial support for our hypothesis which argues that while past relationships help get an exclusive license, the likelihood of receiving one in deals signed post settlement dampens. Specifically, we find our hypothesis to hold true when there has been limited interactions between the parties in the past. When the number of past relationships increase, we find no effect of settlement on the link between past relationships and exclusivity. This implies that while it is hard to rebuild the trust that parties once had over repeated interactions with each other, perhaps longer repeated interactions can withstand transgressions better than shorter ones. Hence, the paper not only considers how licensing agreements post settlement shape the choice of exclusivity, but it also considers how these settlements might have a bearing on the transactional hazards that drive firms to enter into exclusive licensing deals. We conduct our analysis on a set of 324 licensing agreements signed between firms belonging to the U.S. Biopharmaceutical industry and employ the use of a logistic regression model to find general support for our arguments. This industry setting is ideal for our analysis for several reasons. First, licensors and licensees in this industry rely extensively upon exclusive licenses to develop and commercialize their technological ideas and innovations. Second, licensing activity in the biopharmaceutical industry is shrouded with considerable uncertainty as introduction of a new drug on the market requires expensive and time consuming tests, and often partners face considerable uncertainties regarding the investments made by either in developing and commercializing the. Finally, the biopharmaceutical industry is well documented in literature as one which encourages significant patenting activity, and consequently firms in this context are prone to patent litigations which subsequently end up in settlements (e.g., Lanjouw and Schankerman, 1998; Somaya, 2003) .

Contributions

In the first essay, we contribute to the literature on alliances and signaling theory in several ways. First, we empirically show that patent litigations can adversely impact the rate of alliance formation for new ventures. While there is prior research on how a single landmark court decision can impact alliance formation of firms that are public (Filson and Oweis, 2010), our results are more detailed since they examine the micro impact of litigations that each firm attracts as opposed to a broad court decision which impacts multiple firms within the industry. Additionally, our study is distinct in investigating these implications of patent litigation for private firms, who face restricted access to capital and product markets and have difficulties in raising funding. Second, we show that while signals can broadly transmit information about the underlying nature and quality of startups' resources and market prospects, their benefits become limited in the face of patent litigation. Specifically, we show that affiliation with prominent third parties such as venture capital firms and prominent positions developed by firms in their alliance networks, on firm's ability to form alliances can be less beneficial in the context of negative information presented in the form of litigation. The enhanced visibility due to these signals can deteriorate the rate at which these new ventures form alliances. We therefore show that an event such as patent litigation can cause even strong and credible signaling activities from the firm to result in differential impact. (e.g., Gulati and Higgins, 2003; Jensen, 2004; Hsu, 2006; Ozmel *et al.*, 2013).

In the second essay, we contribute to the literature on collaboration and mobility in several ways. First, we show how litigations can be disruptive to the career of an inventor by impacting their mobility. Scholars have shown how technological acquisitions can motivate some inventors to consider changing their jobs (Ernst & Vitt, 2000; Seru, 2014). While the market for an inventor impacted by a disruptive event such as an acquisition might be unaffected, the market for an inventor impacted by a disruptive event such as a patent litigation might shrink. In other words, the sued inventor might not be viewed favorably by competitors when making hiring decisions due to concerns with the costs associated with their reputation and costs associated with hiring. Second, we show that patent litigations differentially impact the formation of collaborative ties between litigated inventors and other inventors in the litigated firm. Prior literature has shown that disruption to inventors commonly occurs during the death of their collaborators (Azoulay, Zivin, and Wang, 2010) or during corporate development activities undertaken by firms such as technological acquisitions. In the face of patent litigations, inventors from the focal firm itself can find it challenging to form relationships that help promote innovation, due to an increase in search costs to find collaborators, an increase in costs of collaboration due to reputational concerns of the sued inventors, and the opportunity cost they have to endure to fight litigation. Finally, we separately analyze the collaborative relationships between sued inventors and inventors that they are collaborating with for the first time, and the collaborative relationships formed between sued inventors and inventors that were known to the sued inventor before the litigation. In doing so, we highlight how the formation of these different ties are impacted by a patent litigation.

In the third essay, we contribute to the literature on the interorganizational governance and contract design in several ways. First, to our knowledge this study represents the first attempt to understand the differences between licensing agreements signed as a consequence of settlement between parties under the shadow of a court and volitional licensing agreements. This adds a novel perspective to the mechanisms of contract design by explicitly theorizing on the influence of the “shadow of the court” on contract design. Second, we show that the choice to grant an exclusive license becomes even more salient in the context of settlement agreements. While prior studies have argued that the choice to grant an exclusive license is subject to the transactional hazards faced by the parties (e.g., Somaya et al., 2011), we show that these hazards are amplified when parties settle their patent litigation. Third, prior literature has argued how exclusive licenses can provide contractual safeguards to licensees in the face of the technological uncertainties that are present in early stage technologies as well as protect them from opportunistic behavior by licensors (e.g., Deeds and Hill, 1999; Somaya et. al., 2011). We show that these hazards are further exacerbated when parties negotiate licensing agreements post settling litigation for early stage technologies. Finally, while prior studies have discussed how reliance on relational governance mechanisms such as interfirm trust can complement formal contracts and reduce the transaction costs between firms (Poppo and Zenger, 2002; Ryall and Sampson, 2009), the impact of the breakdown of trust as a result of the litigation between them and their subsequent impact on the choice to grant exclusivity in formal contracts has been ignored. We show that it is hard to rebuild the trust that parties once had over repeated interactions with each other, which adversely impacts their choice to grant a partner exclusive access to technologies.

CHAPTER II

COLLABORATION UNDER THE SHADOW OF LITIGATION

Introduction

Startups often suffer from restricted access to capital and product markets because of deficient track records (e.g., Rao 1994), and they face challenges in assembling organizational resources for developing their ideas (e.g., Stinchcombe, 1965; Shane and Stuart, 2002). To overcome these impediments to growth, gain access to complementary resources and quickly translate their nascent ideas and innovative technologies into profitable outcomes, startups seek to enter into strategic alliances with established firms. Furthermore, these alliances help startups gain access to better infrastructure and financial resources for research and development (R&D), appropriate returns from knowledge, and gain access to a partner's customers and network of distributors or marketers (e.g., Pisano, 1989; Greis, Dibner, and Bean, 1995; Eisenhardt and Schoonhoven, 1996; Stuart, Hoang and Hybels, 1999; Ahuja, 2000; Lerner, Shane and Tsai, 2003; Rothaermel and Deeds, 2004; Baum and Silverman, 2004; Stuart, Ozdemir, and Ding, 2007; Katila, Rosenberger, and Eisenhardt, 2008).

From the perspective of incumbent firms, however, there is an inherent uncertainty regarding the market prospects of start-ups' latent technologies and consequently a risk of adverse selection. Such risks can make incumbent firms sceptical of allying with start-ups (e.g., Nicholson, Danzon, & McCullough, 2005; Shipilov, Rowley, & Aharanson, 2005). Prior research in strategy and entrepreneurship has shed light on the various ways by which startups attempt to alleviate the effects of informational asymmetries on their ability to transact with investors and strategic partners (e.g. Long, 2002; Certo, 2003; Sanders and Boivie, 2004; Dewally and Ederington, 2006). Specifically, research on interorganizational collaborations formed in high-tech industries has emphasized the roles played by signals such as third-party affiliations with prominent venture capital (VC) firms (Stuart et. al., 1999) and the prominence due to positions developed by new ventures in their alliance networks (Gulati and Gargiulo, 1999; Podolny, 2001) to convey information about their quality to incumbent firms. The new venture's affiliation with prominent VCs and partners help differentiate the start-up from other new ventures as both these signals are observable, costly for new ventures to obtain, and they are correlated with the true underlying quality of the start-up.

While prior research on interorganizational collaborations and signaling theory has emphasized that high quality new ventures can differentiate themselves from other ventures using signals that convey information about their quality to incumbents (Gulati and Higgins, 2003; Ozmel, Reuer, and Gulati, 2013), the impact that patent litigation can have on their alliance prospects, as well as on the credibility and effectiveness of signals, has been neglected. Much of the literature on intellectual property (IP) litigation views it as an exercise that involves substantial private and social costs. For example, literature has shown that patent litigation significantly affects the funding that technology startups receive from VCs (Kiebzak, Rafert, and Tucker, 2014), and patent litigation also adversely affects investments in innovation by lowering the returns from R&D and by exacerbating financing constraints, thereby curbing further innovation and growth. (Bessen and Meurer, 2008; Boldrin and Levine, 2002; Jaffe and Lerner, 2011). Depending on the amount that these startups are sued for, the costs per side can go up to four million dollars (AIPLA Report of Economic Survey, 2003; Smeets, 2014). Thus, in the context of the resource constraints that start-ups experience, these patent litigations create an additional burden on the resources that these firms must dedicate to fight litigation. Patent litigation also involves substantial opportunity costs. Given startups' reliance on alliances to develop and commercialize their technologies, it would also be interesting and valuable to investigate whether and how patent litigation has a bearing on collaborative agreements.

In this paper, we study the impact of litigation on alliance formation. Specifically, patent litigation can lead to an increase in the uncertainty surrounding a startup even in the presence of credible, positive signals and thereby reduce the value of such signals. We suggest that litigation sends negative information about the startup to potential partners and can spoil a startup's prospects for forming alliances. Additionally, we find that due to the visibility enhancing effects of affiliating with prominent venture capital firms and developing prominent positions in alliance networks, this negative information travels more broadly and further damages the alliance prospects of the new venture. Hence, the paper not only considers how patent litigation shapes alliance formation as a key component of their growth and development, but it also considers how patent litigation might have a bearing on the robustness of widely-known signals employed by startups to obtain external resources.

In so doing, we contribute to the literature on alliances and signaling theory in several ways. First, we empirically show that patent litigations can adversely impact the rate of alliance formation for new ventures. While there is prior research on how a single landmark court decision can impact alliance formation of firms that are public (Filson and Oweis, 2010), our results are more detailed since they examine the micro impact of litigations that each firm attracts as opposed to a broad court decision which impacts multiple firms within the industry. Additionally, our study is distinct in investigating these implications of patent litigation for private firms, who face restricted access to capital and product markets and have difficulties in raising funding. Second, we show that while signals can broadly transmit information about the underlying nature and quality of startups' resources and market prospects, their benefits become limited in the face of patent litigation. Specifically, we show that affiliation with prominent third parties such as venture capital firms and prominent positions developed by firms in their alliance networks, on firm's ability to form alliances can be less beneficial in the context of negative information presented in the form of litigation. The enhanced visibility due to these signals can deteriorate the rate at which these new ventures form alliances. We therefore show that an event such as patent litigation can cause even strong and credible signaling activities from the firm to result in differential impact. (e.g., Gulati and Higgins, 2003; Jensen, 2004; Hsu, 2006; Ozmel *et al.*, 2013).

We conduct our empirical analysis using the biopharmaceutical industry as our context. Venture capitalists largely focus their investments in information technology and biopharmaceutical industries (e.g., Lerner, 1995; Hsu, 2006) and play a significant role in providing private financing to startup firms in these sectors (e.g., Sahlman, 1990). Thus, more firms in this industry are VC backed. Additionally, new ventures in this industry rely extensively upon alliances to develop and commercialize their technological ideas and innovations (e.g., Pisano, 1990; Powell, Koput, and Smith-Doerr, 1996; Roijakkers and Hagedoorn, 2006; Anand, Oriani, and Vassolo, 2010). Further, the biopharmaceutical industry is also well documented in literature as one which encourages significant patenting activity (Cohen, Nelson, and Walsh, 2000; Klevorick et al., 1995; Levin et al., 1987), and thus consequently firms in these industries are also prone to patent litigations. Our empirical findings using negative binomial regressions furnish evidence consistent with our theory.

Theory and Hypotheses

Information costs may arise for startups if they wish to avoid disclosing proprietary information, critical for the venture's valuation and growth, in the fear of being misappropriated by potential partners (Arrow, 1962). These startups also have incentives to misrepresent information regarding their intangible resources and prospects, which can make partners wary of an alliance (e.g., Nicholson et al., 2005; Hsu, 2006). Potential partners thus discount the resources and prospects of startups in the presence of information asymmetry, giving rise to the common problem of adverse selection in product, technology, and other markets (Akerlof, 1970). We begin by suggesting that this problem of adverse selection is exacerbated in the presence of patent litigation. As we will elaborate below, patent litigation can increase the uncertainty surrounding the technical and commercial prospects of startups' technologies, not to mention can raise questions about the broader viability of these startup organizations, making potential partners cautious when considering alliances with new ventures subject to litigation.

At the same time, high quality technology startups that possess good ideas and technologies generally seek to separate themselves from inferior startups through credible signals that convey information about their unobservable quality to potential partners (e.g. Stuart et. al. 1999). Signaling theory as developed by Spence (1973) emphasizes that credible signals need to satisfy three essential conditions. They must be (1) observable; (2) costly to obtain, in other words, either an unproductive or a productive investment needs to be made; and (3) such a signal should be correlated with the true quality of the underlying asset (e.g., Luo, Koput, and Powell, 2009). Taken together, these criteria indicate that signals are received and that they can differentiate a firm with attractive resources and prospects from others. For instance, in order to achieve credible signaling, high quality ventures may be willing to give up shares at a discount in order to gain affiliations with prominent VCs (Hsu, 2004). Alternatively, new ventures might take a discount on the first alliance they form to signal their quality by partnering with a prominent incumbent firm (Nicholson, Danzon, & McCullough, 2005). In both cases, investors capture a part of the benefits they provide startups (e.g., future partnerships or investments), and startups are willing to bear this cost of signalling because they can recoup these costs through future business opportunities that are opened up by these affiliations. Firms might signal their value in a variety of ways, particularly as they mature (e.g., board structure, board diversity, board prestige, exporting, engaging prominent underwriters, stock based incentives for the top management team, institutional stock ownership, top management team Legitimacy) (Certo, Daily, and Dalton, 2001; Filatotchev and Bishop, 2002; Certo, 2003; Higgins and Gulati, 2003; Cohen and Dean, 2005; Shaver, 2011), but these two interorganizational relationships have been shown to be critical signals early on in the development of technology ventures, including the formation of partnerships in particular (Stuart et al., 1999; Hsu, 2004; Hsu, 2006; Gulati and Higgins, 2003; Jensen, 2004; Ozmel et al., 2013).

While existing literature on signalling theory has extensively studied the overall impact of VC prominence and alliance network prominence on raising money and other resources from external capital markets, private investors, or partners (Stuart et al., 1999; Gulati and Higgins, 2003; Hsu, 2004; Hsu, 2006; Ozmel et al., 2013), they largely focus on the benefits of such signals in aiding the transmission of information that is favorable to the startup. However, we are yet to understand the degree to which these beneficial effects of signals diminish or are robust in the face of new, negative information about the startup's technologies and prospects. We posit that patent litigation is one such source of negative information that might undermine the development and prospects of new ventures.

Patent litigation

Smaller firms are much more likely to be the subject of Intellectual Property Right (IPR) law suits than larger firms (Lanjouw and Schankerman, 2004). Further, these IPR litigations are more frequent in newer technology areas (Lanjouw and Shankerman, 1998). They have an inverted U shape relationship on the prospects of raising VC funding (Tucker, 2014), and they also tend to halt investments in innovative research and development activities (Boldrin and Levine, 2002; Bessen and Meurer, 2008; Smeets, 2014). In addition to lowering the returns to innovation, and impacting VC funding, they are also expensive to fight in court, and can take several months to resolve (Chien, 2013). Further, precious time spent towards developing and commercializing innovative products is now reduced and is instead diverted towards fighting patent litigation (AIPLA Report of Economic Survey, 2003). Given the resource constraints faced by technology startups, the opportunity costs of these lawsuits can be considerable. These studies highlight how start-ups are afflicted by patent litigation and consequently how their funding and innovation outcomes are adversely affected.

Incumbent firms choose to aggressively enforce and protect their intellectual property using patent litigations (Agarwal, Ganco, and Ziedonis, 2009). They are able to do so especially in countries with strong institutions such as the US where they create a patent thicket around their products which can then be used to deter rivals from using their technology (Paik and Zhu, 2016). Indeed, the patent holder can choose to not settle the patent litigation based on the value of the patent to the firm (Somaya, 2003). On the one hand, if the defendant is the holder of patent, then these firms seek to file a counterclaim using their large patent stock or bring into question the validity and the scope of the legal right granted to such firms (Lemley and Shapiro, 2005). Plaintiffs in such cases seek an injunction against the technologies possessed by new ventures, consequently stifling the competition in the product market. On the other hand, if the defendant does not hold the patent, then these plaintiffs can sue for infringement of their intellectual property. The damages sought by and awarded to plaintiffs under these circumstances can be very high (Smeets, 2014).

We suspect that patent litigation can also have important implications for markets for partners and technologies, though these connections have yet to be pursued in the extant literature. In particular, potential partners are faced with greater uncertainty surrounding the technical and commercial prospects of a start-up's ideas and technologies derived from the considerable legal uncertainty that litigation brings forth. First, when the suit is yet unresolved, it casts a shadow on the value that partner firms can derive from a technology which is mired in litigation, and litigation therefore calls into question the subsequent commercialization prospects of such a technology. Second, given the resource constraints that start-ups face, which is exacerbated by the high cost of litigation, the start-up might not be able to devote the resources, time, and attention to a partnership, as desired by a potential collaborator. This suggests that litigation involving technologies other than the focal ones in a collaboration can undermine the development and commercialization of technologies in an alliance. Given that incumbent firms provide up-front payments as well as other financial and non-financial resources to startups, these resources might be diverted to other projects or to fighting the litigation itself. In a worst-case scenario, a plaintiff could also sue the potential partner if it deems that the partner had made, used, or sold the technology under litigation (Bessen, Meurer, and Ford, 2011). In sum, patent litigation brings several sources of uncertainty that can cause potential partners to shy away from allying with start-ups under litigation. We therefore posit:

Hypothesis 1: Being litigated in patent lawsuits will negatively affect the rate at which new ventures form alliances.

Affiliations with prominent venture capital firms

New ventures often rely on their affiliations with prominent third parties to convey information regarding their technologies to potential partners. These prominent third parties act as brokers of information through the social contacts they acquire by joint investing in new ventures (Sorenson and Stuart, 2001). They gain more prominence in their networks because their partners, in addition to investing with them, also invest jointly with other VC firms in other new ventures (Sorenson and Stuart, 2001).

Further, prominent VCs conduct extensive due diligence before investing in a firm. (Megginson and Weiss, 1991; Hsu, 2006; Koka and Prescott, 2008). They also frequently exchange information with each other about their evaluations of the new venture (Li, 2008) thus forming an extensive communication channel through their networks. Thus, new ventures that rely on prominent VC firms to signal their quality are also highly visible in the VCs syndicate networks, and information about them can quickly travel to the market in general via that network.

Prominent VCs help the startups by not just providing financial resources, but also use their extensive network to facilitate partnerships between investees and recruit talented human capital (Bygrave and Timmons, 1992; Hellmann and Puri, 2000, 2002; Reuer and Devarakonda, 2017). Affiliating with prominent VCs also helps startups alleviate the concerns related to the viability and value of startups' latent technologies (Gulati and Higgins, 2003). Finally, these affiliations help startups establish alliances with incumbent firms (Hsu, 2006). In sum, backing by prominent VCs help startups access resources, make them attractive to potential partners, and help them utilize VC networks to increase visibility and improve access to information.

