Dear Enemy:
Litigation and Cooperation in a Mobile Phone Standard Development Organization

Stephen Jones
University of Wyoming

Aija Leiponen
Cornell University

Gurneeta Vasudeva
University of Minnesota

All authors contributed equally; authors are listed alphabetically by last name. We wish to thank Scott Crawford and participants at the Searle Conference on Innovation Economics at Northwestern University for their input on drafts of this article.

ABSTRACT

We study the impact of conflict on cooperation within wireless telecom standards development. There is limited systematic inquiry into inter-organizational conflict. The research on alliance management emphasizes mechanisms of formal and informal governance such as contractual terms and trust building as strategies to avoid cooperative failure. We build on and compare these insights with insights from evolutionary biology and collective action to highlight strategic implications of conflict while competing for resources. We empirically analyze the effects of patent litigation events on cooperative efforts within the 3GPP standard development organization which sets global standards for mobile communications. We find that, overall, litigation increases cooperation within litigating dyads, supporting the “dear enemy”, or mutual forbearance, view of strategic interaction, but it also shifts defendants’ cooperative efforts towards other firms in the network, as they may divert the technology away from the attacker. We also find that technological distance and relational resources moderate the results. Our findings hold implications for understanding the dynamics of cooperation in technological competition.

Dear Enemy:
Litigation and Cooperation in a Mobile Phone Standard Development Organization

INTRODUCTION

The literature on animal ecology observes that despite direct competition for resources, space and partners, territory holders often show reduced aggression towards their neighbors (e.g. Jaeger, 1981; Temeles, 1994). This paradox, which is sometimes called the ‘dear enemy’ effect, has been explained as an evolutionary response that recognizes the high costs and low payoffs of aggression towards territorial neighbors across a number of different animal species. A parallel literature on the evolution of cooperation has found that in repeated Prisoner’s Dilemma games, cooperative interactions in animals and humans can emerge based on the principles of kinship and reciprocity (Axelrod & Hamilton, 1981). Such cooperation could take different forms, such as mutualism or symbiotic interactions (which includes gains through complementarity and reciprocity) and breeding for direct and indirect genetic benefits (Buston and Balshine, 2007; Clutton-Brock, 2002; Griffin, West, & Buckling, 2004; Hamilton, 1964). Under certain conditions, cooperation can thus be an evolutionarily beneficial strategy.

Economic game theory reaches a similar conclusion as repeated interactions seem to increase the likelihood of cooperative behavior in industrial buyer-supplier relationships (Heide & Miner, 1992) and between legal adversaries (Johnston & Waldfogel, 2002). The above studies of conflict and cooperation among organizations and individuals drew attention to the underlying social processes such as learning and trust, such that when faced with the prospect of repeated interactions, rival parties tend to cooperate with one another rather than retaliate (Axelrod, 1984). Although this corpus of research explains why cooperative strategies are used in settings with repeated interactions, it does not explain how cooperation evolves when defection, conflict, or disagreement arise.

Not unlike other territorial species, firms within an industry often choose to situate themselves in close proximity to their rivals through geographical agglomeration, co-creation networks, consortia and standard-setting organizations. This type of locational proximity, domain similarity or overlapping resource base, while beneficial in creating a shared ecosystem of mutual exchange and interdependence, is also known to perpetuate intense rivalry and competition (Baum & Haveman, 1997). Consequently, a crucial point of departure for our study is that in inter-organizational contexts such as standard development organizations (SDOs), cooperation between firms is enmeshed with the imperatives of balancing private interests with collective outcomes (Ostrom, 2000). For example, firms that participate in SDOs seek to develop compatible and inter-operable platforms with the goal of increasing the adoption for their complementary products in network-based industries (cf. Farrell & Saloner, 1988; Bar & Leiponen, 2014). Towards this goal, firms encounter strong incentives to cooperate and coordinate their technological development with rival firms with whom they may have a history of conflict (Delcamp & Leiponen, 2014). As an illustration of this phenomenon, in many high technology industries such as smart phones, the number of patent complaints has increased by 20% annually since 2006. This has led to an explosion of litigation concerning the licensing of standard essential patents and infringement of product features (Economist, 2010). Despite the frequency of these litigation events, rivals may have little choice but to continue the joint development of technical standards or to maintain licensing contracts. As an example, even after the "patent trial of the century" (Elmer-Dewitt, 2012), Apple and Samsung continued their complementary buyer-supplier relationship (Baj, 2015).

Although the economic literature on the drivers of success in conflict—which include the resources and determination to fight (e.g., Hirshleifer, 1991)—has been useful for understanding firms' litigation strategies in the context of innovation and intellectual property rights (e.g., Graham & Vishnubhakat, 2013; Lanjouw & Schankerman, 2001; Somaya, 2003), these studies have not explicitly delved into the implications for *subsequent* interaction between firms. Our study is among the first to relate the effects of litigation back to co-creation networks such as SDOs that are crucial for firms' innovation outcomes. We examine how legal conflict in innovation influences cooperation between the affected parties in their innovation networks, and how its impact propagates in the cooperation network to indirectly-affected firms. Against this backdrop, we ask how cooperation evolves after legal contestation, not only between the contestants themselves but also how the defendants' cooperative responses vis-à-vis other firms within the co-creation network evolve in response to such conflicts.

In technological competition, firms coalesce in co-creation networks to benefit from mutualism and kinship in the form of shared infrastructure, information exchange and access to consumers as well as to propagate their technology and know-how (Dyer & Singh, 1998; Rosenkopf, Metiu, & George, 2001). In such interdependent settings, cooperation—even in the face of conflict—is likely because regardless of what others do, an individual's 'fitness' in terms of its technological and social standing emerges from being engaged with the larger group (Roberts, 2005). Expressing this idea through a game theoretic perspective, the long-term payoff for cooperation remains higher than the immediate payoff for defection even when another party acts aggressively. Accordingly, we posit the 'dear enemy' effect such that contesting firms may increase their cooperative interactions. Such payoffs for cooperative interaction are underpinned by two main mechanisms—learning about the adversary to overcome information asymmetries and restoring trust in the relationship, both of which are crucial for achieving the interdependent collective interests.

Positing an increase in cooperation as a response to conflict may appear counterintuitive. Research has shown that partners tend to leave relationships when there is friction (Greve, Baum, Mitsuhashi, & Rowley, 2010), not cooperate more. Violations of expectations tend to destroy trust and lead partners to distance themselves from violators or to seek revenge (Bies & Tripp, 1996; Bradfield & Aquino, 1999; Lount, Zhong, Sivanathan, & Murnighan, 2008). Yet, extant research does not adequately consider how the context in which relationships exist may alter the payoffs for cooperation or defection. In the context of high and long-term interdependence in SDOs, cooperative strategies may still lead to better outcomes for the collective even when individual actors face conflict.

Of particular theoretical importance are the contingencies that temper the cooperative interactions between contestants. In this regard, we argue that the more technologically distant the contestants, the stronger the learning imperatives to overcome the informational asymmetries and hence, the greater the cooperative interaction. Moreover, defendants that enjoy a strong relational position in the co-creation network may have less incentives to restore their relationship with the plaintiff. In the presence of multiple existing partnerships, a defendant might rationalize that it has the necessary relational resources to fight back any future disagreements (Skaperdas & Syropoulos, 1996), thereby limiting its interests in cooperating with the plaintiff.

Apart from managing its interactions with the plaintiff, a defendant must also determine its cooperative strategy with other participants within the co-creation network. We suggest that defendants will seek to enhance their cooperation with other participants. By strengthening prior ties and forming new ties, defendants can secure their relational positions to shield themselves from future conflicts. In this manner contestation acts to simultaneously sustain cooperation between the parties to the conflict, while propelling the defendants to expand the scope of their ties to other participants in the network space.