While, such affiliation can be advantageous in the presence of information that is favorable to the start-up, it can also be less beneficial when the information is not favorable to the start-up. When the new venture is under patent litigation, negative information about the new venture's technologies can hamper its prospects of alliance formation for two reasons. First, the high visibility of a prominent VC firm in its syndicate network, would imply that the negative information about the firm is highly visible as well, thus damaging its alliance formation prospects. In the absence of such affiliation, the firm perhaps would be under the radar and could possibly contain the broadcast of negative information. Second, the high visibility of the VC firm would also increase the perceived litigation risk for the startup or the potential for higher demands for license fees for their product, constraining the stream of potential future revenues (Tucker, 2014). Given the further limited commercial prospects of the technologies held by the startup, in addition to the legal uncertainty surrounding the technologies, potential partners would be hesitant to form alliances.

Hypothesis 2: The positive effects of a new venture's affiliation with prominent venture capitalists on the rate of alliance formation will be reduced with patent litigation.

Prominent positions in alliance networks

While affiliation with prominent third parties such as VCs help improve start-ups' prospects, they also rely on their own network of alliance partners to help shape the formation of new alliances. Prior studies have established a clear role for prominent positions developed in alliance networks on the prospects of new ventures to form alliances (e.g., Gulati and Gargiulo, 1999; Jensen, 2003; Gulati & Higgins, 2003). These studies have argued that prominent firms have greater access to information and higher visibility than other firms in that network which can increase the attractiveness of start-ups and can help shape the formation of new alliances.

Further, just like VC firms, alliance partners also carry out due diligence on new ventures before partnering with them (Ozmel, Robinson, and Stuart, 2012). Thus, the fact that ventures have developed prominent positions in alliance networks makes it easier for them to signal and differentiate themselves from other start-ups. As a result, prominent positions in prior alliance networks generally help facilitate future alliances for new ventures (Ozmel et al., 2013). However, this visibility can be detrimental when the firm is under patent litigation in two ways.

First, a new venture that is under patent litigation might be at risk of losing its prominent position in its alliance networks due to the legal uncertainty surrounding its technologies. Thus, the risk of adverse selection is exacerbated for potential partners regarding the value of the alliance with this new venture. Second, by being in a prominent position, negative information about the venture's lawsuit is broadcast throughout its network making it harder for the venture to find alliance partners. From the perspective of incumbent firms, they would be wary of the contested intellectual property that the new venture possesses. Thus, we expect that signal of a new venture's alliance network prominence would be diminished in forming alliances particularly when the venture is under patent litigation.

Hypothesis 3: The positive effects of a new venture's prominent position in alliance networks on the rate of alliance formation will decrease with patent litigation.

Methods

Data and Sample

To test our hypotheses, we merge four different databases to identify information ranging from firms' litigations, alliance formation, their venture information, and patent data. We begin with a sample of venture capital backed US startups that were formed in the year 2000 or later in the biopharmaceutical industry, as captured by Thomson Reuters' VentureXpert database. Most startups in the biopharmaceutical industry are VC-backed, because venture capitalists largely focus their investments in information technology and biopharmaceutical industries (e.g., Lerner, 1994; Hsu, 2006) and play a significant role in providing private financing to startup firms in these sectors (e.g., Sahlman, 1990). Next, in this sample, we manually matched the venture names with those that are brought to court as defendants in patent litigation cases in any of the US courts during the fifteen years from 2000 to 2014. Data to construct our patent litigation variable was assembled from the database provided by LexMachina, which records patent litigations starting from the year 2000. Among the 605 firms that received venture funding, we find that there are 52 firms (8.6%) that are listed as defendants of patent litigation at least once. We then obtained patent information for firms from PatentsView and used their disambiguated assignee names to match them with our sample of firms. We construct a panel where each observation represents a firm-month-year. We do this because on average patent litigations take 11-14 months to get resolved (Chien, 2013), and we would be able to account for the richness in the filing and termination of a lawsuit using such a unit of analysis. The firm exits the sample when it either makes an Initial Public Offering (IPO), or when the last financing round of the firm was 84 months (7 years) from the focal month.

Finally, we use the Thomson Reuters' Recap database to identify all the alliances that are formed in the biopharmaceutical industry by these ventures, starting from January 2000 to December 2014. This database is extensive in its reporting of alliance activity in this industry (Schilling, 2009) and also widely used in the literature (e.g., Ozmel, et. al., 2013). In their data, Recap denotes the party that provides the intellectual property, technology, and R&D services, as the R&D firm, and the counterparty that obtains the license as the client firm.

This industry setting is ideal for our analysis for several reasons. First, new ventures in this industry rely extensively upon alliances to develop and commercialize their technological ideas and innovations (e.g., Pisano, 1990; Powell, Koput, and Smith-Doerr, 1996; Roijakkers and Hagedoorn, 2006; Anand, Oriani, and Vassolo, 2010). Second, collaborative activity in the biopharmaceutical industry is shrouded with considerable uncertainty, and often alliance partners face considerable uncertainties about the prospects of biotech ventures (e.g., Pisano, 1990; Powell, Koput, and Doerr-Smith, 1996; Lerner and Merges, 1998; Jones and Clifford, 2005). Third, these ventures often have short track records and technological resources and capabilities that are difficult to judge (e.g., Stuart et al., 1999; Nicholson, Danzon, and Mccullough, 2002; Levitas and McFadyen, 2009). Fourth, the biopharmaceutical industry is well documented in literature as one which encourages significant patenting activity (Cohen, Nelson, and Walsh, 2000; Klevorick et al., 1995; Levin et al., 1987), and consequently startups in this context are prone to patent litigations. Finally, information on this industry's ventures and their alliance activities are well documented, providing the necessary rich data for rigorous empirical study.

Variables and measurement

Dependent variable. Our main dependent variable is measured as the total number of alliances formed by the focal venture in a 12-month forward window, using data provided by Recap (*Collaborations*). In our sample, the average number of alliances formed by a venture is 1.39, with a maximum of 40 alliances formed in the 12-month forward window.

Explanatory variables. Our main independent variable is an indicator variable that takes the value of 1 if a venture has been under patent litigation anytime in the past 12 months, preceding the focal month, and zero otherwise (*Under Litigation*). In supplemental analyses, we reduced the window to 6 months and 24 months and found this did not alter the results presented below.

As established in prior literature in strategy and sociology (Podolny, 1993, 1994, 2001), we calculate a venture capital firm's prominence (i.e., *VC Prominence*) in their syndicate networks using the centrality measure as defined in Bonacich (1987). The centrality measure as mentioned in Bonacich (1987) includes both the direct and indirect ties formed by the VC firm. To calculate the centrality of the focal VC firm in year t, we measure all the direct and indirect ties formed between the focal VC firm and the other VC firms during the five years preceding the focal year (t-5 to t-1).

$$\text{VC firm centrality}_{i,t}\ (C_{i,t}) = \sum_{j=1}^{N_t} (\alpha_t + \beta_t C_{j,t}) R_{i,j,t}$$

where $C_{j,t}$ is the centrality score of VC firm j in year t, and $R_{i,j,t}$ is an element of the relationship matrix R_t, indicating the co-investments between VC firms i and j during the five-year window. α_t is a scale parameter chosen so that the sum of the squares of centralities of all firms in a network in a particular year equals the number of units in the network (i.e., N_t). β_t is a weighting coefficient, indicating the effect of centralities of investment partners on the firm's centrality and is conventionally set to three-fourths of the reciprocal of the largest eigenvalue of the relationship matrix R_t

Since at any given time t, typically more than one VC invests in the focal venture, we calculate the mean centrality of the VCs invested in that venture as of time t (Ozmel, Reuer, Gulati, 2013). In unreported supplemental analysis, we also calculated the maximum centrality of all the VCs that have invested in the new venture as of time t (Gompers and Lerner, 2004), and we found that the results reported below are robust.

We similarly calculated the focal venture's prominence (Bonacich, 1987) in its alliance networks using the new venture's alliance formation activity within the last five years preceding the focal year (t-5 to t-1) (i.e., *Alliance Network Prominence*) (Baum and Silverman, 2004; Ozmel, et. al. 2017) using the same method described above. In unreported supplemental analysis, we also calculated its alliance activity within the last three years preceding the focal year and found qualitatively similar results.

Control variables.

We begin by adding a control for the total number of patents each venture was granted in the five years preceding the focal year, as a proxy for the knowledge stock held by the venture (*Citation Weighted knowledge stock)*. Being innovative can help the new venture's prospects, and together with forward citations can be inferred to be a measure of their quality (e.g., DeCarolis & Deeds, 1999; Stuart, 2000). We further weighted these patent counts with the forward citations received by the firm as they indicate the impact and value that a patent has had in a technological field. We next control for the size of the syndicate (*Size of the VC Syndicate)*, by calculating the number of VCs that have invested in the new venture (Gompers & Lerner, 2004). Finally, we also account for the *Number of VC funding rounds* that the venture has undergone.

Analysis and Results

Statistical Analyses

Given that our dependent variable is a count variable, and that the conditional variance exceeds the conditional mean we employ the use of negative binomial regressions as an estimation procedure. Negative binomial regressions also relax the assumption of the equality in the mean response and variance, which is imposed by Poisson models, and they also account for potential omitted variable bias (Cameron and Trivedi, 1986; Hausman, Hall, and Griliches, 1984). In further supplemental analysis discussed below, we construct a sample of control firms that are identical to the treated (litigated) firms using a coarsened exact matching (CEM) procedure and utilize the negative binomial regression on the sample as well.

Tables 1a and 1b present descriptive statistics and the correlation matrix. Consistent with our first hypothesis, we see that there is a negative correlation between our main independent variable, *Under Litigation* and our main dependent variable, *Collaborations*. Additionally, the signal sent out by being affiliated with a prominent VC (*VC Prominence),* as well as the venture's prominence in its alliance networks (*Alliance Network Prominence*) exhibit positive correlations with *Collaborations* variable (p<0.05), which is consistent with prior literature (Ozmel et al., 2013).

---------- Insert Table 1a ----------

---------- Insert Table 1b ----------

We now turn to regression analysis to examine the impact of patent litigation on alliance formation, and additionally examine how litigation moderates the relation between alliance formation and the venture's third-party affiliations and the venture's embeddedness in alliance networks. In Table 2, we report results of negative binomial models where the dependent variable is *Collaborations*, the total number of alliances formed by the focal venture in a 12-month forward window. We report heteroskedasticity-robust standard errors clustered on the venture firms. All specifications include the full set of control variables as described previously. We also include month and year fixed effects. Model (1) is the baseline model with only the main explanatory variables and controls. Model (2) includes the main effects and the interaction between *Under Litigation* and the *VC Prominence* variable. Likewise, Model (3) includes main effects and the interaction between *Under Litigation* and our measure of *Alliance Network Prominence*. Finally, Model (4) includes the full set of interactions.

---------- Insert Table 2 ----------

Across all specifications (1)-(4), the coefficient on *Under Litigation* is negative and statistically significant with p<0.01. This provides strong empirical support for our hypothesis 1. For instance, in the full model (4), the coefficient of -0.89 on *Under Litigation* indicates that being litigated in patent lawsuits will reduce the rate at which new ventures form alliances by 59%. We also find positive and statistically significant main effects for *VC Prominence* and *Alliance network prominence* in all models. This is consistent with prior literature on interorganizational collaborations formed in the high-tech industry that has emphasized on the positive role played by third party affiliations and the positions developed by the new venture in its alliance networks on future alliance formation. (Hsu, 2006; Ozmel et al., 2013)

In Model (4) we bring the full set of interactions to the data. The results and signs of the coefficients of our key independent variables and interaction terms are consistent with our hypothesis. The interaction coefficient between *Under Litigation* and *VC Prominence* variables is negative and statistically significant ($p<0.01$). This lends credence to our second hypothesis that the positive effects of a new venture's affiliation with prominent VCs on the rate of alliance formation reduces with litigation. Additionally, the interaction coefficient *Under Litigation* and *Alliance network prominence* variables is negative and statistically significant ($p<0.01$). Thus, hypothesis 3 is also supported. The positive effects of a new venture's position in alliance networks on the rate of alliance formation also decrease with litigation.

Given that we estimate a non-linear model, we also plot the interaction coefficients in Figures 1 and 2. We observe an apparent downward slope in Figure 1 which shows the diminishing effect of the *VC Prominence* signal on the rate of alliance formations as a firm is increasingly under patent litigation. In figure 2 as well, we observe that there is a negative effect of new venture's prominent position in alliance networks on the rate of alliance formations as the firm is increasingly under patent litigation.

Robustness Analyses

To account for the possible differences in quality of firms that are attracting litigation compared to those that are not, we begin by constructing a control group of firms that are identical to the litigated firms on certain characteristics. We use the coarsened exact matching procedure (Blackwell, Iacus, King, and Porro, 2010) to construct our matched sample. The idea behind CEM is to temporarily coarsen each variable into substantively meaningful groups. One then does an exact match on these coarsened data and then only retains the original (uncoarsened) values of the matched data. To generate the groups, we adhere to the following steps. First, the control firm must be in the same Industry Subgroup as the treated firm in VentureXpert, since different industry subgroups can have different propensity to attract litigation and can form alliances differently from others. Second, the control firm must be founded in the same State as the treated firm since the geographic distance is known to affect alliance formation (Reuer and Lahiri, 2013). Third, the control firm must have undergone the same round of funding as the treated firm. The more the funding, the less reliant the firm needs to raise capital from potential partners to commercialize their technologies (Gulati and Higgins, 2003; Ozmel et. al., 2013). Fourth, we also consider the founding year of the control firm, since we want them to be similar to the conditions in which the treated firm was founded. We perform CEM based on the outlined steps and find that the measure of overall imbalance with respect to the full joint distribution of the covariates as indicated by the multivariate L1 distance statistic, dropped from 0.55 to 0.18, indicating a good match as a substantial reduction of imbalance is observed (Blackwell et al., 2010) (See Table 3 for estimation results). The L1 statistic varies between 0 and 1, with larger values of the statistic indicating larger imbalance between the groups.

---------- Insert Table 3 ----------

Across all specifications, the coefficient on *Under Litigation* is negative and statistically significant with p<0.01. This provides strong empirical support for our hypothesis 1. For instance, in the full model (4), the coefficient of -0.80 on *Under Litigation* indicates that being litigated in patent lawsuits will reduce the rate at which new ventures form alliances by 55% even when we account for differences in quality of the firms being litigated. As before, in Model (4) we bring the full set of interactions to the data. The results and signs of the coefficients of our key independent variables and interaction terms are again consistent with our hypotheses. The interaction coefficient *Under Litigation* and *VC Prominence* variables is negative and statistically significant (p<0.01) even in this sample. This lends confidence to our second hypothesis that the positive effects of a new venture's affiliation with prominent VCs on the rate of alliance formation reduces with litigation. Additionally, the interaction coefficient *Under Litigation* and *Alliance network prominence* variables is negative and statistically significant (p<0.01). Thus, hypothesis 3 is also supported. The positive effects of a new venture's position in alliance networks on the rate of alliance formation also decrease with litigation.

Second, in unreported estimates, we also used the zero-inflated negative binomial (ZINB) regressions due to the presence of a sizeable number of zeroes in our dependent variable (about 60%). This model assumes that the zeroes are generated by a different process than the other counts in the dependent variable. In the first stage of the model, a binary probability model first determines whether a zero or a nonzero outcome occurs, and then a second stage negative binomial regression is run on the non-zero outcomes. The Vuong test is an erroneous measure to test whether the negative binomial should be used over the ZINB because the non-zero-inflated negative binomial model is not strictly non-nested in its zero-inflated counterpart (Wilson, 2015). The results support our hypothesis.

Discussion

Key Findings and Contribution

The last couple of decades has witnessed a significant increase in the number of patent litigations, especially in industries in which patents are a key source of competitive advantage. While most extant research examines how patent litigation affects start-ups' investments in innovation or their ability to raise external financing, it often neglects how litigation may also affect their ability to form collaborative relationships with incumbent firms; one of the key avenues of developing and commercializing their technologies. We investigate the impact of firm level patent litigation on the formation of alliances by new ventures. We find strong empirical evidence that patent litigation adversely impacts the rate at which start-ups form alliances in the high-tech industry. In addition, we also examine the effectiveness of signals on alliance formation when the venture is under patent litigation. While, the remedial role of affiliation with prominent VCs and prominent positions in alliance networks might be valued by incumbent firms as credible signals that convey information about their unobservable qualities, their effectiveness in attracting potential partners is reduced when the firm is under patent litigation.

We contribute to the literature on alliances and signaling theory in several ways. First, we advance understanding about the determinants of alliance formation. We empirically show that patent litigations can adversely impact the rate of alliance formation for new ventures. While there is prior research on how two landmark court rulings impacted alliance formation for recently public firms (Filson and Oweis, 2010), our study is the first to investigate its impact on private firms who face restricted access to capital and product markets and encounter difficulties in raising funding easily. Further, our results are more detailed since they depend on the differential impact of litigations that each firm attracts as opposed to a broad court decision which impacts multiple firms within the industry.

Second, we show that while signals can broadly transmit information about the underlying quality of startups', their benefits are limited. Specifically, we show that affiliation with prominent third parties such as venture capital firms and prominent positions developed by firms in their alliance networks on firm's ability to form alliances can be less beneficial in the context of negative information presented in the form of litigation. The enhanced visibility due to these signals can dampen the rate at which these new ventures form alliances.

Limitations and Future Research Directions

Future research could improve on this paper in several directions. First, we have not yet distinguished between the patent litigations initiated by rival firms from the ones initiated by Non-Practicing entities (NPEs). In our setting, this concern is allayed by survey based and empirical evidence that the biopharmaceutical industry has seen far fewer patent demand letters from NPEs than in sectors like software, or chemicals and manufacturing (Chien, 2013; Tucker, 2014). In other sectors, NPEs are said to initiate frivolous litigations by alleging infringement using low quality patents (Shreshta, 2010). Nevertheless, further studies could expand on our study and discuss the differential impact of litigation initiated by incumbent firms vis-à-vis those initiated by NPEs.

Second, future research can also examine the generalizability of our findings on the effectiveness of signals by studying high-tech ventures beyond the biopharmaceutical industry. For example, the software industry is another sector where technological entrepreneurship is increasingly prevalent and where IP in the form of patents are a key source of competitive advantage.

Finally, given our focus on VC prominence and alliance network prominence as signals which are heavily emphasized in the alliance research to help form strategic alliances, ample opportunities exist to examine other signals that can potentially remedy the negative effect of patent litigation.

Notwithstanding these limitations, we believe that this study provides significant contributions to the relation between patent litigation and inter-organizational collaborations.