We test our hypotheses related to repeated interaction and collective action in a technological and relational landscape in the context of the 3GPP standards development organization, which brings together firms from a number of industries engaged in the development of mobile phone technologies. 3GPP is the internationally-recognized body for developing global mobile communications standards. Each year hundreds of member firms from the U.S., Europe, and Asia collaborate to produce thousands of technical contributions that comprise the specifications for

3G, 4G, and beyond. Many of these firms possess patents (called standard-essential patents or SEPs) upon which the contributions are built. Conflicts arise when firms believe others have failed to gain the needed licenses or when licensing arrangements are believed to be onerous and unfair (thus breaking the 3GPP requirement that licensing arrangements be fair, reasonable, and non-discriminatory). The 3GPP SDO is an appropriate setting to test our arguments because it represents a well-defined organizational space wherein firms with competing and complementary technologies collaborate voluntarily to achieve collective outcomes. The technology standards that SDOs seek to create are akin to public goods that hinge on collective action among a variety of organizations that can differ in terms of their organizational (Simcoe, 2012) and institutional backgrounds (Vasudeva, Alexander, & Jones, 2014). Yet, despite a large and growing literature on the complexities of such private institutional arrangements to address collective action problems (Gardner et al., 2010), little is known about the processes underlying cooperation between various parties against a backdrop of contestation.

Our study tracks the evolution of intense cooperative activities over a period of eight years. From an empirical standpoint, the novelty of our work emerges from isolating instances of conflict using intellectual property right lawsuits among the parties and linking these to observable cooperative outcomes in corresponding technological working groups within 3GPP. We identify patent lawsuits directly related to the technical specifications under development in the standardization committee in question and observe the pattern of cooperation both before and after the initiation of the lawsuit. We test hypotheses regarding the impact of the lawsuit on the cooperative activity among the parties directly affected by the lawsuit (the plaintiff and defendants) as well as those indirectly affected through the cooperative efforts of a defendant. In this manner we investigate how firms deal with conflict and disagreement with their co-creation partners.

We find that defendants and plaintiffs increase their level of cooperation after the initiation of a lawsuit, supporting our arguments for the dear enemy effect. Our argument is bolstered by the additional findings that technological distance amplifies cooperation while relational scope or centrality diminishes it. Further, we find that defendants expand their cooperative strategy by increasing their level of coauthoring with co-defendants and other firms in the network. This dual outcome of increasing cooperation with both the plaintiff and others network actors highlights defendants' efforts to build contingencies against future conflict even while expanding their cooperation with plaintiffs. We also find that these results are moderated by the defendant's technological and relational characteristics.

THEORY AND HYPOTHESES

For the purpose of our theorization about the evolution of cooperation, the alliance management literature provides a useful starting point. Several studies have taken a lifecycle view of alliances whereby repeated interactions between partners allow partners to learn and update their expectations of efficiency and equity and make the necessary adjustments to the alliance (Arino & de la Torre, 1998; Doz, 1996; Ring & Van de Ven, 1994). External environmental conditions such as technological breakthroughs and demand shocks are also known to disrupt the pattern of cooperation and result in "ferment" (Anderson & Tushman, 1990) whereby network relationships are reconfigured (Tushman & Rosenkopf, 1998). Cooperative technology development can thus evolve depending on the technological marketplace and the participants' strategic interactions.