Table 1a: Descriptive Statistics

Variables	**Definitions**	**Mean**	**Standard Deviation**
Collaborations	Total number of alliances formed by the focal venture in a 12-month forward window	1.38	3.17
Under Litigation	Dummy that takes value 1 if the venture underwent patent litigation in the past 12 months, preceding the focal month	0.01	0.09
VC Prominence	Centrality measure for venture capital firm's prominence in their syndicate networks (as defined in Bonacich, 1987)	0.03	0.03
Network Prominence	Focal venture's centrality in its alliance networks (as defined in Bonacich, 1987)	.003	0.007
Citation Weighted Knowledge Stock	Total number of patents the venture was granted in the five years preceding the focal year	0.65	3.61
Size of VC Syndicate	Number of venture capital firms that have invested in the new venture	9.24	12.39
Number of VC Funding Rounds	Number of venture capital funding rounds	2.59	2.65

N=65701

Table 1b: Correlation Matrix

		1	2	3	4	5	6	7
1	Collaborations	1						
2	Under Litigation	-0.022*	1					
3	VC Prominence	0.057*	-0.005	1				
4	Alliance Centrality	0.179*	0.005	0.174*	1			
5	Citation Weighted knowledge stock	0.039*	0.022*	0.125*	0.131*	1		
6	Size of VC Syndicate	0.102*	-0.013*	0.446*	0.331*	0.186*	1	
7	Number of VC Funding Rounds	0.116*	-0.006	0.380*	0.288*	0.153*	0.828*	1

N=65701; *p<0.05

Table 2: Results of Negative Binomial Regressions for Alliance Formation

VARIABLES	(1) Collaboration	(2) Collaboration	(3) Collaboration	(4) Collaboration
Under Litigation in the Past 12 months	-1.02***	-0.76***	-0.94***	-0.89***
	(0.07)	(0.07)	(0.10)	(0.10)
VC Prominence	0.05***	0.03***		0.06***
	(0.01)	(0.01)		(0.01)
Under Litigation X VC Prominence		-0.43***		-0.37***
		(0.08)		(0.09)
Alliance Network Prominence	0.40***		0.40***	0.40***
	(0.01)		(0.01)	(0.01)
Under Litigation X Alliance Network Prominence			-0.13	-0.24**
			(0.07)	(0.07)
Citation Weighted Knowledge Stock	0.004*	0.01***	0.00*	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
Size of VC Syndicate	-0.01***	-0.00	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Number of VC Funding Rounds	0.09***	0.09***	0.10***	0.09***
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-1.00***	-1.09***	-1.02***	-0.99***
	(0.13)	(0.12)	(0.13)	(0.13)
Year Fixed Effects (χ^2)	568.93***	518.86***	562.92***	567.57***
Month Fixed Effects (χ^2)	19.37*	10.29	18.25	19.31*
χ^2	2943.9***	1737.46***	2958.64***	2992.91***
α (dispersion parameter)	7.78	8.02	7.78	7.77
Observations	65,701	65,701	65,701	65,701

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Table 3: Results of Negative Binomial Regressions for Alliance Formation (Matched Sample)

	(1)	(2)	(3)	(4)
VARIABLES	Collaborations	Collaborations	Collaborations	Collaborations
Under Litigation in the Past 12 months	-0.88***	-0.70***	-0.86***	-0.80***
	(0.07)	(0.07)	(0.10)	(0.10)
VC Prominence	0.10***	0.06**		0.10***
	(0.02)	(0.02)		(0.02)
Under Litigation X VC Prominence		-0.44***		-0.42***
		(0.08)		(0.09)
Alliance Network Prominence	0.33***		0.32***	0.33***
	(0.02)		(0.02)	(0.02)
Under Litigation X Alliance Network Prominence			-0.05	-0.18*
			(0.07)	(0.07)
Citation Weighted Knowledge Stock	0.002	0.01	0.004	0.001
	(0.00)	(0.00)	(0.00)	(0.00)
Size of VC Syndicate	-0.01***	-0.00	-0.01**	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Number of VC Funding Rounds	0.12***	0.11***	0.12***	0.12***
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-1.00***	-1.09***	-1.06***	-1.00***
	(0.14)	(0.14)	(0.14)	(0.14)
Year Fixed Effects (χ2)	189.92***	243.3***	191.55***	189.35***
Month Fixed Effects (χ2)	3.87	2.35	3.55	3.85
χ2	1195.41***	673.43***	1160.1***	1223.09***
α (dispersion parameter)	7.12	7.31	7.14	7.12
Observations	42,030	42,030	42,030	42,030

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Figure 1

Interation effect between litigation and VC prominence on the rate of alliance formation

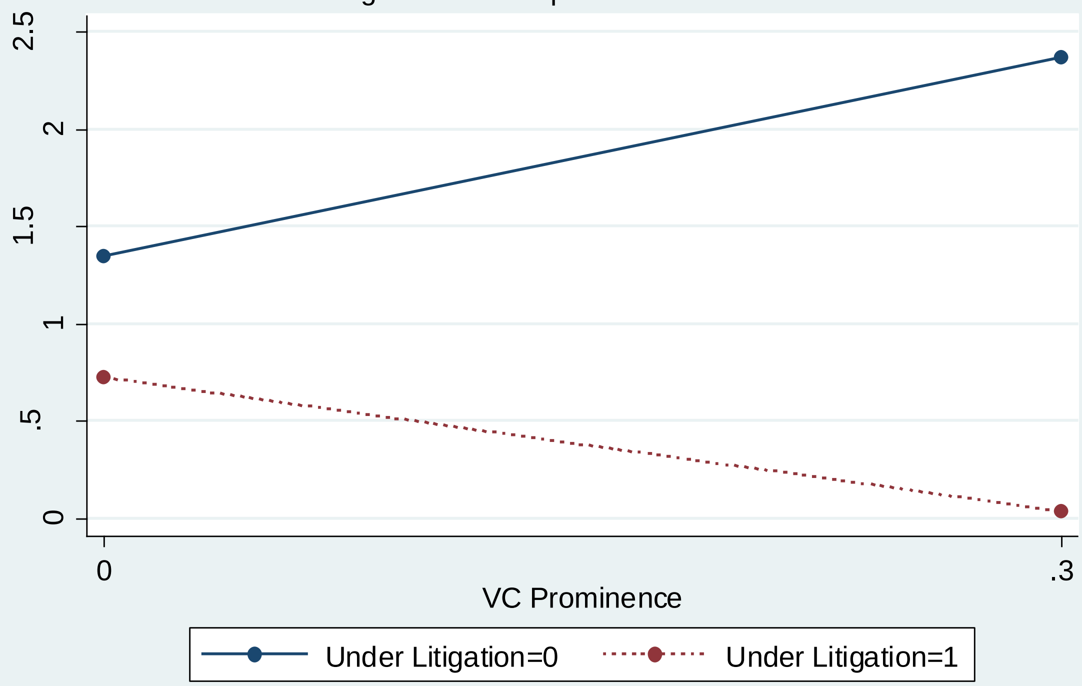
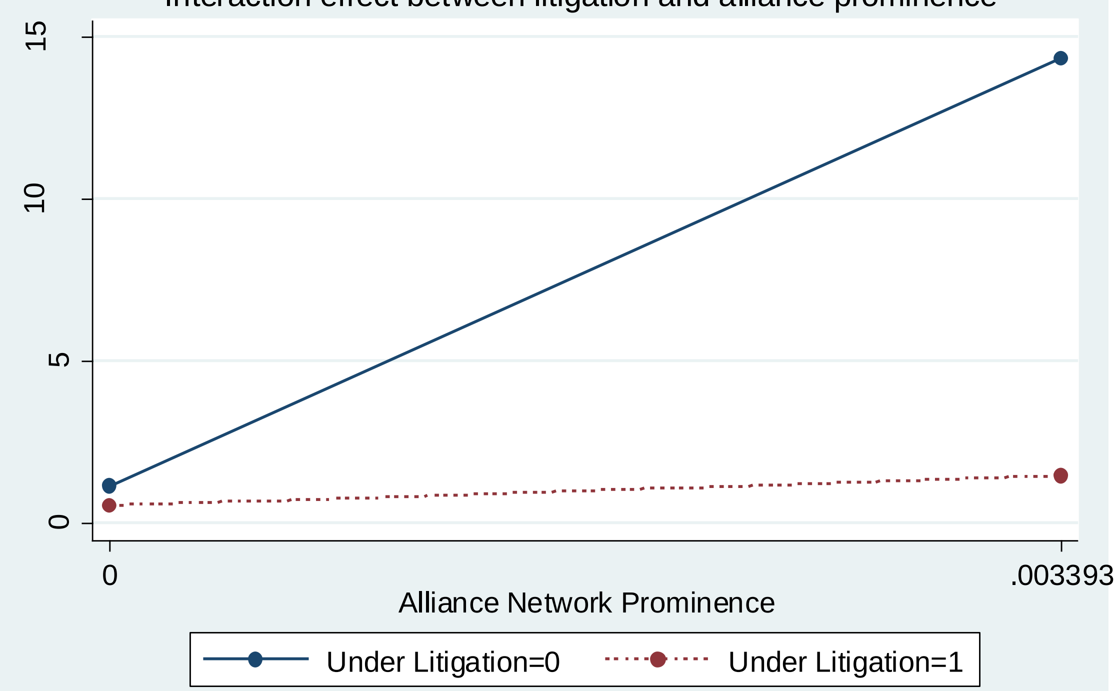


Figure 2

Interaction effect between litigation and alliance prominence



CHAPTER III

INVENTOR DISRUPTION IN THE WAKE OF PATENT LITIGATION

Introduction

In high-tech industries, mobility and collaboration are ways by which firms and inventors innovate (Ahuja, 2000; Tzabbar, 2009). Inventor mobility allows inventors to pursue opportunities outside of their current employment (Singh and Agrawal, 2011). These inventors leave with the experience and know-how that they have developed in their previous firms which can then be utilized by their new employers to produce more knowledge (Song, Almeida, and Wu, 2003; Rosenkopf and Almeida, 2003). Collaboration between inventors allows firms to produce knowledge as inventors can draw from a larger and a more diverse pool of inventors (Fleming, Mingo, and Chen, 2007; Wuchty, Jones, and Uzzi, 2007; Singh and Fleming, 2010).

However, disruptive events can impact these knowledge creation activities. Prior research has emphasized how disruptive events such as death of their collaborators or technological acquisitions can impact inventors' collaboration and their mobility (Ernst and Vitt, 2000; Azoulay, Zivin, Wang, 2010). While inventors certainly are affected by these disruptive events, they might not have to face as much of a reputational cost and an opportunity cost as they would if they were impacted by a disruptive event such as patent litigation. Indeed, much of the literature on intellectual property (IP) litigation views it as an exercise that involves substantial private and social costs for the firm. For example, the literature has shown that patent litigation significantly affects the rate of innovation of the companies involved in the litigation (Kiebzak, Rafert, and Tucker, 2014). Studies also show that patent litigation also adversely affects investments in innovation by lowering the returns from R&D and by exacerbating financing constraints, thereby curbing further innovation and growth. (Bessen and Meurer, 2008; Boldrin and Levine, 2002; Jaffe and Lerner, 2011).

Although prior studies have shed much light on the negative impact of patent litigation at the level of the firm, scholars have overlooked the impact that it may have on the inventors directly involved in the litigation. Anecdotal evidence suggests that distractions in management induce significant indirect costs (Bessen and Meurer, 2007, 2008) with personnel devoting time away from work to fight litigation (Science, Technology, and Economic Policy (STEP) Report, 2005; Bessen and Meurer, 2008). Moreover, these litigations are subject to frequent reporting in the media (Agarwal, Ganco, and Ziedonis, 2009). This negative attention from the media can cause reputational damage to the employees of the firm (Harrison, Boivie, Sharp, and Gentry, 2017).

Consequently, this leaves a gap in our understanding of the impact of patent litigation on their ability to move between firms as well as their collaboration with other inventors within the firm, two activities that help in the creation of knowledge. We suggest patent litigation increases some of the costs of hiring litigated inventors, which can impede their movement between firms. Additionally, we suggest that patent litigation can impact some of the costs of collaborating with the sued inventors, thus they can impact the creation of collaborative ties between litigated inventors and other inventors from the litigated firm.

In so doing, we contribute to the literature on collaboration and mobility in several ways. First, we show how litigations can be disruptive to the career of an inventor by impacting their mobility. Scholars have shown how technological acquisitions can motivate some inventors to consider changing their jobs (Ernst & Vitt, 2000; Seru, 2014). While the market for an inventor impacted by a disruptive event such as an acquisition might be unaffected, the market for an inventor impacted by a disruptive event such as a patent litigation might shrink. In other words, the sued inventor might not be viewed favorably by competitors when making hiring decisions due to concerns with the costs associated with their reputation and costs associated with hiring.

Second, we show that patent litigations differentially impact the formation of collaborative ties between litigated inventors and other inventors in the litigated firm. Prior literature has shown that disruption to inventors commonly occurs during the death of their collaborators (Azoulay, Zivin, and Wang, 2010) or during corporate development activities undertaken by firms such as technological acquisitions. In the face of patent litigations, inventors from the focal firm itself can find it challenging to form relationships that help promote innovation, due to an increase in search costs to find collaborators, an increase in costs of collaboration due to reputational concerns of the sued inventors, and the opportunity cost they have to endure to fight litigation.

Finally, we separately analyze the collaborative relationships between sued inventors and inventors that they are collaborating with for the first time, and the collaborative relationships formed between sued inventors and inventors that were known to the sued inventor before the litigation. In doing so, we highlight how the formation of these different ties are impacted by a patent litigation.

The paper is structured as follows: Section 2 outlines the theoretical background used in the paper. Section 3 describes the data and methods used in the empirical analyses. Section 4 presents the results, and section 5 discusses the implications and future lines of research.

Theory and hypothesis

In the following sections, we describe the disruptive event (patent litigation filings) followed by developing hypothesis on how they have consequences for mobility and collaborative tie formation.

In our study, patent litigation happens when the patent of the focal firm is challenged by rival firms. Litigating against rivals can generate value for the firm (Agarwal, Ganco, & Ziedonis, 2009). Large firms frequently create a patent thicket around their products to enjoy the exclusionary benefits that patents provide for several years and can choose to aggressively protect their IP against rivals (Paik and Zhu, 2016). If the defendant is the holder of patent, then these firms seek to file a counterclaim using their large patent stock or bring into question the validity and the scope of the legal right granted to such firms (Lemley and Shapiro, 2005). Plaintiffs in such cases seek an injunction against the technologies possessed by new ventures, consequently stifling the competition in the product market. The damages sought by and awarded to plaintiffs can be very high (Smeets, 2014). For example, in the pharmaceutical industry, median litigation costs in cases involving liabilities over $25 million cost around $1.8 million, and cases involving liabilities less than $10 million cost around $706,000. (AIPLA Report of the Economic Survey, 2017).

A disruptive event to a defendant firm has an impact not only on the firm but also the inventors involved in the lawsuit. Anecdotal evidence suggests that distractions in management induce significant indirect costs (Bessen and Meurer, 2007, 2008). These employees, including technical personnel such as inventors, devote significant time in preparing for the litigation process in addition to time spent in attending the proceedings at the court (Science, Technology, and Economic Policy (STEP) Report, 2005; Bessen and Meurer, 2008).

These costs can impact the rate of innovation (AIPLA Report of the Economic Survey, 2005) as well. Additionally, being experts on the very inventions they have patented, these inventors when called to the court to testify might reveal tacit information that was meant to be within the boundaries of the firm.

Inventor mobility

Inventors help in the creation and transfer of knowledge particularly in high-tech industries. They can help rival firms improve their technological position (Tzabbar, 2009) and help them remain on the forefront of the technological development by learning from newly hired inventors (Rosenkopf and Almeida, 2003; Agrawal et al., 2006; Singh and Agarwal, 2011) or from former employees (Somaya, Williamson, and Lorinkova, 2008). These studies focus on the beneficial impacts experienced by firms receiving the inventors.

However, firms that lose talented scientists to rival firms experience deleterious effects. Evidence shows that knowledge that was proprietary to the firm and that was confined to the firm boundaries is now available to rivals due to them hiring the focal firm's inventors (Liebeskind, 1996; Song, Almeida, and Wu, 1999; Palomeras and Melero, 2010). In addition, to rivals poaching inventors, these inventors themselves tend to move in search for better opportunities (Singh & Agrawal, 2011). Scholars have shown how such mobility events can negatively impact firm performance (Shaw, Park & Kim, 2013), with the switching inventors even experiencing a decrease in their individual performance (Groysberg, Lee, and Nanda, 2008). When disruptive events such as technological acquisitions occur, inventors tend to leave the target firm whether the acquisition is completed or withdrawn (Seru, 2014). On the other hand, acquiring firm inventors can experience a loss of social status and centrality causing them to move (Ernst and Vitt, 2002). Finally, Kapoor and Lim (2007) find that there is no significant difference between the mobility rate of acquired and non-acquired inventors. These studies provide mixed evidence of the impact of a disruptive event such as an acquisition on mobility.

However, these studies assume that there are rival firms that are always looking to hire inventors looking to move to their firm because of the benefits that rivals accrue as we mentioned above. In our context, patent litigation, as a disruptive event, negatively impacts inventors' prospects of moving between firms. In high-tech industries, scholars have shown how focal firms use the threat of litigation on rival firms to prevent them from poaching their inventors (Agarwal, Ganco, and Ziedonis, 2006). On the other hand, we suggest that when sued by rival firms, focal firm inventors' prospects of moving are further damaged. First, it reduces the attractiveness of the inventor to rival firms. Although these rivals would benefit from hiring inventors, these sued inventors come with the baggage of being visible and thus scrutinized due to their litigation history. These inventors' ability to recombine previous knowledge that was under litigation to create new inventions in the rival firm would be restricted. The commercialization prospects of any subsequent technology that has been developed by recombining knowledge these inventors gain from their previous firms would be called into question as well. Thus, these rivals would be disinclined to hire sued inventors from focal firms. Second, focal firms themselves can place restrictions on the mobility of the inventor until the outcome of the litigation. Inventors spend a lot of time preparing responses and appearing as an expert witness in the court to provide their testimonies (Science, Technology, and Economic Policy (STEP) Report, 2005; Bessen and Meurer, 2008). If these inventors are let go, it might restrict the firm's chances of a favorable outcome in the litigation. Further, if they do end up joining rivals, these firms have incentives to prevent the inventor from providing a testimony for their former employer in the court. Thus, it is also in the best interest of the focal firm to not let the inventor leave. In sum, patent litigation brings a number of sources of uncertainty that can damage the prospects of sued inventors to leave the firm. We therefore posit:

H1: Litigation has a reduces the likelihood of inventor mobility: After the litigation, sued inventors are less likely to change firms, compared to the pre-litigation period

Collaboration

Collaboration between inventors in high-tech industries plays an increasingly prominent role in developing cutting edge research because of the nature of scientific and engineering developments (Wuchty et al., 2007). Firms enable the creation of knowledge by facilitating collaborative relationships between employees. These inventions produced by teams of collaborators are in fact more valuable than inventions produced by lone inventors (e.g., Singh and Fleming, 2010). Additionally, these collaborations often result in the combination of complementary specialized knowledge that raises the value of the invention to the firm (Fleming et al., 2007). Further, individuals partnering with high-quality collaborators can experience a significant impact on their own inventions (Azoulay, Zivin, & Wang, 2010; Grigoriou & Rothaermel, 2014; Oettl, 2012). Inventors, in particular, can benefit from collaboration because establishing ties can increase the value and novelty of inventions and can reduce the likelihood of creating less valuable inventions (Fleming, 2001; Fleming et al., 2007; Singh & Fleming, 2010).

One of the main determinants of collaboration is the cost of finding a suitable partner with whom to collaborate. Scholars have provided evidence that not all collaborations have the same value. The value of a collaboration depends on the type of knowledge, the diversity of the team, and the geographic dispersion of the inventors. Fleming and his colleagues (2007) showed that valuable inventions were the result of bringing non overlapping knowledge to a team with high levels of cohesion. Team diversity can also be present in the form of geographic dispersion. Tzabbar and Vestal (2015) showed that geographic dispersion among the inventors in a team can help the team to create novel inventions. Therefore, even though collaboration is important, the value of the collaboration depends on what the collaborators can bring to the table. While the extent of intra-firm collaboration differs across firms (Toh & Polidoro, 2013), it has been consistently shown that firms tend to benefit largely from the interaction between inventors (Carnabuci & Operti, 2013; Grigoriou & Rothaermel, 2014; Guler & Nerkar 2012).