Studies on cooperative success highlight the notion that fair dealing in alliances goes beyond economic and rational calculations, and instead takes a more social-psychological perspective whereby the relational quality in terms of trust and reciprocity is central to cooperation success (e.g., Gulati, 1995; Das & Teng, 1998; Zaheer, McEvily and Perrone, 1998). Subsequent work sought to explain how such relational quality in alliances can be secured through various structural and relational configurations such as repeated alliances (Gulati & Gargiuolo, 1999). In other work, Gulati and Singh (1998) highlighted the role of coordination costs that could accentuate the need for formalization of alliance governance. In contrast to these relational approaches, the transaction-cost view of cooperative structures emphasized the role of governance arrangements in mitigating transaction hazards such as expropriation of intangible assets (Oxley, 1997). Subsequent work has integrated the transaction cost and trust-based perspectives to argue that high levels of trust are compatible with less formal governance as trust substitutes for governance, and trust complements governance in determining performance outcomes (Dyer & Singh, 1998; Gulati & Nickerson, 2008; Poppo & Zenger, 2002). Katila, Rosenberger, and Eisenhardt (2008) introduced the aspect of partner choice, whereby technology startups' resource needs are balanced against expropriation concerns when choosing partners. Relatedly, Vasudeva, Spencer, and Teegen (2013) emphasized competitive versus cooperative institutional norms as drivers of partner selection and innovation outcomes in inter-firm alliances. Yet, despite the established wisdom that alliances are more likely to succeed as partners learn about each other and develop mechanisms to build trust to prevent conflict and alliance failure, there is limited research examining whether or when a history of conflict will induce cooperative failure or, alternatively, propel tighter cooperation.

Dear Enemy: Cooperation between Contestants

Game theory highlights that in repeated games, cooperation between parties is likely to emerge as a forward-looking strategy that considers future payoffs rather than past conflicts (Axelrod & Hamilton, 1981). Based on this perspective, in evolutionary biology, the 'dear enemy' recognition involves animal populations such as salamanders or ants that are less aggressive toward familiar territorial neighbors than toward strangers (e.g., Jaeger, 1981). The dear enemy view of competition provides insights into repeated interactions in a defined territory whereby individuals consider a trade-off between fighting a rival neighbor for resources versus fending off new infiltrators that could compete for both resources and partners. A similar perspective in the strategy literature recognizes that neighboring rivals may cooperate to prevent the insurgence of distant rivals (Polidoro & Toh, 2011). We draw on these insights to propose two processes—one that emphasizes learning and the other trust repair—that shape firms’ cooperative behaviors with contestants in repeated play settings.

Conflict could trigger attention to learning from the conflicting partner because, in a repeated play settings, the shadow of the future can increase mutual interest in reducing information asymmetries between rivals. In other words, sudden conflict can highlight existing asymmetries and the need for greater cooperation. It can lead to the recognition of complementarities that would induce firms to pool resources for mutual gains. As conflicting parties pool resources, they not only reduce the potential for opportunism by increasing mutual commitment in the form of investments in relationship-specific assets (Ahmadjian & Oxley, 2006), but they also hold the potential to retaliate in case one party decides to defect (Heide & Miner, 1992). Additionally, by diverting resources from continued conflict or a ‘war of attrition’, contestants can combine resources to fend off new entrants that infringe on their territory (Polidoro & Toh, 2011). By renegotiating and increasing their cooperative endeavors, partners are able to improve their long-term prospects in the close technological space.

Moreover, from a social-psychological standpoint, conflict can have an especially punitive effect on the contestants’ mutual trust and reputation that are bound together in a co-creation network. While defection from the relationship may be desired when conflict arises (Lount, et al., 2008), the benefit of mutual gains may instead lead firms to continue or even increase their cooperation. Conflict may lead mutually-dependent firms to enact trust repair processes (Kramer & Lewicki, 2010). At the inter-organizational level, these include structural reforms that reduce negative interactions and increase positive ones (Dirks, Lewicki, & Zaheer, 2009). Consequently, cooperation can help build positive perceptions to restore trust (Gulati & Sytch, 2008; Zaheer, McEvily & Perrone, 1998) and serve as a social glue (Robinson & Stuart, 2007) in repeated play settings. Based on this reasoning, one might expect cooperation between contesting parties to increase.

Litigation is a form of conflict that has the potential to inhibit cooperation between parties; however, within the technological context of SDOs, the dear enemy effect as outlined above is likely to increase cooperation.

> *Hypothesis 1: A litigation event concerning a standard essential patent will increase cooperation between the contesting firms in the working group concerned with that standard.*

The Contingent Role of Technological Distance between Contestants

While repeated interaction can generate cooperation to realize the benefits of standard-setting work, we highlight situations in which the interests to learn and restore trust might amplify or break down.

The dear enemy hypothesis implies that, even though all individuals within a population compete for the same set of resources, their response to territorial disputes depends on their initial geographical distance from one another. Heinze et al. (1996) speculate that the dear enemy phenomenon arises because adjacent populations are likely to peacefully co-exist in neighboring territories due to the aforementioned low payoffs and high costs of aggression, whereas the appearance of individuals from a more distant population might indicate their interest in finding a new nesting place, and therefore be more threatening to the survival of the focal group. In this case, the benefits of aggression (i.e., survival) are substantially increased.

The territorial view of competition is fruitful for understanding standard-setting competition because the cooperative and competitive activity can be analyzed within the technological landscape of the communication system to be standardized, and because participants are making territorial claims to control specific areas of the landscape via standard-essential patent rights. However, we expect technological distance between contestants to influence cooperation in a different way than geographic distance among animals. In contrast to geographic migration, technological migration is much more difficult to achieve. Technological capabilities evolve in a gradual and path-dependent manner (Helfat, 1994; Stuart & Podolny, 1996), and it is difficult for a firm to make a sudden leap into another firm's technological territory if they have not started to build such capabilities a long time ago. In other words, a surprising migration into a new part of the landscape by a rival is highly unlikely because of cognitive constraints and path dependence that perpetuate local search (Cohen & Levinthal, 1989; Nelson & Winter, 1982).

While technologically distant firms are significantly less threatening than technologically close firms, and technological proximity can be used to measure rivalry in the technology landscape, the same cognitive mechanisms that produce local search behaviors also inhibit interactions with technologically distant rivals. Accordingly, consistent with the dear enemy hypothesis a number of studies of technological cooperation attest to more social interactions and knowledge flows between technologically proximate firms in contexts such as technical committees (Rosenkopf et al., 2001).

We suggest that contests between technologically distant firms could draw attention to the need for closer cooperation, the absence of which may have led to informational asymmetries and conflicts in the first place. Firms may also begin to recognize that technological distance offers more complementary benefits in standardization efforts (Bar & Leiponen, 2014), and thus make greater efforts to work with each other through "give and take"—or forbearance in the language of Williamson (1991). Only major aggression or the emergence of drastically altered payoffs might trigger firms to attack in such a repeated game (Baker et al., 2002).

In sum, if repeated interaction in adjacent technological areas with closer rivals gives rise to the dear enemy recognition, then we would expect firms to be even more lenient toward their complementors who are a productive part of the overall ecosystem and unlikely to directly challenge the technology space the focal firm controls through their SEPs. In contrast, we would more aggressive behaviors to unfold when contests arise between firms that occupy a very similar technology niche:

> *H2: Subsequent cooperation after the litigation event between the plaintiff and defendant will be amplified by their technological distance.*

The Contingent Role of the Defendant's Relational Scope

A defendant's response to aggression may also be affected by its prior ties within the technological landscape. A broader relational scope implies a greater degree of centrality and hence, access to and control over valued resources (Burt, 1982). Beyond access to technological resources, network centrality also increases an actor's knowledge of a system's power distribution, or the accuracy of his or her assessment of the social and political landscape (Freeman, Romney & Freeman, 1987). Moreover, those who understand how a system works can exercise power and influence within that system (Ibarra, 1993; Krackhardt, 1990; Pfeffer, 1981), and mobilize support against a common enemy or around a common cause.