However, disruptions to inventors can hinder the collaborative relationships that they intend to form. Prior literature has largely studied disruptions in the formation of collaborative relationships by observing an exogenous shock such as the death of a superstar scientist and by observing the change in firm boundaries as a result of technological acquisitions. Azoulay, Zivin, & Wang (2010) show that death of an eminent inventor results in a decrease of publications for their collaborators, although such a death can result in fields unconnected to the star scientist see an uptick in their citation rate (Azoulay, Rosen, and Zivin, 2019). On the other hand, integrating newly acquired firms can disrupt the normal operations of both the target and the acquiring firm (Krug and Hegarty, 1997; Ranft and Lord, 2002). Challenges can arise in the cultural and organizational aspects of both the firms which subsequently result in loss of social status and centrality for the inventor in the firm (Ernst and Vitt, 2000; Paruchuri, Nerkar, and Hambrick, 2006).

In contrast to the aforementioned disruptions, patent litigation disrupts the formation of collaborative ties between sued inventors and other inventors of the focal firm. We suggest that litigation shines a spotlight on the sued inventors because of analyst and media coverage of the lawsuit. Their work is now under scrutiny by the court, by the analysts, as well as by other inventors within the firm. Although there is no direct evidence of patent litigation against the firm, impacting the inventor, prior research has identified how such negative events affecting the firm can damage the reputation of employees within the firm (Harrison et. al, 2018). In the context of a patent litigation, this effect could be even worse. Anecdotal evidence suggest that inventors experience disruption as they must dedicate a significant portion of their time in preparing their responses, and providing expert witness testimonies in the court (Science, Technology, and Economic Policy (STEP) Report, 2005; Bessen and Meurer, 2008). These opportunity costs leave visible inventors unable to devote resources, time, and attention to developing an invention in the focal firm. Additionally, due to a high level of scrutiny on their work, their technical capabilities to create subsequent inventions of value would be called into question, at least for the duration that the case is unresolved. We delineate the formation of collaborative ties between sued inventors and inventors that they have worked with before and those that they have not worked with before the filing of the litigation.

New collaborators

New collaborators, defined as inventors who have not worked with the sued inventor before the filing of the lawsuit, might be hesitant to collaborate with these inventors involved in the lawsuit. First, finding new collaborators for inventors can be difficult even when they are in geographically proximate settings (Boudreau, Brady, Ganguli, Gaule, Guinan, Hollenberg, Lakhani, 2017; Catalini, 2018). Patent litigation can further increase the search costs for finding new collaborators even if they work for the same firm. Second, as these new collaborators have not worked with the sued inventor before, they might be less inclined to associate with inventors whose reputation might be suspect given the ongoing litigation. Third, since subsequent projects of the sued inventor also would be subject to scrutiny due to the visibility brought about by the current litigation, these new collaborators would be wary of starting new projects with them. Fourth, since the technical capabilities of the sued inventors to create inventions of value to the firm are under intense scrutiny, these new collaborators would be further reluctant to ally with the sued inventor. Finally, while litigated inventors might find it difficult to find new collaborators, firms would also be hesitant to assign new collaborators to work with litigated inventors. Such inventors' workloads are already burdened by the opportunity costs of being involved in patent litigation. Further, as subsequent projects of the sued inventor would also be subject to scrutiny due to the visibility brought about by the current litigation, the firm would not want to penalize the new collaborator by forcing them to work with the litigated inventor. Firms might want to ease the burden on the litigated inventor by putting them in comfortable situations. In sum, patent litigation brings several sources of uncertainty that can cause new collaborators to shy away from allying with sued inventors. We therefore posit:

H2: Litigation decreases the likelihood of forming new collaborations: After the litigation, sued inventors are less likely to form new ties with other inventors, compared to the pre-litigation period

Previous collaborators

On the other hand, previous collaborators, defined as inventors who have worked with the sued inventor before the filing of the lawsuit, might be willing to collaborate with these inventors involved in the lawsuit. First, as these collaborators have invented patents with the sued inventor before, they would be more aware of the reputation of the sued inventor in spite of the ongoing litigation against them. Second, these repeated collaborators would be more aware of the technical capabilities of the sued inventor to produce inventions of value when compared to any other category of employees or the analysts at large. Third, from the perspective of the sued inventor, to compensate for the loss in the form of new collaborators they might want to strengthen their relationships with repeat collaborators and form collaborative ties with them. Indeed, because such strong ties between individuals can help in the generation of creative ideas, especially when the actors are motivated to work closely together (Sosa, 2010). Finally, given the time constraints due to the opportunity costs of fighting patent litigation, sued inventors might exhibit comfort in working with collaborators with whom they had a prior relationship. In sum, previous collaborators would be more inclined to associate with sued inventors. We therefore posit:

H3: Litigation increases the likelihood of forming repeated collaborations: After the litigation, sued inventors are more likely to form ties with previous collaborators, compared to the pre-litigation period

Data and identification strategy

To test our hypothesis, we merge several datasets to identify information ranging from inventors' litigations, to their patent information. We begin with a sample of inventors that started to apply for patents in the year 2000 or later from the United States Patent and Trademark Office (USPTO). Next, in the sample, we matched the inventor names with those that worked in firms that were brought to court as defendants in patent litigation cases in any of the US courts during the sixteen years from 2000 to 2015. These were assembled from the database provided by Lexis Nexis, which records patent litigations starting from the year 2000. We collected the information for the litigated patents, such as assignee, application year, and the list of inventors for each patent. One important step to build the data set was to ensure that the litigated patents in the lawsuit were owned by the defendant, and not the plaintiff. To accomplish this, we matched the assignee names listed on the patents to the names of the defendants mentioned in the lawsuit by using a computer algorithm. We augmented this information with inventor-level data from Patents View. To understand the impact that patent litigations have on subsequent collaborative relationships and mobility of litigated inventors, we focus on the first litigation case where these inventors were brought to court as defendants. We define the litigation year as the year of the first case if they were involved in more than one litigation.

We implemented a difference-in-differences research design to study the effect of litigation on inventor-level outcomes. We created a control group that consists of inventors who were active in the USPTO database during the period of the focal inventor's litigation case and had been active in the USPTO database for the same number of years as the litigated inventor. We matched each litigated (treated) inventor to five control inventors. The matching was done based on the year of the litigation (e.g. if Inventor A is sued for the first time in 2002, then they were matched to control inventors available in 2002) and the number of years since the first patent (i.e. their Tenure in USPTO data).

Variables

Dependent variables: We use three dependent variables to test our hypothesis. To test our first hypothesis *H1*, we define $Mobility_{it}$ as one when an inventor switches between employers, and zero otherwise. Seventeen percent of inventors moved firms in our sample. Using the raw USPTO data to calculate our mobility measure may be challenging because assignee names are not disambiguated. However, the Patents View data has clean names for the assignees, so we rely on this database's name disambiguation algorithm combining it with extensive manual checks. We track the career of the inventor by creating a table where each inventor was associated with an assignee each year. We ensure that this is an event where an inventor has indeed changed firms and not simply stayed with a firm that has simply changed names. For example, we were cautious with American Home Products Corporation (AHPC) which changed its name to Wyeth in 2002. Such a change would indicate that the inventor has not moved between firms but that the firm has simply undergone a name change.

To test our second hypothesis *H2* we create an indicator variable that takes a value 1 when the number of New collaborators ($NewCollab_{it}$) that the focal inventor i has formed relationships with in year t that did not work with the focal inventor before the litigation year was greater than or equal to 1, and 0 otherwise. The average number of new collaborators that an inventor worked with in our sample is 0.67 with a maximum of 45 collaborators.

Finally, to test our third hypothesis *H3* we create an indicator variable that takes a value 1 when the number of Previous Collaborators ($PreviousCollab_{it}$) that the focal inventor i has worked with in year t that they had worked with at least once prior to the litigation year is greater than or equal to 1, and 0 otherwise. The average number of collaborators that an inventor worked with is 1.36 with a maximum of 397 inventors. We observe both the collaboration variables by virtue of collecting information on the list of patents belonging to the focal inventor from PatentsView database.

Independent variables:

$After_{it}$ is a time dummy variable that equals one for the period after the litigation year and equals to zero for the period prior to the patent litigation. As we stated before, we focus on the first litigation case where these inventors were brought to court as defendants. We define the litigation year as the year of the first case if they were involved in more than one litigation. $Treated_i$ is equal to zero when the inventor is in the control group and equal to one when the inventor is in the group of litigated inventors. Thus the interaction term $Treated_i * After_{it}$ is our Diff-in-Diff variable that captures the main effect. In other words, we first calculate the difference on the focal outcome variable for the period before and after the year of the litigation for each of the litigated and the control inventors. Then, we calculated the difference of these differences. This difference of differences is captured by the coefficient of the interaction described above.

We use a time window of five years before and after the litigation year to test our hypothesis. We include inventor fixed effects (γ_i) to control for time invariant inventor level differences in their characteristics that can drive our results. Additionally, we include year dummies (τ_t) to account for macroeconomic events happening in a given year that could impact our outcome variables.

Thus the main regression models that we estimate in our diff-in-diff research design are:

$$Mobility_{it} = \beta_1 After_{it} + \beta_2 (Treated_i * After_{it}) + \gamma_i + \tau_t + \epsilon_{it}$$

$$NewCollab_{it} = \beta_3 After_{it} + \beta_4 (Treated_i * After_{it}) + \gamma_i + \tau_t + \epsilon_{it}$$

$$PreviousCollab_{it} = \beta_5 After_{it} + \beta_6 (Treated_i * After_{it}) + \gamma_i + \tau_t + \epsilon_{it}$$

Results

Table 1 and 2 present the descriptive statistics and the correlations respectively. We observe that 16% of the inventors in our sample belong to the treated group of inventors. Twenty four percent of inventors in our sample worked with new collaborators and 28% of inventors worked with previous collaborators. Seventeen percent of our inventors moved firms. We observe that the correlation between the treated group of inventors and new collaborators is negative, between the treated group of inventors and previous collaborators is positive, and surprisingly the treated group of inventors and mobility is positive.

We employ the use of Linear probability models to test our hypothesis, since our main dependent variables are all indicator variables which take the value of either 1 or 0. Table 3 shows the regression results of the analysis. We include inventor and year fixed effects in all regressions, and all reported standard errors are robust. Since we include these inventor fixed effects, all time invariant measures that do not vary within an inventor such as $Treated_i$, and their interaction effects are not estimated. In models 1-3, we estimate the effect of litigations on the outcomes- $Mobility_{it}$, $NewCollab_{it}$, *and* $PreviousCollab_{it}$- using a difference in difference analysis as described before, where the coefficient of interest is that of the interaction $Treated_i * After_{it}$. In model 1 which tests the effect of patent litigation on the inventor mobility (H1), the coefficient of the interaction is negative and statistically significant ($p<0.05$). This lends credence to hypothesis H1 that post patent litigation the likelihood of a litigated inventor leaving the focal firm reduces by 3% when compared to the control group of inventors. In model 2, that tests the effect of patent litigation on the likelihood of finding new collaborators (H2), the coefficient of the interaction $Treated_i * After_{it}$ is negative and statistically significant ($p<0.001$). This coefficient shows that post litigation the likelihood of finding new collaborators that work with a litigated inventor reduces by 6% when compared to the control group of collaborators who were not impacted by litigation. This provides empirical evidence towards H2. In model 3, that tests the effect of patent litigation on the likelihood of collaborating with previous collaborators (H3) the coefficient of the interaction effect is positive and significant with $p<0.05$ in support of our hypothesis H3. This coefficient shows that post litigation the likelihood of collaborating with previous collaborators increases by 3% when compared to the control group of collaborators who are not impacted by litigation. Overall, the results suggest that litigation negatively affect inventors, in prospects of both mobility and future new collaborations, while having a positive impact on repeat collaborations.

We display the parallel trends assumption that helps validate the diff-in-diff model. Figures 1 and 2 compare the trends before and after litigation for treated and the control group of inventors. Figure 1 displays the number of moves made by the two groups of inventors before and after patent litigation. It shows that the two groups of inventors are largely similar before the litigation period and that the litigated inventors are making fewer moves post-litigation. Figure 2 displays the number of new collaborators for the two groups of inventors before and after patent litigation. It shows that the two groups of inventors are largely similar before the litigation period and that the number of new collaborators that work with the litigated inventor go down post-litigation.

Robustness checks

First, to account for alternative explanations for our hypothesis on new collaborative ties formed by litigated inventors, we look at the impact of litigation on patents being filed by a single inventor. If these litigated inventors were facing challenges forming new collaborative relationships, do they instead work alone and file for more solo patents? To address this question, we compare the patents filed by a litigated inventor to those being filed by the control group of inventors using the difference in difference estimator that we described above. Table 4, Models 1 provide further credence to H2. In Table 4, Model 1, we see that the coefficient on $Treated_i * After_{it}$ is not statistically significantly different from zero. In other words, we did not find any effect on solo patenting for litigated inventors post the event.

Second, we also check if the productivity of inventors is affected by patent litigation. Melero, Palomeras, and Wehrheim (2020) provide evidence that inventors who are granted an additional patent tend to not change their employers on average. In our context, if the productivity of these inventors filing patents were to increase post-litigation, one would expect them to stay at the firm. In Table 4, Models 2, we simply test whether the productivity of inventors is impacted by ongoing patent litigation. We measure productivity as the number of new patents filed by the inventor i in year t. In Table 4, Model 2, we find we see that the coefficient on $Treated_i * After_{it}$ is not statistically significantly different from zero. In other words, we did not find any effect on productivity for litigated inventors post the event.

Third, we isolate our hypothesis 2 and 3 to only those collaborators who remain at the focal firm in Table 5. We first calculate the total number of moves made by the inventor in the 3 years prior to the focal year. We then create a binary variable, *Mobility 3 yr*, that takes a value of 1 if the inventor moved firms in the last 3 years, and 0 otherwise. Models 1 and 2 estimate the effect of litigations on the outcomes using LPM regressions. The interaction term $Treated_i * After_{it} * Mobility\ 3yr$ in both models is not statistically different from zero. This indicates that there is no difference in the likelihood of forming new and previous collaborations by litigated inventors when they either choose to move or choose to stay. The interaction effect of $Treated_i * After_{it}$ is in line with the previous hypothesis, that the likelihood of forming new collaborations as indicated in H1 impacts litigated inventors adversely.

Finally, we introduce count measures of our dependent variables instead of the indicator variables we have worked with so far, in Table 6. *New collaborators* variable is measured by counting the number of collaborators that the focal inventor has in a year that did not work with the inventor prior to the year of litigation, the *Previous collaborators* variable is measured by counting the number of collaborators that the focal inventor has in a year that did work with the inventor prior to the litigation. In models 1 and 2, we estimate the effect of litigations on the outcomes using OLS regressions, where the coefficient of interest is that of the interaction $Treated_i * After_{it}$. In all these models, we largely find support for our hypothesis.

Discussion

This study enhances the richness of the literature on inventor collaboration, inventor mobility, and patent litigation. First, a stream of literature on inventor collaboration has focused on how inventors' careers are disrupted due to the death of their collaborators or alluded to how technological acquisitions can affect the formation of collaborative ties. We add to this stream of literature by focusing on patent litigation as a disruptive event that heterogeneously impacts the formation of collaborative ties. On the one hand, we show that litigated inventors have difficulties forming collaborative ties with colleagues they have never worked with prior to the litigation on average. On the other hand, we show that for colleagues with whom they had collaborated with prior to the litigation, we find a positive effect. Interestingly, we observe that productivity of inventors does not change even when they are impacted by patent litigation. This could raise the question of why the likelihood of new and previous collaboration be affected. While the search costs for finding new collaborators are high, the litigated inventors increase collaborations with previous co-workers which can thus show why their productivity remains unaffected. Previous literature has also shown how strong ties between individuals can further help in the generation of new ideas (Sosa, 2010), and thus such an increase in ties with previous co-workers would thus help the inventor's not impact their productivity. Additionally, we see that litigation does not impact their ability to produce patents on their own. This provides some evidence that inventors look for potentially other ways in which their productivity can remain unaffected.

Second, a stream of literature on employee mobility has shown how disruptions such as technological acquisitions can make employees consider leaving the firms. We show how patent litigation can be a disruptive event that can prevent employees from leaving the firm. Finally, while much of the literature on patent litigation has focused on its impact at the firm level, we delve much deeper and look at its impact on the specific inventors involved in that lawsuit, when compared to other employees within the firm who might not be affected by it.

Limitations and future research

Future research could improve the paper in several ways. First, we studied the effects of litigation and its impact on knowledge creation activities of inventors. One can look at the impact of litigation on other outcomes that can affect an inventor's career. One such example is their future direction of research. These sued inventors might move away from pursuing their research in the litigated field. This may or may not have far reaching consequences for the advancement of scientific research. Second, one thing we have in common with all studies of patent litigation is that we only observe litigation if a lawsuit has been filed. There is no information on unobserved outcomes such as threatening letters sent by rivals and using such letters to settle their case. One could conduct surveys with smaller firms and gather responses on the incidence of such letters and measure their impact on the knowledge creation activities of firms as well. Third, we are empirically limited in teasing apart the impact of a helping facilitate the formation of collaborative relationships among individuals as opposed to teams where the inventors form them on their volition. Finally, we do not observe those inventors who do not patent but are still involved in patent litigation due to paucity of such information either in the databases or in the limited available court documents. Since we are concerned with patenting in the high-tech industry, which is characterized by firms aggressively trying to protect their intellectual property, the relative impact of not observing such inventors should be low.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
New Collab	29,666	0.24	0.43	0	1
Previous Collab	29,666	0.28	0.45	0	1
Mobility	29,666	0.17	0.37	0	1
After	29,666	0.47	0.50	0	1
Treated	29,666	0.16	0.37	0	1
Solo Patents	29,666	0.34	1.21	0	47

Table 2: Correlation matrix

		1	2	3	4	5	6
1	**New Collab**	1					
2	**Previous Collab**	0.3255*	1				
3	**Mobility**	0.3002*	0.2565*	1			
4	**After**	-0.0261*	0.1195*	0.0778*	1		
5	**Treated**	-0.0120*	0.1127*	0.0615*	0.0174*	1	
6	**Solo Patents**	0.0405*	0.0205*	0.1807*	0.0017	0.0720*	1

Table 3: Results of the impact of litigation utilizing difference in difference design using linear probability models

Variables	(1) Mobility	(2) New Collab	(3) Previous Collab
After	0.01	0.03**	0.02
	(0.01)	(0.01)	(0.01)
Treated X After	-0.03*	-0.06***	0.03*
	(0.01)	(0.01)	(0.01)
Constant	0.05*	0.79***	0.11***
	(0.02)	(0.03)	(0.02)
Year FE	Included	Included	Included
Inventor FE	Included	Included	Included
F-Stat	16.58***	26.58***	44.80***
Within R-Squared	0.01	0.02	0.04
Observations	29666	29666	29666

Note: Models (1) - (3) implements difference in difference strategy using Linear Probability Model (LPM) regressions. The *After* dummy is equal to zero for the period before the litigation case and is equal to one for the period after the litigation. The *Treated* dummy is equal to zero when the inventor is in the control group and equal to one when the inventor is in the group of litigated inventors. Each model uses a different dependent variable- the *New collaborators* variable is equal to one if the number of collaborators that the focal inventor has in a year that did not work with the inventor before is greater than or equal to one and zero otherwise, the *Previous collaborators* variable is equal to one if the number of collaborators that the focal inventor has in a year that did work with the inventor before is greater than or equal to one and zero otherwise and finally, the *Mobility* variable is defined as one when an inventor switches employers, and zero otherwise. All regressions control for inventor and year fixed effects.
Standard errors are robust and are reported in parentheses.

†Significant at the 10 percent level, * Significant at the 5 percent level, ** Significant at the 1 percent level, *** Significant at the 0.1 percent level.

Table 4: Robustness checks using OLS

Variables	(1) Solo Patents	(2) Productivity
After	0.02	0.03
	[0.02]	[0.04]
Treated X After	-0.08	-0.09
	[0.07]	[0.12]
Year FE	Included	Included
Inventor FE	Included	Included
F-Stat	6.47***	8.94***
R-Squared	0.01	0.01
Observations	29666	29666

Standard errors are robust and are reported in parentheses.
†Significant at the 10 percent level, * Significant at the 5 percent level, ** Significant at the 1 percent level, *** Significant at the 0.1 percent level.

Table 5: Robustness checks utilizing difference in difference design using linear probability models

Variables	(1) New Collab	(2) Previous Collab
After	0.03***	-0.02†
	[0.01]	[0.01]
Treated X After	-0.07***	0.03
	[0.02]	[0.03]
Mobility3yr	-0.01	0.01
	[0.02]	[0.02]
After X Mobility3yr	-0.11***	-0.02
	[0.02]	[0.02]
Treated X Mobility3yr	-0.06†	0.03
	[0.038]	[0.04]
Treated X After X Mobility3yr	0.10	-0.03
	[0.10]	[0.04]
Year FE	Included	Included
Inventor FE	Included	Included
F-Stat	9.04***	23.85***
R-Squared	0.01	0.03
Observations	19119	19119

Standard errors are robust and are reported in parentheses.

†Significant at the 10 percent level, * Significant at the 5 percent level, ** Significant at the 1 percent level, *** Significant at the 0.1 percent level.

Table 6: Robustness checks using count measures and OLS

Variables	(1) New Collab	(2) Previous Collab
After	0.08*	-0.05
	[0.03]	[0.11]
Treated X After	-0.11*	-0.15
	[0.05]	[0.19]
Year FE	Included	Included
Inventor FE	Included	Included
F-Stat	9.14***	12.75***
R-Squared	0.01	0.01
Observations	29666	29666

Models (1) - (2) implement difference in difference strategy using OLS regressions. The *After* dummy is equal to zero for the period before the litigation case and is equal to one for the period after the litigation. The *Treated* dummy is equal to zero when the inventor is in the control group and equal to one when the inventor is in the group of litigated inventors. The *Startup Inventor* dummy is equal to one when the inventor belongs to a startup and zero otherwise. Each model uses a different dependent variable-the *New collaborators* variable is measured by counting the number of collaborators that the focal inventor has in a year that did not work with the inventor before, the *Previous collaborators* variable is measured by counting the number of collaborators that the focal inventor has in a year that did work with the inventor before. All regressions control for inventor and year fixed effects.

Standard errors are robust and are reported in parentheses.

†Significant at the 10 percent level, * Significant at the 5 percent level, ** Significant at the 1 percent level, *** Significant at the 0.1 percent level.

Figure 1: Parallel trends assumption for inventor mobility

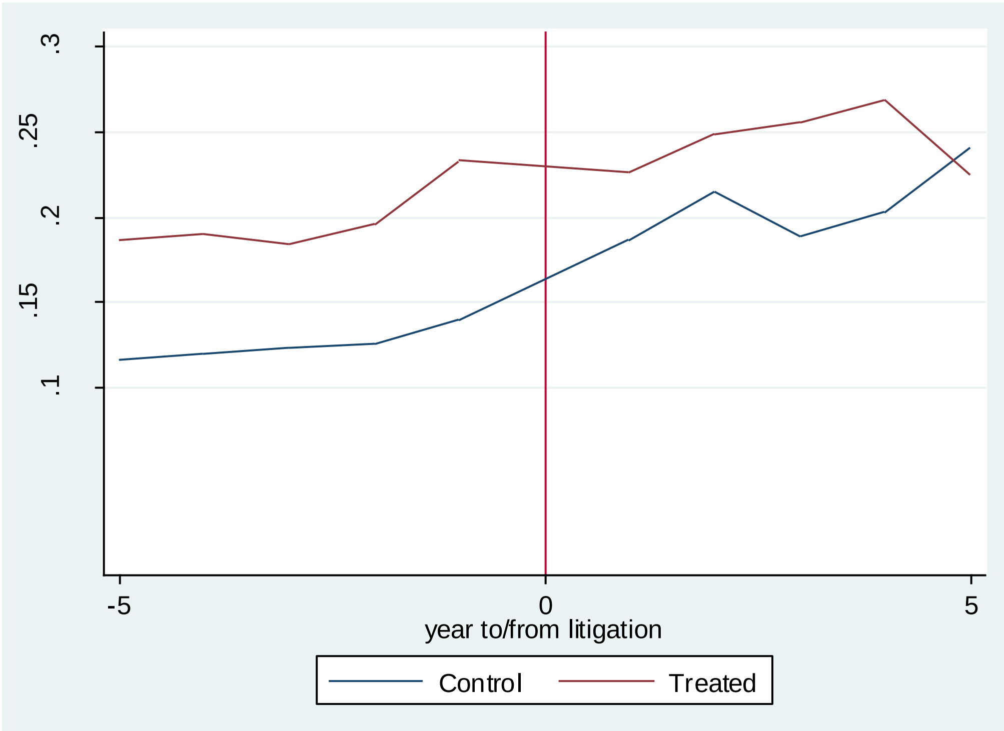
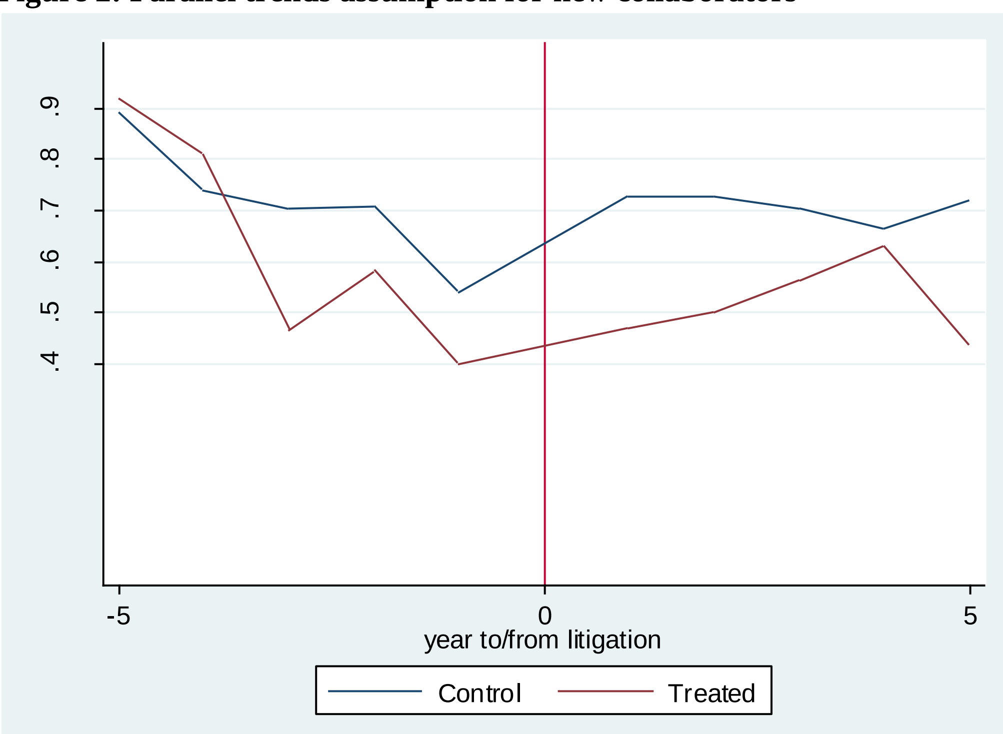


Figure 2: Parallel trends assumption for new collaborators



CHAPTER IV
STARTING OFF ON THE WRONG FOOT: THE FORMATION OF LICENSING AGREEMENTS IN THE SHADOW OF THE COURT

Introduction

Firms in high-technology industries sign licensing agreements which help transfer their intellectual property (Contractor and Lorange, 2002). Prior literature on technology licensing has shown how licensing helps licensors generate economic value from their inventions (Gambardella, Giuri, and Luzzi, 2007; Sakakibara, 2010), help firms without complementary capabilities to commercialize their inventions (Arora and Ceccagnoli, 2006), and accelerate the invention process for licensees (Leone and Reichstein, 2012). When such agreements are negotiated voluntarily between the parties, their design revolves around the critical choice of granting an exclusive license, which may generate higher license fees but come at the expense of precluding emerging outside options (e.g., Anand and Khanna, 2000; Somaya, Kim, and Vonortas, 2011; Aulakh, Jiang, and Li, 2013).

However, the literature is scant on the design choices that firms make when they are forced to negotiate and come to an agreement. Despite the costs and uncertainty involved in litigation, intellectual property (IP) litigations among high-tech firms, help them to enforce and thus safeguard their technologies from unauthorized use by their rivals. When firms engage in litigation, they often settle their cases rather than go all the way through the trial. In fact, prior literature has found that approximately 80% of the cases end up in settlements (e.g., Lanjouw and Schankerman, 1998; Kesan, and Ball, 2006). They also note that courts promote settlements between parties to save the public the expense of a trial or a lengthy settlement. The parties consequently are forced to negotiate licensing agreements in the shadow of the court, or they risk litigating the case to judgement.

Thus, the design of settlement agreements is of key strategic importance to managers as it sends a strong signal to partners and competitors. In this paper, we seek to understand how volitional licensing agreements differ from agreements signed as a result of settlement between parties. We test these differences in the choice to grant exclusive licenses. We suggest that licensing agreements post settlement are less likely to include exclusivity provisions when compared to volitional licensing agreements due to the transactional hazards in dealing with a licensee that the licensor does not trust. Additionally, we argue that the transactional hazards faced by licensees, from the inherent uncertainty present in early stage technologies which drive them towards seeking exclusive deals (Somaya et. al., 2011), are further exacerbated when negotiating for an exclusive license consequent to settling their litigation. Finally, we also suggest that the licensing agreements signed post settlement increase the uncertainty in dealing with partners with whom the licensors had a prior relationship, due to the breakdown of trust between them. Hence, the paper not only considers how licensing agreements post settlement shape the choice of exclusivity, but it also considers how these settlements might have a bearing on the transactional hazards that drive firms to enter into exclusive licensing deals. We conduct our analysis on a set of licensing agreements signed between firms belonging to the U.S. Biopharmaceutical industry and find general support for our arguments.

We contribute to the literature on the interorganizational governance and contract design in several ways. First, to our knowledge this study represents the first attempt to understand the differences between licensing agreements signed as a consequence of settlement between parties under the shadow of a court and volitional licensing agreements. This adds a novel perspective to the mechanisms of contract design by explicitly theorizing on the influence of the "shadow of the court" on contract design. Second, we show that the choice to grant an exclusive license becomes even more salient in the context of settlement agreements. While prior studies have argued that the choice to grant an exclusive license is subject to the transactional hazards faced by the parties (e.g., Somaya et al., 2011), we show that these hazards are amplified when parties settle their patent litigation. Third, prior literature has argued how exclusive licenses can provide contractual safeguards to licensees in the face of the technological uncertainties that are present in early stage technologies as well as protect them from opportunistic behavior by licensors (e.g., Deeds and Hill, 1999; Somaya et. al., 2011). We show that these hazards are further exacerbated when parties negotiate licensing agreements post settling litigation for early stage technologies. Finally, while prior studies have discussed how reliance on relational governance mechanisms such as interfirm trust can complement formal contracts and reduce the transaction costs between firms (Poppo and Zenger, 2002; Ryall and Sampson, 2009), the impact of the breakdown of trust as a result of the litigation between them and their subsequent impact on the choice to grant exclusivity in formal contracts has been ignored. We show that it is hard to rebuild the trust that parties once had over repeated interactions with each other, which adversely impacts their choice to grant a partner exclusive access to technologies.

Theory and Hypothesis

Designing effective contracts to address the tension between cooperation and competition in technology licensing is a critical challenge (e.g., Lioukas and Reuer 2020). While licensing affords many benefits, including access to partner's resources and capabilities, it equally creates the risk of knowledge misappropriation and conflict. Regulating the partner's access to knowledge is therefore a key element in the negotiation process of a licensing agreements.

However, not all licensing deals start off on the right foot. Especially in highly competitive industries where the pressure to innovate is high, the temptation to take a shortcut and misappropriate competitor's intellectual property is a menace. When intellectual property is protected through patents, the inventor can litigate against the infringer and claim damages. In this case, the parties seek the intervention of a third party to settle their disputes.

Interestingly though, patent litigations can also present the impetus for a licensing deal, negotiated in the shadow of the court. In negotiating these licensing deals, the focus lies on the rights granted to the intellectual property. In particular, the intellectual property owner can choose between granting exclusive access to the technology or maintaining residual rights by granting a non-exclusive license. Exclusive licenses preclude the licensor from licensing the technology to other licensees, limiting their dealings to one party. On the one hand, they provide licensees with a contractual safeguard which help protect their investments in complementary assets in the wake of a licensor's lack of ex-post commitment in developing the technology. On the other hand, they help licensors increase the incentives for the licensee to provide effort on commercializing their technology. Additionally, they also help the licensor safeguard its technology against expropriation of knowledge and development of substitutes by licensees (Somaya et al., 2011). Thus, by inducing credible commitments (Williamson, 1983), exclusive licenses help both parties reduce their transaction costs.

Taken together, these arguments are centered around the assumption that ex-ante, both the parties are willing to voluntarily transact with each other. They also assume that both the parties would be incentivized to put in their best effort in the presence of a contractual safeguard such as an exclusive license and are hence willing to be locked in with each other. Thus, we are yet to understand the degree to which these contractual hostages' function in incentivizing best efforts especially when the parties face increasingly high transactional hazards. We posit that licensing agreements signed post settlement present a unique transactional uncertainty for the parties, and can enrich our understanding of the design choices that firms make in such contracts when compared to choices made when the transactional costs of doing business with a partner on their volition.

We build our arguments on the general idea that uncertainty about the legal proceedings, uncertainty about the technology, and uncertainty about the behavior of the partner contribute to increasing the transactional hazards that firms face which influences their choice to grant an exclusive license.

Volitional versus Settlement Agreements

To prevent the unauthorized use of their valuable technology by rivals, incumbent firms choose to enforce and protect their intellectual property using patent litigations (Agarwal, Ganco, and Ziedonis, 2009) despite the costs. On the one hand, if the defendant is the holder of patent, then these firms seek to file a counterclaim using their patent portfolio or bring into question the validity and the scope of the legal right granted to rival firms (Lemley and Shapiro, 2005). Plaintiffs in such cases seek an injunction against the technologies possessed by defendants, consequently stifling the competition in the product market. On the other hand, if the defendant does not hold the patent, then these plaintiffs can sue for infringement of their intellectual property. The damages sought by and awarded to plaintiffs under these circumstances can be very high (Smeets, 2014). While the patent holder can choose to not settle the patent litigation based on the value of the patent to the firm (Somaya, 2003), however, most patent lawsuits end up being settled by the parties (Lanjouw and Schankerman, 1998; Kesan and Bell, 2006).

It is in the best interest of parties to settle their patent litigation for a few reasons. First, if the IP holder loses the case, it would be a pyrrhic victory for the party that wins. While they would want to reap the benefits of a cost and time-intensive effort of winning the litigation to use the technology in question, competitors would also be able to reap the benefits of the technology despite not investing or exerting any effort in the lawsuit. Settling the litigation would thus help the licensee license the technology from the IP holder while not letting third parties reap the benefits of a court decided judgement (Crane, 2002). Second, IP holders view settlement as a strategic choice (Somaya, 2003) to extract more value out of licensees. Crane (2002) even suggests that such licensing agreements post settlement might be anti-competitive, as the patentee "may act as the manager of a price-fixing cartel, ostensibly settling patent infringement claims with its competitors by licensing its patented technology, collecting some insignificant royalty, and then setting the prices charged by other manufacturers". Indeed, Patricia Davis, Senior Vice President and General Counsel of Palomar Medical Technologies, commented[1]:

"*The resolution of this lawsuit against Alma as well as the resolution last spring of the lawsuits against Cutera demonstrate the strength of Palomar's patent portfolio. As in the past, when forced to litigate, we will seek higher royalties than when competitors take a license on a voluntary basis. As we announced on November 7, 2006, our license agreement with Cynosure was on more favorable terms simply because we were not forced to sue Cynosure prior to executing the license. We have notified our unlicensed competitors that for now Palomar remains willing to offer licenses. Our willingness and the rates of such licenses, however, may change as competitors continue to wait for us to sue them for patent infringement.*"

Thus, as these arguments suggest, firms would be willing to settle and write subsequent licensing agreements. When signing these licensing agreements firms decide on one of the unique attributes in licensing transactions: the decision to be committed to doing business with a partner

[1] https://www.sec.gov/Archives/edgar/data/881695/000088169507000021/ex991.htm

exclusively. As explained earlier, while the literature has focused on how exclusive licenses can help reduce transactional hazards between firms and function as contractual safeguards, in the context of agreements signed post settlement, they might not function as intended. First, the transactional hazards of entering into an exclusive licensing agreement with a licensee with whom the licensor was involved in a litigation, would be high. The licensor would be reluctant to hand out an exclusive license, while the licensee would be reluctant to seek such an exclusive license. From the perspective of a licensor, it would call into question the efforts of the licensee to commercialize the invention. Additionally, it would also call into question, the licensee’s intention of expropriating valuable know-how received from the licensor and to develop substitutes from the technology. From the perspective of a licensee, while an exclusive license would help it have a contractual hostage over the licensor, the latter could choose not to develop the technology further or could choose to not share valuable know-how with the licensee (Arora, 1995). Second, the licensor would want to indicate to partners and competitors about its enforcement of valuable intellectual property as well as to capture the rents that it would have otherwise lost in the absence of a lawsuit against the potential infringer. Some evidence exists that firms can command significantly higher revenues from exclusive licensing deals rather than non-exclusive deals (Arora and Fosfuri, 2003; Aulakh et. al., 2013). However, in the absence of non-enforcement of their IP rights against unauthorized use of its technology, it might stand to lose revenues from the infringer as well as indicate to other partners and competitors that the technology is available to use without licensing, losing rents from them as well. Thus, we posit,

Hypothesis 1: When compared to volitional licensing agreements, deals that are signed post settlement are less likely to include exclusivity between the licensor and the licensee

Early stage technologies

A major source of uncertainty in licensing agreements emanates from the maturity of the focal technology. Prior literature has focused on the licensing choices of firms when these licenses involve technologies in early, embryonic stages as opposed to those that are more mature. For instance, in the biopharmaceutical industry, for every 10000 compounds screened one drug would reach the product market (Rothaermel and Deeds, 2004). The entire process can take up to 12 years with close to $2870 million being spent on development of the drug, pre-clinical trials, clinical trials, manufacturing, marketing, and distribution (DiMasi et. al., 2016). Thus, when the technology is in its earlier stages of development, licensor's involvement in developing the technology is even more crucial to the licensee (Somaya et. al., 2011). These technologies require additional investments by the licensee who might be reluctant to do so in the absence of an exclusive license (Anand and Khanna, 2000; Lemley, 2008). Hence, in order to reduce licensor opportunism, licensees seek exclusive licenses to act as a contractual hostage (Deeds and Hill, 1999; Ahmadjian and Oxley, 2006) to safeguard against technology specific investments they make to commercialize the invention (Somaya et al., 2011).