In technology standard setting contexts such social and political adeptness can be especially valuable for framing contests (Lounsbury, 2002; Hargrave & Van de Ven, 2006) and for galvanizing collective action against a common enemy (Garud, Jain & Kumaraswamy, 2002). Like bicyle racers 'running in packs' can help firms "cue their pace to one another and take turns breaking wind resistance until the ending sprint" (Van de Ven, 2005: 371). It follows that a defendant which has a number of prior ties within the co-creation network will have less interests in engaging with the plaintiff to overcome informational asymmetries or to restore trust and reputation-based advantages for the standard-setting work.

Similar cooperative strategies are observed in animal species that share a common enemy (Bshary & Bshary, 2010). For example, the fish studied by Bshary and Bshary (ibid.) attack the aggressor fish which leads the aggressor to attack them less frequently. Thus, all the potential targets benefit from such counter attacks. The interesting aspect of punishment and ostracism in both humans and animals is that the victims of aggression expend resources to create collective benefits. In humans, aggressive strategies by one party might lead to costly punishment or ostracism by the potential victims and thus, enhance the benefits or probability of survival for all potential victims. It follows therefore that:

> *H3: Subsequent cooperation after the litigation event between the plaintiff and defendant will be diminished by the defendant's relational scope* or *centrality.*

The Defendant’s Cooperation Strategy with Other Participants

The preceding arguments concerning the advantages of relational scope suggest that aggression by one party in a competitive territory may propel the defendants to expand their cooperation vis-à-vis other parties as a deterrent. In particular, legal challenge by a plaintiff might induce cooperation between defendants and between defendants and other parties. In humans, aggression by one party can lead to cooperation by others in either directly punishing the aggressor (Ostrom et al., 1992) or by ostracizing them (Hirshleifer & Rasmusen, 1989) to protect their collective interests.

In standard setting, aggression takes the form of patent litigation that is intended to defend a specific technological resource. Patent enforcement thus hurts the parties that are seen by the aggressor as being too close to the resource or as unfairly benefitting from it. The targets in this case—the potential infringers of the patented technology—may attempt to undermine the aggressor by developing other technological resources to circumvent the patented technology. Thus cooperation by the co-defendants or defendants and other parties may follow litigation in case their interests are aligned in moving the standardized technology away from the aggressor’s territory. Thereby, the defendants are likely to create public goods that benefit the broader ecosystem as they develop associated technologies or strategies to avoid the patented technology. In this way, the defendant adopts a dual strategy: while cooperating more with plaintiffs to benefit from the mutual payoffs, defendants may also build stronger cooperative relationships with others to reduce dependence on the plaintiff’s technologies and to counteract future aggressions.

> *H4a-b: Patent litigation will increase subsequent cooperation (a) between co-defendants and (b) between defendants and other parties.*

DATA AND METHOD

Empirical Context

We test our hypotheses in the global mobile telecommunications industry. We specifically examine collaborative efforts among firms in the 3GPP standards development organization. 3GPP consists of seven major standards-setting organization partners based in Europe, North America, Japan, China, Korea, and India (Baron et al, 2015). It is the dominant hub for global standards development in the telecommunications arena. From 1999 through 2008, 3GPP developed the 3G standard Universal Mobile Telecommunications System (UMTS; see Figure 1). It then started development of the 4G standard Long Term Evolution (LTE), with its first release in 2009 (Baron et al, 2015). 3GPP's planning for the 5G standard started in 2016 (3GPP, 2017). Hundreds of firms are 3GPP members: some actively contribute to the development of standards while others observe the standards process to keep up to date with new advancements. We focus only on active contributors.