However, the inherent uncertainty of investing in early stage technologies would be even higher for deals signed post settlement for several reasons. First, the licensee would find it difficult to verify the amount of effort the licensor will put into transferring the tacit know-how associated with the technology (Williamson, 1983; Arora, 1995; Santoro and McGill, 2005), especially when ex-ante, the transaction is taking place under the shadow of the court. If ex-post, the licensor indeed skimps on the effort in transferring the tacit know how required to further develop the technology, an exclusive license becomes less valuable to the licensee who might already be reluctant to invest resources in complementary assets. Second, in early stage licensing deals, licensees are dependent on licensors for commercial success of the product (Jensen and Thursby, 2001; Somaya et al, 2011). In an environment characterized by mistrust between the parties, the licensee might find it difficult to depend on the licensor to repeatedly interact with it in developing the embryonic technology. It might be not willing to seek an exclusive license to limit interactions with the licensor, and it might be open to commercializing the technology through existing channels without investing further in the relationship while sharing the revenues with them.

Hypothesis 2: The likelihood of engaging in exclusive licensing in early stage licenses is reduced in licensing deals that are signed post settlement.

Past relationships

While the previous hypothesis is centered around the technological uncertainty that firms face, we now discuss uncertainty that arises due to breakage of trust that was built up in past relationships among the parties. There is no direct evidence that tests the link between the choice to grant exclusivity and past relationships formed by firms, while evidence about the impact of relational governance mechanisms on formal contracts has been mixed. On the one hand, scholars have shown how firms can rely on relational governance mechanisms such as the trust they develop between each other, the routines they have established over time, the reputation they have built, in order to complement formal contracts and reduce the exchange hazards in the focal transaction (Poppo and Zenger, 2002; Ryall and Sampson, 2009). These scholars have argued about how past relationships between firms can complement formal contracts by observing an increase in the contract detail, penalties included in the contracts, and improved mechanisms to monitor the relationship ex-post (Mayer and Argyres, 2004; Ryall and Sampson, 2009). On the other hand, another stream of literature suggest that relational governance mechanisms may function as substitutes to formal contracts. These studies argue for the presence of routines and processes developed when interacting with each other that reduces behavioral uncertainty in the relationship and builds trust, which in turn reduces the need for formal contracts (Dyer and Singh, 1998; Gulati and Singh, 1998; Gulati and Gargiulo, 1999).

Contracts signed post settlement present a unique challenge for parties that had a past licensing relationship. Breach of trust between two familiar parties may feel much worse than between two non-familiar parties. Similar to the ferocious court battles between divorced couples where no party is willing to grant the partner a dime due to the disappointment they experienced. First, these parties have built a relationship over repeatedly licensing with each other in the past. Such relationships help in reducing the behavioral uncertainty of either firm. When one party sues the other in a patent lawsuit, it represents a breakage of this trust that firms have built over time. Firms would be hesitant to work with each other again, and the deals would not include exclusivity provisions, as such provisions require extensive coordination between the parties, ex-post for the success of the product. Second, licensors would want to send out a strong indication to potential partners about the penalties they would incur in future contracts if they were to engage in patent litigation. If the licensor were to give out an exclusive license, post settlement, to parties with whom they had a prior relationship, the partners might perceive that the licensor is willing to overlook transgressions over their intellectual property and still be committed to working with the violator closely.

Hypothesis 3: The likelihood of engaging in exclusive licensing deals when the parties have past licensing relationships is reduced in licensing deals that are signed post settlement.

Methods

Data and sample

We test our hypothesis on a set of licensing agreements signed between firms belonging to the Biopharmaceutical industry. We begin with a sample of 243 settlement agreements that were downloaded from the PACER and BioScience Advisors (Biosci) databases. Biosci is a consulting firm that accumulates contracts in the biopharmaceutical industry. We hand-coded each of these agreements to identify several licensing terms and other firm related information that were present in those contracts. We then append this information to the volitional licensing deals from the Biosci database. Finally, to calculate patent related measures we merged this information with patent data obtained from PatentsView database. In the full sample, about 25% of licensing agreements signed post settlement engage in exclusivity, when compared to 92.5% of those that were signed volitionally. Since our data is cross-sectional, we do not make causal claims concerning how settlements *cause* the exclusion of exclusivity in contracts

This industry setting is ideal for our analysis for several reasons. First, licensors and licensees in this industry rely extensively upon exclusive licenses to develop and commercialize their technological ideas and innovations (Anand and Khanna, 2000; Lemley, 2008). Second, licensing activity in the biopharmaceutical industry is shrouded with considerable uncertainty as introduction of a new drug on the market requires expensive and time consuming tests, and often partners face considerable uncertainties regarding the investments made by either in developing and commercializing the invention (e.g., Lerner and Merges, 1998; DiMasi et. al., 2016; Somaya et. al., 2011). Third, the biopharmaceutical industry is well documented in literature as one which encourages significant patenting activity (Cohen, Nelson, and Walsh, 2000; Klevorick et al., 1995; Levin et al., 1987), and consequently firms in this context are prone to patent litigations which subsequently end up in settlements (e.g., Lanjouw and Schankerman, 1998; Somaya, 2003) . Finally, information on the licensing activities in this industry are well documented, providing the necessary rich data for rigorous empirical study.

Variables and measurement

Dependent variables: We use two dependent variables to test our hypotheses and to conduct additional robustness checks. Our main dependent variable *Exclusive license* is binary and takes the value of one if an exclusive license was granted and zero if the license is non-exclusive. We diligently scoured through the settlement contracts and relied on Biosci coding for volitional licensing contracts.

Explanatory variables: Early Stage is a dummy variable that takes the value 1 if the licensed technology is in Phase I of clinical trials or earlier and 0 if it has progressed to Phase II of the clinical trials or later. Beginning with the discovery of the lead molecule, followed by the preclinical testing and Phase I of the clinical trials where the drug is tested on 20-100 volunteers, the process is fraught with a high degree of uncertainty (DiMasi et. al., 2016). As the drug progresses to the later stages of the clinical trials, partners have more time to study the efficacy of the drug in a smaller number of humans, and thus the transactional hazards of signing a deal at this stage considerably reduce when compared to the earlier stages (e.g., Lerner, Shane, and Tsai, 2003; Rothaermel and Deeds, 2004).

Our next explanatory variable considers the *past relationships* formed between the licensor and licensee. This continuous variable ranges between zero and six in our sample, indicating the number of times the parties interacted with each other in the past. Higher interactions help build trust and reduce opportunistic behavior by either party (e.g., Ryall and Sampson, 2009)

Control variables: We begin by controlling for the *licensee knowledge stock* and *licensor knowledge stock.* These variables relate to the stock of knowledge each partner had accumulated through patents granted in the five years preceding the year in which the contract was signed. We further weighted these patent counts with the forward citations received for it as they indicate the impact and value that a patent has in a technological field (e.g., Reuer and Devarakonda, 2016). Partners that have developed a larger portfolio of knowledge over the years have more options to license their technology instead of being locked in exclusively with each other.

We also control for the centrality of the parties in each of their respective networks through two measures- *Licensee network centrality* and *licensor network centrality*. We calculate these variables using the Bonacich (1987) centrality measure by including both the direct and indirect licensing partners for each of these parties. This measure estimates the outside options that are available to a firm as a result of its licensing network (Baum and Silverman, 2004; Ozmel, Yavuz, Reuer, and Zenger, 2017). Including this measure helps us control for the choices in exclusivity that firms make as a result of the options available beyond the current partner. To calculate the centrality of the focal firm in contract year *t*, we measure all the direct and indirect ties formed between the focal firm and the other partner firms during the five years preceding the contract year (*t*-5 to *t*-1).

$$\text{Network centrality}_{i,t}\ (C_{i,t}) = \sum_{j=1}^{N_t} (\alpha_t + \beta_t C_{j,t}) R_{i,j,t}$$

where $C_{j,t}$ is the centrality score of focal firm *j* in year *t*, and $R_{i,j,t}$ is an element of the relationship matrix R_t, indicating the licensing relationships between firms *i* and *j* during the five-year window. α_t is a scale parameter chosen so that the sum of the squares of centralities of all firms in a network in a particular year equals the number of units in the network (i.e., N_t). β_t is a weighting coefficient, indicating the effect of centralities of partners on the firm's centrality and is conventionally set to three-fourths of the reciprocal of the largest eigenvalue of the relationship matrix R_t.

Licensee licensing experience and licensor licensing experience, account for the individual licensing experience of each party (e.g., Hoang and Rothaermel, 2005). We calculate this measure by adding the number of previous alliances each partner had before the focal contract year, and then take a log of that value. These variables account for the firm's capabilities in managing licensing relationships by establishing routines that help reduce the transactional hazards in dealing with them (Gulati, Lavie, and Singh, 2009).

The variable *university* accounts for the presence of a university as a party in the licensing deal where prior literature found that most of their technologies are licensed exclusively (e.g., Jensen and Thursby, 2001). *Deal size* controls for financial information about the deal (Robinson and Stuart, 2007). It includes the sum of upfront payments as well as any milestone payments that the licensor is expected to receive over the life of the deal. We then take the log of this value to use in our estimation.

To account for the closeness of the knowledge that the firms have accumulated, we control for *technology proximity*. We calculate the measure between the licensor and the licensee dyad as the cosine similarity between the technology vectors of the two firms (Jaffe, 1986; Branstetter and Sakakibara, 2002). We begin by using all the patents from the five years prior to the focal year of signing the contract. Next, for each dyad, we created the patent class vectors *i* and *j* using the number of patents that the target and the acquiring firms had in each patent class. The cosine distance formula for vectors *i* and *j* is as follows:

$$\textit{Technology proximity } (i,j) = \frac{i \cdot j}{||i||\,||j||}$$

Since the vectors can only contain non-negative elements, this measure ranges from zero to one and indicates the proximity between the vectors *i* and *j*.

Finally, we also include fixed effects for technological *phase*, *and year* of the contract. *Phase* fixed effects control for variations in the design of contracts due to the phase of development of the drug. *Year* fixed effects control for macroeconomic events that happen in a particular year which can alter the design of contracts.

Results

Statistical Analyses

Table 1 and 2 present the descriptive statistics and the correlations respectively. We observe that 39% of our contracts are signed as a part of a *settlement*, and 58% of the contracts involve technologies that are in an *early stage*. We observe that the correlation between *early stage* and *settlement* is negative, and surprisingly the correlation between *settlement* and *licensor licensing experience* is positive. We also notice that the correlation between *exclusive license* and the independent variables and the controls are in expected directions, in line with prior literature. Finally, we also observe that the correlation between *exclusive license* and *settlement* is negative.

We employ a logistic regression model to test our hypothesis, since our main dependent variable is an indicator that takes a value of either one or zero (Wiersema and Bowen, 2009). Table 3 shows the regression results of the analysis. We include year and phase fixed effects in all regressions, and all reported standard errors are robust. To account for possible differences in the quality of licensing agreements signed as a result of settlement between firms and volitional licensing agreements, we use matching procedures. Specifically, we use the coarsened exact matching (CEM) procedure (Blackwell, Iacus, King, and Porro, 2009) to construct our matched sample. The idea behind CEM is to temporarily coarsen each variable into substantively meaningful groups. One then does an exact match on these coarsened data and only retains the original (uncoarsened) values of the matched data. We begin by constructing a control group of volitional licensing agreements that are identical to these treated agreements signed as a result of settlement based on certain characteristics we describe below.

To generate the control groups, we adhere to the following steps. First, the control agreements must be in the same technology area as the treated agreement, since agreements signed for different technology areas can differ in their choices to grant an exclusive license. Additionally, these areas can have different propensity to attract litigation and can thus design their contracts differently from others. Second, the control agreements must be signed in the same phase of clinical development to account for differences in the design of agreements signed at different technological stages. The earlier the stage, the greater is the uncertainty in the technology being used, and the greater the need for contractual safeguards to protect the parties. Finally, we also consider the year in which the agreement was signed as a matching variable, to account for macroeconomic differences creeping into the choices to grant exclusive licenses in the contracts. We perform CEM based on the outlined steps and find that the measure of overall imbalance with respect to the full joint distribution of the covariates as indicated by the multivariate L1 distance statistic, dropped from 0.97 to 0.01, indicating a good match as a substantial reduction of imbalance is observed (Blackwell et al., 2010). The L1 statistic varies between zero and one, with larger values of the statistic indicating larger imbalance between the groups.

Table 3 shows the results of our logistic regression estimates on our matched sample, Model (1) is the baseline model with only the main explanatory variables and controls. Model (2) includes the main effects and the interaction between *settlement* and the *early stage* variable.

Likewise, Model (3) includes main effects and the interaction between *settlement* and *past relationships*. Finally, Model (4) includes the full set of interactions.

Across all specifications (1)-(4) in Table 3, the coefficient on *settlement* is negative and statistically significant (p=0.000). For instance, in the model (1), the coefficient of -2.94 on *settlement* indicates that the odds of being granted an exclusive license post settlement are smaller by 0.053 compared to volitional licensing agreements. This provides strong empirical support for our hypothesis 1, in which we argue that deals signed post settlement are less likely to include exclusivity provisions between the licensor and the licensee.

Our second hypothesis predicts that the likelihood of gaining an exclusive license for early stage technologies, reduces in deals signed post settlement. In model (4), the interaction coefficient between *settlement* and *early stage* is negative and statistically significant (p=0.05). This lends credence to our second hypothesis. Given that we estimate a non-linear model, we plot this interaction effect in Figure 1. We observe an apparent downward slope in Figure 1 when the variable settlement takes the value one, which shows the diminishing effect of the chances of firms gaining an exclusive license for early stage deals post settlement.

Further, to test our third hypothesis (H3) that deduces the impact of signing licensing agreements post *settlement* on the likelihood of obtaining an exclusive license when the parties had prior relationships, we again turn to Model (4). We observe that the interaction coefficient between *settlement* and *past relationships* is negative but not statistically significant. We conduct additional tests on this non-linear interaction effect and present our findings in Figure 2. We observe in this figure that there are two panels which contain the predictive margins of the interaction effect *settlement* at different values of *past relationships*. We find when the variable *settlement* takes the value of one, at lower values of *past relationships* the probability of obtaining an exclusive license decreases when compared to the corresponding values in the panel where the variable *settlement* takes the value of zero. In other words, at the highest values of past relationships, we see no effect on the grant of exclusive licenses, irrespective of whether the deals were signed post settlement or not. The impact of *settlement* matters more for parties that had limited interactions with each other in the past, which adversely impacts the probability to grant exclusive licenses. This figure provides partial support for our hypothesis 3.

Robustness Analyses

In these analyses we test whether limiting the scope of licensing contracts could provide more options to the licensor against licensee opportunism. Following Anand and Khanna (2000) and Somaya et. al., (2011) we construct an additional variable to account for the licensing restrictions available to licensors. The variable takes a value of one if the exclusive license is unrestricted for use worldwide, takes a value of two if the exclusive license is restricted by geographic regions, and takes a value of three if the license is non-exclusive. In Table 4, we report estimates from multinomial logit models conducted on the full sample, with non-exclusive licensing as the reference category. This allows us to compare the likelihood of choosing each of the focal license type when compared to the others. We discuss the magnitude of the estimated relationships using relative risk ratios which are obtained by taking the exponential of the coefficients and interpreted similarly to logit models. In our context, the categories are based on the geographic restrictions that are placed on the licensees if they were to receive an exclusive license when compared to the reference category of receiving a non-exclusive license (e.g., Anand and Khanna, 2000; Somaya et. al., 2011). First, we find that in model 1 and model 2, there is a strong preference for handing out non-exclusive licenses when compared to exclusive licenses of either category in deals signed post settlement. Second, we find that in licenses which involve early stage technologies, there is a weak preference (p=0.098) for non-exclusive licenses over unrestricted exclusive licenses in deals signed post settlement. Additionally, in this model, there is no significant preference for non-exclusive licenses over geographically restricted licenses in early stage licensing deals. Third, we find that in licenses where the parties had prior licensing relationships, deals signed post settlement tend to have a strong likelihood of granting non-exclusive licenses when compared to geographically restricted exclusive licenses, while there is no significant difference in the preference for geographically unrestricted licenses when compared to the non-exclusive ones. Taken together, these robustness analyses suggest that although firms prefer restricted or unrestricted exclusive licenses when compared to non-exclusive licenses in early stage technologies or when they have a past relationship with each other, these relationships are modified in the presence of transactional hazards presented by settlements.

Discussion

In this paper, we study the inclusion of exclusivity provisions in agreements signed post settlement and compare them to those signed volitionally. In doing so, this study enhances the richness of the literature on the interorganizational governance and contract design in several ways. First, we find that exclusive licenses are indeed less likely to be included in deals signed post settlement. While prior studies have argued that the choice to grant an exclusive license is subject to the transactional hazards faced by the parties (e.g., Somaya et al., 2011), this finding shows that these hazards are amplified when parties settle their patent litigation. There would be questions raised about the efforts put in by either part ex-post. Additionally, the licensor would want to send a strong signal to partners and competitors about how they deal with transgressions of their IP. This also adds a novel perspective to the mechanisms of contract design by explicitly theorizing on the influence of the "shadow of the court" on contract design.

Second, we find that in licensing agreements that include early stage technologies, the likelihood of being granted an exclusive license are dampened in deals signed post settlement. Prior literature has argued how exclusive licenses can provide contractual safeguards to licensees in the face of the technological uncertainties that are present in early stage technologies as well as protect them from opportunistic behavior by licensors (eg., Deeds and Hill, 1999; Somaya et. al., 2011). We show that these hazards are further exacerbated when parties negotiate licensing agreements post settling litigation for early stage technologies. Specifically, we argue that while licensees need to depend on the licensor for transferring know-how in deals signed volitionally, the uncertainty in the licensor transferring know-how in deals signed post settlement increases, which might push licensees to not seek exclusive licenses. This implies that there are boundaries to the relationship between early stage licensing deals and the likelihood of being granted an exclusive license.

Finally, we show partial support for our hypothesis which argues that while past relationships help get an exclusive license, the likelihood of receiving one in deals signed post settlement dampens. Specifically, we find our hypothesis to hold true when there has been limited interactions between the parties in the past. When the number of past relationships increase, we find no effect of settlement on the link between past relationships and exclusivity. This implies that while it is hard to rebuild the trust that parties once had over repeated interactions with each other, perhaps longer repeated interactions can withstand transgressions better than shorter ones.

Limitations and Future Research

Future research could improve on this paper in several directions. First, in our setting survey based and empirical evidence states that biopharmaceutical industry has far fewer patent demand letters from Non-Practicing Entities (NPEs) when compared to sectors such as software, or chemicals, and manufacturing (Chien, 2013; Kiebzak, Rafert, and Tucker, 2014). In other sectors, NPEs are said to initiate frivolous litigations by alleging infringement using low quality patents (Shreshta, 2010). Further studies could expand on our study and discuss the differential impact of settling litigation where one of the parties is an NPE vis-à-vis those settled by incumbent firms.

Second, future research can also examine the external validity of our findings in settlement contracts signed in industries such as IT. These industries have shorter development life cycle and lower R&D costs for their products when compared to the long-term development cycle and high R&D costs in the biopharmaceutical industry.

Third, studies on relational governance mechanisms have found that contracts signed between partners who had prior experience with each other would contain more penalties, better monitoring, and more detail (Ryall and Sampson, 2009). A natural next step would be to check if such provisions are included in contracts signed post settlement as well.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Exclusive License	324	0.59	0.49	0	1
Settlement	324	0.39	0.49	0	1
Early Stage	324	0.58	0.49	0	1
Past Relationships	324	0.20	0.60	0	6
Licensee knowledge stock	324	0.57	2.25	0	15.11
Licensor knowledge stock	324	0.65	3.54	0	43.23
Licensee network centrality	324	0.01	0.01	0	0.03
Licensor network centrality	324	0.00	0.00	0	0.03
Licensee licensing experience	324	-0.15	0.69	-0.46	5.34
Licensor licensing experience	324	0.02	0.98	-0.42	7.90
University dummy	324	0.10	0.30	0	1
Deal size (log)	324	11.90	7.53	0	21.17
Technology proximity	324	0.12	0.27	0	0.98

Table 2: Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Exclusive License	1												
2	Settlement	-0.53*	1											
3	Early Stage	0.36*	-0.66*	1										
4	Past Relationships	0.06	-0.04	0.01	1									
5	Licensee knowledge stock	0.11*	-0.20*	0.21*	0.04	1								
6	Licensor knowledge stock	-0.04	-0.14*	-0.02	-0.04	0.11*	1							
7	Licensee network centrality	0.06	-0.27*	0.18*	0.03	0.1	0.13*	1						
8	Licensor network centrality	-0.09	0.01	0.05	0.15*	-0.02	-0.03	0.15*	1					
9	Licensor licensing experience	-0.18*	0.22*	-0.15*	0.42*	-0.04	-0.06	-0.06	0.48*	1				
10	Licensee licensing experience	0.04	-0.07	0.06	0.25*	0.08	-0.05	0.43*	-0.05	0.20*	1			
11	University dummy	0.25*	-0.09	0.18*	-0.06	-0.06	0.01	-0.19*	-0.04	-0.02	-0.08	1		
12	Deal size (log)	0.20*	-0.34*	0.31*	0.02	0.12*	-0.08	0.20*	0.09	-0.13*	0.05	-0.05	1	
13	Technology proximity	0.08	0.06	-0.11*	0.03	0.31*	-0.01	0.08	-0.04	0.02	0.17*	-0.04	-0.02	1

Table 3: Logit estimates on matched sample

VARIABLES	(1) Exclusive License	(2) Exclusive License	(3) Exclusive License	(4) Exclusive License
Settlement	-2.94***	-2.61***	-2.85***	-2.48***
	(0.55)	(0.64)	(0.59)	(0.71)
Early Stage X Settlement		-1.78†		-1.85*
		(0.94)		(0.94)
Past Relationships X Settlement			-0.33	-0.42
			(0.69)	(0.69)
Early Stage	1.07	2.31*	1.11	2.42*
	(0.71)	(0.94)	(0.72)	(0.98)
Past Relationships	0.59	0.62	0.73	0.80
	(0.36)	(0.37)	(0.52)	(0.51)
Licensee knowledge stock	-0.06	-0.10	-0.07	-0.11
	(0.14)	(0.14)	(0.13)	(0.13)
Licensor knowledge stock	-0.13**	-0.13*	-0.12**	-0.13*
	(0.04)	(0.06)	(0.04)	(0.06)
Licensee network centrality	53.30	46.06	53.00	45.37
	(66.37)	(65.19)	(64.90)	(63.18)
Licensor network centrality	-95.66	-85.18	-95.94	-85.43
	(65.54)	(64.96)	(64.93)	(64.46)
Licensee licensing experience	-0.86	-0.84	-0.86	-0.84
	(0.49)	(0.46)	(0.49)	(0.45)
Licensor licensing experience	-0.16	-0.20	-0.13	-0.16
	(0.37)	(0.39)	(0.40)	(0.42)
University dummy	3.83**	4.16**	3.75**	4.07*
	(1.27)	(1.58)	(1.27)	(1.59)
Deal size (log)	0.06	0.06	0.06	0.06
	(0.04)	(0.04)	(0.04)	(0.04)
Technology proximity	2.14*	2.03*	2.13*	2.01*
	(0.86)	(0.88)	(0.86)	(0.87)
Constant	-16.29***	-15.54***	-15.20***	-15.30***
	(1.69)	(1.61)	(1.58)	(1.52)
Phase Dummies	126.91***	141.85***	124.15***	143.94***
Year Dummies	134.15***	128.17***	123.93***	128.97***
Observations	324	324	324	324
Pseudo R-Squared	0.466	0.473	0.467	0.474
Wald Chi-sq	187.07***	322.459	295.713	326.878

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, † p<0.10

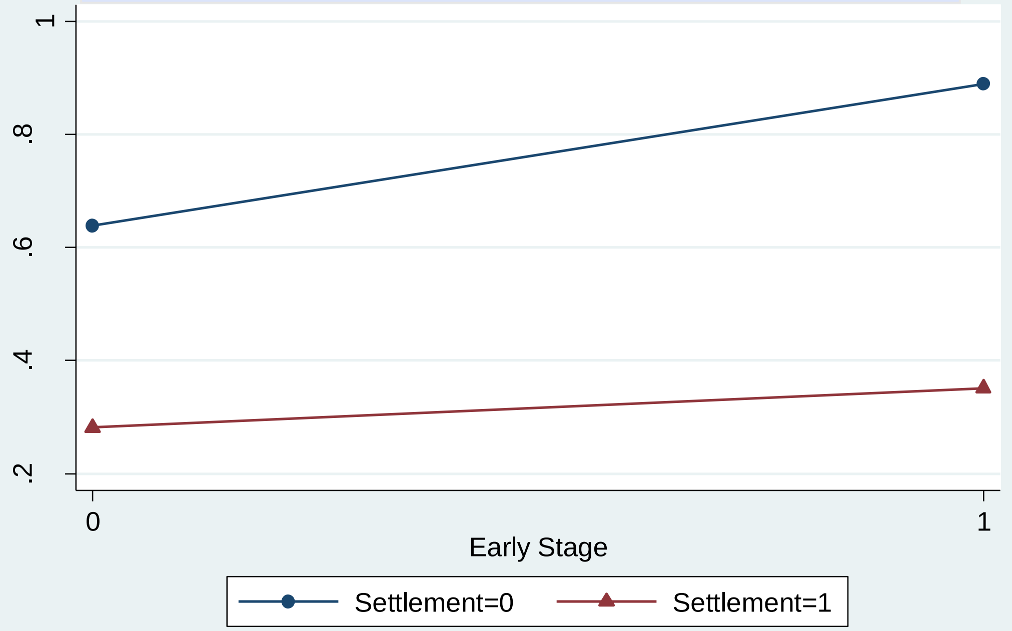
Table 4: Multinomial Logit with geographic restrictions (Full Sample)

	Non-exclusive licensing (ref. category)	
VARIABLES	**Exclusive Worldwide License (1)**	**Exclusive Limited License (2)**
Settlement	-1.95***	-4.01***
	(0.38)	(0.44)
Early Stage X Settlement	-0.91†	1.48
	(0.55)	(1.01)
Past Relationships X Settlement	-0.07	-14.02***
	(0.29)	(0.51)
Early stage	4.04***	1.71**
	(0.56)	(0.55)
Past Relationships	0.22*	0.21*
	(0.09)	(0.09)
Licensee knowledge stock	0.02	0.02
	(0.02)	(0.02)
Licensor knowledge stock	-0.02**	-0.02*
	(0.01)	(0.01)
Licensee network centrality	22.35*	-80.57***
	(10.02)	(11.88)
Licensor network centrality	-23.47	-47.38*
	(17.98)	(21.47)
Licensee licensing experience	-0.09	-0.01
	(0.07)	(0.08)
Licensor licensing experience	-0.01	-0.12
	(0.08)	(0.08)
University dummy	1.35***	-0.68
	(0.37)	(0.45)
Deal size (log)	0.07***	0.02**
	(0.01)	(0.01)
Technology proximity	0.76**	0.43
	(0.26)	(0.28)
Constant	-2.66*	0.48
	(1.05)	(1.16)
Phase Dummies	Included	Included
Year Dummies	Included	Included
Technology Dummies	Included	Included
Observations	7,132	7,132
Pseudo R-Squared	0.322	0.322

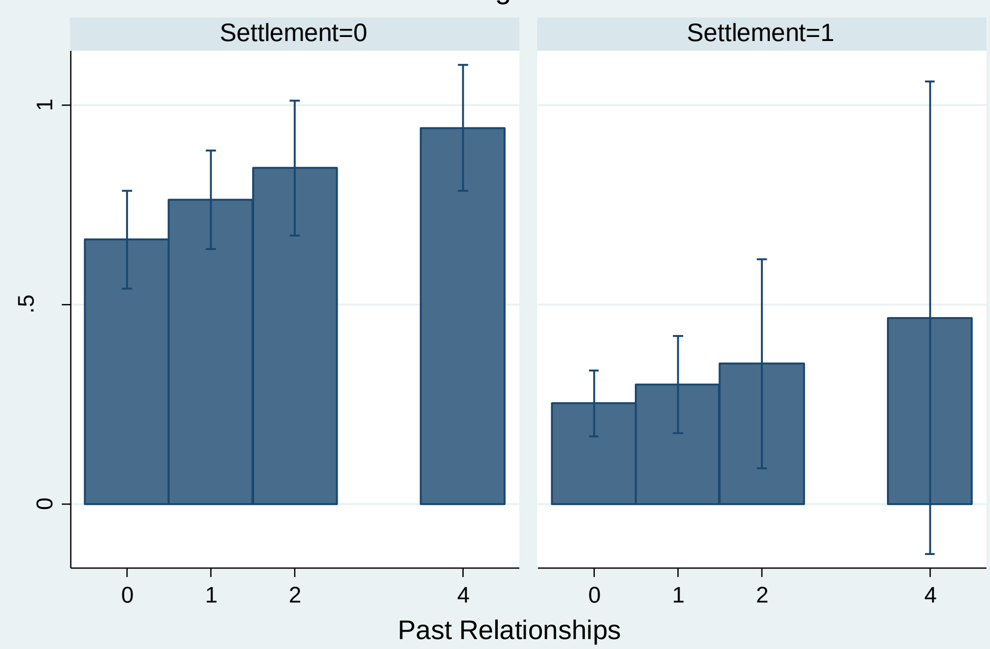
Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05 † p<0.10

Figure 1. Predictive margins: Interaction effect of early stage and settlement



Predictive Margins: Interaction effect of Past Relationships X Settlement
Fig. 2



CHAPTER V

CONCLUSION

In this dissertation, I studied the impact of the filing and resolution of patent litigation on firm level and individual level outcomes. I developed theory and gathered empirical evidence to demonstrate that patent litigation does change the way that firms and inventors collaborate, change how firms design and govern their collaboration, as well as change the ways in which inventor's career prospects are impacted.

In the first essay, we investigate the impact of firm level patent litigation on the formation of alliances by new ventures. We find strong empirical evidence that patent litigation adversely impacts the rate at which start-ups form alliances in the high-tech industry. In addition, we also examine the effectiveness of signals on alliance formation when the venture is under patent litigation. While, the remedial role of affiliation with prominent VCs and prominent positions in alliance networks might be valued by incumbent firms as credible signals that convey information about their unobservable qualities, we find that their effectiveness in attracting potential partners is reduced when the firm is under patent litigation.

In the second essay, we enhance the richness of the literature on inventor collaboration, inventor mobility, and patent litigation. First, a stream of literature on inventor collaboration has focused on how inventors' careers are disrupted due to the death of their collaborators or alluded to how technological acquisitions can affect the formation of collaborative ties. We add to this stream of literature by focusing on patent litigation as a disruptive event that heterogeneously impacts the formation of collaborative ties. On the one hand, we show that litigated inventors have difficulties forming collaborative ties with colleagues they have never worked with prior to the litigation on average. On the other hand, we show that for colleagues with whom they had collaborated with prior to the litigation, we find a positive effect. Interestingly, we observe that productivity of inventors does not change even when they are impacted by patent litigation. This could raise the question of why the likelihood of new and previous collaboration be affected. While the search costs for finding new collaborators are high, the litigated inventors increase collaborations with previous co-workers which can thus show why their productivity remains unaffected. Previous literature has also shown how strong ties between individuals can further help in the generation of new ideas (Sosa, 2010), and thus such an increase in ties with previous co-workers would thus help the inventor's not impact their productivity. Additionally, we see that litigation does not impact their ability to produce patents on their own. This provides some evidence that inventors look for potentially other ways in which their productivity can remain unaffected. Second, a stream of literature on employee mobility has shown how disruptions such as technological acquisitions can make employees consider leaving the firms. We show how patent litigation can be a disruptive event that can prevent employees from leaving the firm. Finally, while much of the literature on patent litigation has focused on its impact at the firm level, we delve much deeper and look at its impact on the specific inventors involved in that lawsuit, when compared to other employees within the firm who might not be affected by it.

In the third essay, we study the inclusion of exclusivity provisions in agreements signed post settlement and compare them to those signed volitionally. In doing so, this study enhances the richness of the literature on the interorganizational governance and contract design in several ways. First, we find that exclusive licenses are indeed less likely to be included in deals signed post settlement. While prior studies have argued that the choice to grant an exclusive license is subject to the transactional hazards faced by the parties (e.g., Somaya et al., 2011), this finding shows that these hazards are amplified when parties settle their patent litigation. There would be questions raised about the efforts put in by either part ex-post. Additionally, the licensor would want to send a strong signal to partners and competitors about how they deal with transgressions of their IP. This also adds a novel perspective to the mechanisms of contract design by explicitly theorizing on the influence of the “shadow of the court” on contract design. Second, we find that in licensing agreements that include early stage technologies, the likelihood of being granted an exclusive license are dampened in deals signed post settlement. Prior literature has argued how exclusive licenses can provide contractual safeguards to licensees in the face of the technological uncertainties that are present in early stage technologies as well as protect them from opportunistic behavior by licensors (eg., Deeds and Hill, 1999; Somaya et. al., 2011). We show that these hazards are further exacerbated when parties negotiate licensing agreements post settling litigation for early stage technologies. Specifically, we argue that while licensees need to depend on the licensor for transferring know-how in deals signed volitionally, the uncertainty in the licensor transferring know-how in deals signed post settlement increases, which might push licensees to not seek exclusive licenses. This implies that there are boundaries to the relationship between early stage licensing deals and the likelihood of being granted an exclusive license. Finally, we show partial support for our hypothesis which argues that while past relationships help get an exclusive license, the likelihood of receiving one in deals signed post settlement dampens. Specifically, we find our hypothesis to hold true when there has been limited interactions between the parties in the past. When the number of past relationships increase, we find no effect of settlement on the link between past relationships and exclusivity. This implies that while it is hard to rebuild the trust that parties once had over repeated interactions with each other, perhaps longer repeated interactions can withstand transgressions better than shorter ones.

REFERENCES

Agarwal R, Ganco M, Ziedonis RH (2009a) Reputations for toughness in patent enforcement: implications for knowledge spillovers via inventor mobility. *Strategic Management Journal* 30(13):1349–1374.

Ahmadjian C, Oxley J (2006) Using Hostages to Support Exchange: Dependence Balancing and Partial Equity Stakes in Japanese Automotive Supply Relationships. J Law Econ Organ 22(1):213–233.

Ahuja G (2000) Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. Administrative Science Quarterly 45(3):425–455.

Akerlof GA (1970) The Market for “Lemons”: Quality Uncertainty and the Market Mechanism. Q J Econ 84(3):488–500.

Anand BN, Khanna T (2000) The Structure of Licensing Contracts. The Journal of Industrial Economics 48(1):103–135.

Anand J, Oriani R, Vassolo RS (2010) Alliance Activity as a Dynamic Capability in the Face of a Discontinuous Technological Change. Organization Science 21(6):1213–1232.

Arora A (1995) Licensing Tacit Knowledge: Intellectual Property Rights And The Market For Know-How. Economics of Innovation and New Technology 4(1):41–60.

Arora A, Ceccagnoli M (2006) Patent Protection, Complementary Assets, and Firms’ Incentives for Technology Licensing. Management Science 52(2):293–308.

Arora A, Fosfuri A (2003) Licensing the market for technology. Journal of Economic Behavior & Organization 52(2):277–295.

Arrow K (1962) Economic welfare and the allocation of resources for invention. The rate and direction of inventive activity: Economic and social factors. (Princeton University Press, New Jersey), 609–626.

Association AIPL (2003) AIPLA Report of Economic Survey, 2003 (Fetzer-Kraus, Inc).

Aulakh PS, Jiang MS, Li S (2013) Licensee technological potential and exclusive rights in international licensing: A multilevel model. J Int Bus Stud 44(7):699–718.

Azoulay P, Fons-Rosen C, Graff Zivin JS (2019) Does Science Advance One Funeral at a Time? American Economic Review 109(8):2889–2920.

Azoulay P, Graff Zivin JS, Wang J (2010) Superstar Extinction. Q J Econ 125(2):549–589.

Baum JAC, Silverman BS (2004) Picking winners or building them? Alliance, intellectual, and human capital as selection criteria in venture financing and performance of biotechnology startups. Journal of Business Venturing 19(3):411–436.

Bessen J, Ford J, Meurer MJ (2011) The Private and Social Costs of Patent Trolls Property. Regulation (4):26–35.

Bessen JE, Meurer Michael James (2008) Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk (Princeton University Press).

Bessen JE, Meurer Michael J. (2008) The Private Costs of Patent Litigation (Social Science Research Network, Rochester, NY).

Bhagat S, Brickley JA, Coles JL (1994) The costs of inefficient bargaining and financial distress: Evidence from corporate lawsuits. Journal of Financial Economics 35(2):221–247.

Blackwell M, Iacus S, King G, Porro G (2009) Cem: Coarsened Exact Matching in Stata. The Stata Journal 9(4):524–546.

Boldrin M, Levine D (2002) The case against intellectual property. American Economic Review 92(2):209–212.

Bonacich P (1987) Power and Centrality: A Family of Measures. American Journal of Sociology 92(5):1170–1182.

Boudreau KJ, Brady T, Ganguli I, Gaule P, Guinan E, Hollenberg A, Lakhani KR (2017) A Field Experiment on Search Costs and the Formation of Scientific Collaborations. The Review of Economics and Statistics 99(4):565–576.

Branstetter LG, Sakakibara M (2002) When Do Research Consortia Work Well and Why? Evidence from Japanese Panel Data. American Economic Review 92(1):143–159.

Bygrave WD, Timmons J (1992) Venture Capital at the Crossroads (Social Science Research Network, Rochester, NY).

Cameron AC, Trivedi PK (1986) Econometric models based on count data. Comparisons and applications of some estimators and tests. Journal of Applied Econometrics 1(1):29–53.

Carnabuci G, Operti E (2013) Where do firms' recombinant capabilities come from? Intraorganizational networks, knowledge, and firms' ability to innovate through technological recombination. Strategic Management Journal 34(13):1591–1613.

Catalini C (2017) Microgeography and the Direction of Inventive Activity. Management Science 64(9):4348–4364.

Certo ST (2003) Influencing Initial Public Offering Investors with Prestige: Signaling with Board Structures. AMR 28(3):432–446.

Certo ST, Daily CM, Dalton DR (2001) Signaling Firm Value through Board Structure: An Investigation of Initial Public Offerings. Entrepreneurship Theory and Practice 26(2):33–50.

Chien CV (2008) Of Trolls, Davids, Goliaths, and Kings: Narratives and Evidence in the Litigation of High-Tech Patents Frontiers in Empirical Patent Law Scholarship. N.C. L. Rev. (5):1571–1616.

Cockburn IM, MacGarvie MJ (2009) Patents, Thickets and the Financing of Early-Stage Firms: Evidence from the Software Industry. Journal of Economics & Management Strategy 18(3):729–773.

Cohen BD, Dean TJ (2005) Information asymmetry and investor valuation of IPOs: top management team legitimacy as a capital market signal. Strategic Management Journal 26(7):683–690.

Cohen WM, Nelson RR, Walsh JP (2000) Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not) (National Bureau of Economic Research).

Contractor FJ, Lorange P (2002) The growth of alliances in the knowledge-based economy. International Business Review 11(4):485–502.

Crama P, Reyck BD, Degraeve Z (2008) Milestone Payments or Royalties? Contract Design for R&D Licensing. Operations Research 56(6):1539–1552.