The major work of technical standards development occurs within 3GPP working groups (Baron et al., 2015). Each working group (WG) maintains and develops specific technical domains or specifications of the overall system. These working groups roll up into three distinct technical specifications groups (TSGs): Radio-Access Network (RAN), which maintains specifications for how mobile phones (user equipment), base stations (node Bs), and radio network controllers (RNCs) interface and communicate; Core Network and Terminals (CT), which maintains specifications for the core network and its interfaces, protocols for mobile phones, and specifications for SIM cards; and Service and System Aspects (SA), which maintains specifications for the overall architecture of the system.[1] Table 1 provides a brief description of the technical domain of each WG. Our analysis is broken down by WG because firms' collaborative efforts occur at that level. While some large telecommunication firms (e.g. Qualcomm) will participate in many WGs, other more specialized firms will participate in only one or two. And even though a firm may

---

[1] An introductory video for UMTS is available at: https://www.youtube.com/watch?v=qNddSi0wugw. A similar video for 4G LTE is available at: https://www.youtube.com/watch?v=aGRTBA1tYRo.

span multiple WGs, the engineers within the firm will not; different engineers will contribute to different WGs. Further, firms' decisions to participate in specific technological domains is best captured at the WG level. Moreover, each working group has its own leadership structure and technical meetings. Thus, our focus on WGs allows us to accurately observe the collaborative networks that exist for distinct technological domains.

The process of developing new standards begins with proposals for new features from 3GPP members. These proposals are broken into work items assigned to specific WGs. Once the work items are approved, technical work begins to create the specifications. Members submit technical solutions—known as contributions—to the WG for their consideration. These contributions are voted on for approval at WG meetings (Baron et al, 2015). Contributions may be submitted by individual firms or by groups of firms. Hundreds of contributions are required to create one technical specification. And a WG will maintain from as few as 30 to over 100 technical specifications.

In our analysis, we focus on the contributions that comprise technical specifications. They are the finest-grained unit that captures the technical expertise contributed by firms. Because we are interested in collaboration, we focus on contributions authored by two or more firms.

Sample

Data sources. Our sample is comprised of data from four different sources. First, our sample of technical contributions was provided by the Searle Center on Law, Regulation, and Economic Growth at Northwestern University (Baron & Spulber, 2015). The Searle Center scraped data from the 3GPP.org website. Second, we collected a sample of all known standard essential patents (SEPs) by scraping the ETSI.org website. The European Telecommunications Standards Institute (ETSI) works closely with 3GPP to publish globally-applicable telecommunications standards. Using ETSI, firms declare patents they possess that they deem as essential to specific technical specifications. Third, we collected litigation data between 3GPP firms focused on SEPs. The data were downloaded from Lex Machina. Lex Machina mines and aggregates litigation data in the U.S. (Most case filings dealing with telecommunications patent disputes are litigated in the U.S.) Fourth, we downloaded patent forward-citation data from Thompson Reuters for declared SEPs.

We created a WG-quarter-dyad panel from 2005-Q2 through 2012-Q3, which is the range of time that contributions were available for study. This time period covers late contributions to the 3G standard and early to middle contributions to the 4G standard (Release 7 through 11). The dyads in each WG-quarter capture a snapshot of the coauthoring network at a given time in a given technological domain. The networks were created using contribution documents. A contribution document includes (a) the assigned WG, (b) the submission date to a WG meeting for consideration and approval, and (c) the firms that authored the contribution. For each WG, we grouped submissions by quarter and counted the number of documents that each dyad in the network coauthored. For many dyads, the number of coauthored documents was zero (which is common for social networks). The total number of observations was 1.4 million.

We added SEP attributes to WG firms in the panel through the technical specification number and firm name published in the ETSI data. We added litigation attributes (from Lex Machina) to WG dyads using the patent publication number (which matches to SEPs in the ETSI data) and firm names documented in the case filing. We added forward-citation attributes (from Thompson Reuters) to the panel using the patent publication number.