Crane DA (2002) Exit Payments in Settlement of Patent Infringement Lawsuits: Antitrust Rules and Economic Implications. Fla. L. Rev. 54:747.

DeCarolis DM, Deeds DL (1999) The impact of stocks and flows of organizational knowledge on firm performance: an empirical investigation of the biotechnology industry. Strategic Management Journal 20(10):953–968.

Deeds DL, Hill CWL (1999) An examination of opportunistic action within research alliances: Evidence from the biotechnology industry. Journal of Business Venturing 14(2):141–163.

DiMasi JA, Grabowski HG, Hansen RW (2016) Innovation in the pharmaceutical industry: New estimates of R&D costs. Journal of Health Economics 47:20–33.

Dyer JH, Singh H (1998) The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage. AMR 23(4):660–679.

Eisenhardt KM, Schoonhoven CB (1996) Resource-based View of Strategic Alliance Formation: Strategic and Social Effects in Entrepreneurial Firms. Organization Science 7(2):136–150.

Ernst H, Vitt J (2000) The influence of corporate acquisitions on the behaviour of key inventors. R&D Management 30(2):105–120.

Farre-Mensa J, Hegde D, Ljungqvist A (2020) What Is a Patent Worth? Evidence from the U.S. Patent "Lottery." The Journal of Finance 75(2):639–682.

Filatotchev I, Bishop K (2002) Board composition, share ownership, and 'underpricing' of U.K. IPO firms. Strategic Management Journal 23(10):941–955.

Filson D, Oweis A (2010) The impacts of the rise of Paragraph IV challenges on startup alliance formation and firm value in the pharmaceutical industry. Journal of Health Economics 29(4):575–584.

Fleming L (2001) Recombinant Uncertainty in Technological Search. Management Science 47(1):117–132.

Fleming L, Mingo S, Chen D (2007) Collaborative Brokerage, Generative Creativity, and Creative Success. Administrative Science Quarterly 52(3):443–475.

Gambardella A, Giuri P, Luzzi A (2007) The market for patents in Europe. Research Policy 36(8):1163–1183.

Gompers PA, Lerner J (2004) The venture capital cycle (MIT press, Cambridge, MA).

Greis NP, Dibner MD, Bean AS (1995) External partnering as a response to innovation barriers and global competition in biotechnology. Research Policy 24(4):609–630.

Grigoriou K, Rothaermel FT (2014) Structural Microfoundations of Innovation: The Role of Relational Stars. Journal of Management 40(2):586–615.

Groysberg B, Lee LE, Nanda A (2008) Can They Take It With Them? The Portability of Star Knowledge Workers' Performance. Management Science 54(7):1213–1230.

Gulati R, Gargiulo M (1999) Where Do Interorganizational Networks Come From? American Journal of Sociology 104(5):1439–1493.

Gulati R, Higgins MC (2003) Which ties matter when? the contingent effects of interorganizational partnerships on IPO success. Strategic Management Journal 24(2):127–144.

Gulati R, Lavie D, Singh H (2009) The nature of partnering experience and the gains from alliances. Strategic Management Journal 30(11):1213–1233.

Gulati R, Singh H (1998) The Architecture of Cooperation: Managing Coordination Costs and Appropriation Concerns in Strategic Alliances. Administrative Science Quarterly 43(4):781–814.

Guler I, Nerkar A (2012) The impact of global and local cohesion on innovation in the pharmaceutical industry. Strategic Management Journal 33(5):535–549.

Hagiu A, Yoffie DB (2013) The New Patent Intermediaries: Platforms, Defensive Aggregators, and Super-Aggregators. Journal of Economic Perspectives 27(1):45–66.

Hall BH, Ziedonis RH (2001) The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995. The RAND Journal of Economics 32(1):101–128.

Harrison JS, Boivie S, Sharp NY, Gentry RJ (2017) Saving Face: How Exit in Response to Negative Press and Star Analyst Downgrades Reflects Reputation Maintenance by Directors. AMJ 61(3):1131–1157.

Hausman JA, Hall BH, Griliches Z (1984) Econometric Models for Count Data with an Application to the Patents-R&D Relationship (National Bureau of Economic Research).

Hellmann T, Puri M (2002) Venture Capital and the Professionalization of Start-Up Firms: Empirical Evidence. The Journal of Finance 57(1):169–197.

Hoang H, Rothaermel FT (2005) The Effect of General and Partner-Specific Alliance Experience on Joint R&D Project Performance. AMJ 48(2):332–345.

Hsu DH (2004) What Do Entrepreneurs Pay for Venture Capital Affiliation? The Journal of Finance 59(4):1805–1844.

Hsu DH (2006) Venture Capitalists and Cooperative Start-up Commercialization Strategy. Management Science 52(2):204–219.

Jaffe AB (1986) Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits and Market Value (National Bureau of Economic Research).

Jaffe AB, Lerner J (2011) Innovation and its discontents: How our broken patent system is endangering innovation and progress, and what to do about it (Princeton University Press).

Jensen M (2003) The Role of Network Resources in Market Entry: Commercial Banks' Entry into Investment Banking, 1991–1997. Administrative Science Quarterly 48(3):466–497.

Jensen R, Thursby M (2001) Proofs and Prototypes for Sale: The Licensing of University Inventions. American Economic Review 91(1):240–259.

Jones A, Clifford L Drug discovery alliances. Nature Reviews Drug Discovery. Retrieved (September 13, 2019), https://www.nature.com/articles/nrd1856.

Judiciary USCHC on the (2015) Innovation Act: Report Together with Dissenting Views (to Accompany H.R. 9) (including Cost Estimate of the Congressional Budget Office). (U. S. Government Publishing Office).

Kale P, Singh H (2007) Building firm capabilities through learning: the role of the alliance learning process in alliance capability and firm-level alliance success. Strategic Management Journal 28(10):981–1000.

Kapoor R, Lim K (2007) The Impact of Acquisitions on the Productivity of Inventors at Semiconductor Firms: A Synthesis of Knowledge-Based and Incentive-Based Perspectives. AMJ 50(5):1133–1155.

Katila R, Rosenberger JD, Eisenhardt KM (2008) Swimming with Sharks: Technology Ventures, Defense Mechanisms and Corporate Relationships. Administrative Science Quarterly 53(2):295–332.

Kesan JP, Ball GG (2006) How Are Patent Cases Resolved - An Empirical Examination of the Adjudication and Settlement of Patent Disputes. Wash. U. L. Rev. 84:237.

Kiebzak S, Rafert G, Tucker CE (2016) The effect of patent litigation and patent assertion entities on entrepreneurial activity. Research Policy 45(1):218–231.

Kim J (2011) Alliance governance and technological performance: some evidence from biotechnology alliances. Ind Corp Change 20(4):969–990.

Klevorick AK, Levin RC, Nelson RR, Winter SG (1995) On the sources and significance of interindustry differences in technological opportunities. Research Policy 24(2):185–205.

Koka BR, Prescott JE (2008) Designing alliance networks: the influence of network position, environmental change, and strategy on firm performance. Strategic Management Journal 29(6):639–661.

Krug JA, Hegarty WH (1997) Postacquisition turnover among U.S. top management teams: an analysis of the effects of foreign vs. domestic acquisitions of U.S. targets. Strategic Management Journal 18(8):667–675.

Lanjouw JO, Schankerman M (1997) Stylized Facts of Patent Litigation: Value, Scope and Ownership (National Bureau of Economic Research).

Lanjouw JO, Schankerman M (2001) Characteristics of Patent Litigation: A Window on Competition. The RAND Journal of Economics 32(1):129–151.

Lanjouw JO, Schankerman M (2004) Protecting Intellectual Property Rights: Are Small Firms Handicapped? The Journal of Law and Economics 47(1):45–74.

Lemley MA (2007) Are Universities Patent Trolls. Fordham Intell. Prop. Media & Ent. L.J. 18:611.

Lemley MA, Shapiro C (2005) Probabilistic Patents. Journal of Economic Perspectives 19(2):75–98.

Leone MI, Reichstein T (2012) Licensing-in fosters rapid invention! the effect of the grant-back clause and technological unfamiliarity. Strategic Management Journal 33(8):965–985.

Lerner J (1995a) Venture Capitalists and the Oversight of Private Firms. The Journal of Finance 50(1):301–318.

Lerner J (1995b) Patenting in the Shadow of Competitors. The Journal of Law and Economics 38(2):463–495.

Lerner J, Merges RP (1998) The Control of Technology Alliances: An Empirical Analysis of the Biotechnology Industry. The Journal of Industrial Economics 46(2):125–156.

Lerner J, Shane H, Tsai A (2003) Do equity financing cycles matter? evidence from biotechnology alliances. Journal of Financial Economics 67(3):411–446.

Levin RC, Klevorick AK, Nelson RR, Winter SG, Gilbert R, Griliches Z (1987) Appropriating the returns from industrial research and development. Brookings papers on economic activity 1987(3):783–831.

Levitas E, McFadyen MA (2009) Managing liquidity in research-intensive firms: signaling and cash flow effects of patents and alliance activities. Strategic Management Journal 30(6):659–678.

Li D, Eden L, Hitt MA, Ireland RD (2008) Friends, Acquaintances, or Strangers? Partner Selection in R&D Alliances. AMJ 51(2):315–334.

Li Y (2008) Duration analysis of venture capital staging: A real options perspective. Journal of Business Venturing 23(5):497–512.

Liebeskind JP (1996) Knowledge, strategy, and the theory of the firm. Strategic Management Journal 17(S2):93–107.

Lioukas CS, Reuer JJ (2020) Choosing Between Safeguards: Scope and Governance Decisions in R&D Alliances. Journal of Management 46(3):359–384.

Long C (2002) Patent Signals. The University of Chicago Law Review 69(2):625–679.

Luo XR, Koput KW, Powell WW (2009) Intellectual capital or signal? The effects of scientists on alliance formation in knowledge-intensive industries. Research Policy 38(8):1313–1325.

Mayer KJ, Argyres NS (2004) Learning to Contract: Evidence from the Personal Computer Industry. Organization Science 15(4):394–410.

Megginson WL, Weiss KA (1991) Venture Capitalist Certification in Initial Public Offerings. The Journal of Finance 46(3):879–903.

Melero E, Palomeras N, Wehrheim D (2020) The Effect of Patent Protection on Inventor Mobility. Management Science.

Nicholson S, Danzon PM, McCullough J (2005) Biotech-Pharmaceutical Alliances as a Signal of Asset and Firm Quality. The Journal of Business 78(4):1433–1464.

OECD (2004) Patents, Innovation and Economic Performance OECD Conference Proceedings: OECD Conference Proceedings (OECD Publishing).

Oettl A (2012) Reconceptualizing Stars: Scientist Helpfulness and Peer Performance. Management Science 58(6):1122–1140.

Oldroyd JB, Morris SS (2012) Catching Falling Stars: A Human Resource Response to Social Capital's Detrimental Effect of Information Overload on Star Employees. AMR 37(3):396–418.

Ozmel U, Reuer JJ, Gulati R (2012) Signals across Multiple Networks: How Venture Capital and Alliance Networks Affect Interorganizational Collaboration. AMJ 56(3):852–866.

Ozmel U, Robinson DT, Stuart TE (2013) Strategic alliances, venture capital, and exit decisions in early stage high-tech firms. Journal of Financial Economics 107(3):655–670.

Ozmel U, Yavuz D, Reuer JJ, Zenger T (2017) Network Prominence, Bargaining Power, and the Allocation of Value Capturing Rights in High-Tech Alliance Contracts. Organization Science 28(5):947–964.

Paik Y, Zhu F (2016) The Impact of Patent Wars on Firm Strategy: Evidence from the Global Smartphone Industry. Organization Science 27(6):1397–1416.

Palomeras N, Melero E (2010) Markets for Inventors: Learning-by-Hiring as a Driver of Mobility. Management Science 56(5):881–895.

Paruchuri S, Nerkar A, Hambrick DC (2006) Acquisition Integration and Productivity Losses in the Technical Core: Disruption of Inventors in Acquired Companies. Organization Science 17(5):545–562.

Pisano GP (1989) Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry. J. L. Econ. & Org. (1):109–126.

Pisano GP (1990) The R&D boundaries of the firm: an empirical analysis. Administrative science quarterly 35(1):153–176.

Podolny JM (1993) A Status-Based Model of Market Competition. American Journal of Sociology 98(4):829–872.

Podolny JM (1994) Market Uncertainty and the Social Character of Economic Exchange. Administrative Science Quarterly 39(3):458–483.

Podolny JM (2001) Networks as the Pipes and Prisms of the Market. American Journal of Sociology 107(1):33–60.

Poppo L, Zenger T (2002) Do formal contracts and relational governance function as substitutes or complements? Strategic Management Journal 23(8):707–725.

Powell WW, Koput KW, Smith-Doerr L (1996) Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. Administrative Science Quarterly 41(1):116–145.

Ranft AL, Lord MD (2002) Acquiring New Technologies and Capabilities: A Grounded Model of Acquisition Implementation. Organization Science 13(4):420–441.

Rao H (1994) The Social Construction of Reputation: Certification Contests, Legitimation, and the Survival of Organizations in the American Automobile Industry: 1895–1912. Strategic Management Journal 15(S1):29–44.

Reuer JJ, Devarakonda R (2017) Partner Selection in R&D Collaborations: Effects of Affiliations with Venture Capitalists. Organization Science 28(3):574–595.

Reuer JJ, Devarakonda SV (2015) Mechanisms of Hybrid Governance: Administrative Committees in Non-Equity Alliances. AMJ 59(2):510–533.

Reuer JJ, Lahiri N (2013) Searching for Alliance Partners: Effects of Geographic Distance on the Formation of R&D Collaborations. Organization Science 25(1):283–298.

Robinson DT, Stuart TE (2007) Financial Contracting in Biotech Strategic Alliances. The Journal of Law and Economics 50(3):559–596.

Roijakkers N, Hagedoorn J (2006) Inter-firm R&D partnering in pharmaceutical biotechnology since 1975: Trends, patterns, and networks. Research Policy 35(3):431–446.

Ronspies JA (2004) Does David Need a New Sling - Small Entities Face a Costly Barrier to Patent Protection. J. Marshall Rev. Intell. Prop. L. 4:[i].

Rosenkopf L, Almeida P (2003) Overcoming Local Search Through Alliances and Mobility. Management Science 49(6):751–766.

Rothaermel FT, Deeds DL (2004) Exploration and exploitation alliances in biotechnology: a system of new product development. Strategic Management Journal 25(3):201–221.

Ryall MD, Sampson RC (2009) Formal Contracts in the Presence of Relational Enforcement Mechanisms: Evidence from Technology Development Projects. Management Science 55(6):906–925.

Sahlman WA (1990) The structure and governance of venture-capital organizations. Journal of Financial Economics 27(2):473–521.

Sakakibara M (2010) An empirical analysis of pricing in patent licensing contracts. Ind Corp Change 19(3):927–945.

Sanders WG, Boivie S (2004) Sorting things out: valuation of new firms in uncertain markets. Strategic Management Journal 25(2):167–186.

Santoro MD, McGill JP (2005) The effect of uncertainty and asset co-specialization on governance in biotechnology alliances. Strategic Management Journal 26(13):1261–1269.

Schilling MA (2009) Understanding the alliance data. Strategic Management Journal 30(3):233–260.

Seru A (2014) Firm boundaries matter: Evidence from conglomerates and R&D activity. Journal of Financial Economics 111(2):381–405.

Shane S, Somaya D (2007) The effects of patent litigation on university licensing efforts. Journal of Economic Behavior & Organization 63(4):739–755.

Shane S, Stuart T (2002) Organizational Endowments and the Performance of University Start-ups. Management Science 48(1):154–170.

Shaw JD, Park TY, Kim E (2013) A resource-based perspective on human capital losses, HRM investments, and organizational performance. Strategic Management Journal 34(5):572–589.

Shipilov AV, Rowley TJ, Aharonson BS (2006) When Do Networks Matter? A Study of Tie Formation and Decay. Baum JAC, Dobrev S, Van Witteloostuijn A, eds. Advances in Strategic Management. 481–519.

Shrestha SK (2010) Trolls or Market-Makers - An Empirical Analysis of Nonpracticing Entities Note. Colum. L. Rev. (1):114–160.

Singh J, Agrawal A (2010) Recruiting for Ideas: How Firms Exploit the Prior Inventions of New Hires. Management Science 57(1):129–150.

Singh J, Fleming L (2009) Lone Inventors as Sources of Breakthroughs: Myth or Reality? Management Science 56(1):41–56.

Smeets R (2014) Does Patent Litigation Reduce Corporate R&D? An Analysis of US Public Firms (Social Science Research Network, Rochester, NY).

Somaya D (2003) Strategic determinants of decisions not to settle patent litigation. Strategic Management Journal 24(1):17–38.

Somaya D, Kim Y, Vonortas NS (2011) Exclusivity in licensing alliances: using hostages to support technology commercialization. Strategic Management Journal 32(2):159–186.

Somaya D, Williamson IO, Lorinkova N (2008) Gone but Not Lost: The Different Performance Impacts of Employee Mobility Between Cooperators Versus Competitors. AMJ 51(5):936–953.

Song J, Almeida P, Wu G (2003) Learning–by–Hiring: When Is Mobility More Likely to Facilitate Interfirm Knowledge Transfer? Management Science 49(4):351–365.

Sorenson O, Stuart TE (2001) Syndication Networks and the Spatial Distribution of Venture Capital Investments. American Journal of Sociology 106(6):1546–1588.

Sosa ME (2010) Where Do Creative Interactions Come From? The Role of Tie Content and Social Networks. Organization Science 22(1):1–21.

Spence M (1973) Job Market Signaling. Q J Econ 87(3):355–374.

Stinchcombe AL (1965) Organizations and social structure. Handbook of organizations 44(2):142–193.

Stuart TE (1998) Network Positions and Propensities to Collaborate: An Investigation of Strategic Alliance Formation in a High-Technology Industry. Administrative Science Quarterly 43(3):668–698.

Stuart TE (2000) Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. Strategic Management Journal 21(8):791–811.

Stuart TE, Hoang H, Hybels RC (1999) Interorganizational Endorsements and the Performance of Entrepreneurial Ventures. Administrative Science Quarterly 44(2):315–349.

Stuart TE, Ozdemir SZ, Ding WW (2007) Vertical alliance networks: The case of university–biotechnology–pharmaceutical alliance chains. Research Policy 36(4):477–498.

Toh PK, Polidoro F (2013) A competition-based explanation of collaborative invention within the firm. Strategic Management Journal 34(10):1186–1208.

Tzabbar D (2009) When Does Scientist Recruitment Affect Technological Repositioning? AMJ 52(5):873–896.

Tzabbar D, Vestal A (2015) Bridging the Social Chasm in Geographically Distributed R&D Teams: The Moderating Effects of Relational Strength and Status Asymmetry on the Novelty of Team Innovation. Organization Science 26(3):811–829.

Wiersema MF, Bowen HP (2009) The use of limited dependent variable techniques in strategy research: issues and methods. Strategic Management Journal 30(6):679–692.

Williamson OE (1983) Credible Commitments: Using Hostages to Support Exchange. The American Economic Review 73(4):519–540.

Wilson P (2015) The misuse of the Vuong test for non-nested models to test for zero-inflation. Economics Letters 127:51–53.

Wuchty S, Jones BF, Uzzi B (2007) The Increasing Dominance of Teams in Production of Knowledge. Science 316(5827):1036–1039.

Zollo M, Reuer JJ, Singh H (2002) Interorganizational Routines and Performance in Strategic Alliances. Organization Science 13(6):701–713.