Data selection and matching. Our interest is the effect of a litigation filing (the treatment) on a dyad’s subsequent coauthoring. Accurately estimating the effect is complicated by the nature of the data. First, coauthoring dyads inhere in a network. Thus, litigating dyads are not independent of other dyads, and the effect of litigation may spill over within the network. Second, litigants are not randomly distributed within the sample. It is often the more active participants in a WG—those who are contributing frequently—that are litigants. Thus, the full sample of non-litigants does not resemble those who are litigants, and a comparison between the two may be biased. Third, litigation may occur within a WG dyad and within a WG network multiple times over time. Thus, observing coauthoring after a litigation filing is complicated by other filings that subsequently might occur. We address these problems through a number of means.

We addressed the problem of non-independent treatments by explicitly modeling some dyads types that may be affected by litigation and removing from the untreated group other dyad types that may be affected by litigation. In H1 and H2 we are interested in plaintiff-defendant dyads; in H3, we add co-defendant and defendant-other dyads. The plaintiff-defendant and defendant-defendant dyads include firms named in the litigation. The defendant-other dyads include an ego who was a litigant and an alter who was not. We are interested in the effect of the treatment on these three types of dyads. While other dyad combinations are possible (e.g., plaintiff-other dyad), we focus only on defendant dyads. This allows us to be more confident that the treatment is exogenous. Other dyads within the network for a given WG-quarter (which may be affected by the treatment) are excluded from the sample so that they are not used in the comparison group.

We addressed the problem of sample selection by using a matching procedure. (We chose a matching procedure over other selection-adjustment techniques, such as a two-step selection model, because we possessed good covariates but lacked an appropriate instrument.) The matching procedure allowed us to matched treated dyads with untreated dyads (from untreated WGs) that were similar on observable characteristics. (The standard assumption for a matching model such as ours is that the treatment assignment is independent of the potential outcome given the observable covariates [Stuart, 2010].) We matched exactly (1) the quarter in which the litigation occurred and (2) whether a dyad coauthored one or more documents in the past year (coded as 1; 0 otherwise). We used exact matching on these two characteristics because of their importance and to reduce the computational complexity of subsequent nearest neighbor matching.

Along with exact matching, we used nearest neighbor matching with the shortest Mahalanobis distance to find comparable observations. We matched without replacement and selected one untreated observation for every treatment observation. The covariates used in the nearest neighbor matching were: pre-treatment coauthoring, which was calculated as the count of documents coauthored by the dyad in the previous year; pre-treatment case filings, which was calculated as the count of litigation filings in the WG in the previous year; WG citation-weighted patents, which was calculated as the 5-year forward citations for SEPs owned by dyad members and belonging to the WG; technological distance, which was calculated as the Euclidean distance between the technological profiles[2] of the dyad members; and no authoring by dyad member,[3] which is coded as 1 if either party had not authored documents in the WG up to the given quarter. These variables capture critical reasons why a dyad may litigate. As shown in Table 2, there were 14,292 treated observations, and all of them were matched to untreated observations (100% match). Diagnostics in Table 2 show that the standardized difference (Stuart 2010) between treated and untreated observations improved (i.e., decreased) due to matching. Only the standardized difference for pre-treatment case filings remained above the 0.25 heuristic for matching sufficiency. Thus, the matching procedure substantially improved the similarity of the non-litigation dyads to the litigation dyads. (We will describe in our supplementary analysis additional matching procedures we used to address the lingering shortcomings of this matching procedure.)

We addressed the problem of repeated treatments by including a control in our model for off-quarter filings, as described in the Variables section.

Panel transformation. After we created a matched sample, we transformed our panel to accommodate the difference-in-difference estimation strategy. The transformed panel was keyed by WG, litigation filing quarter, dyad, and pre-post filing time. For each treated dyad in a WG-quarter, 9 rows were created in the transformed panel: the rows captured coauthoring (and other attributes)

---

[2] The technological profile of a firm within a WG was a vector of counts, with the index being the technical specifications in the WG. An element was the cumulative number of documents authored by a firm in a technical specification up to the given quarter.

[3] This variable is included because the technological distance calculation requires that each firm author at least one document. It distinguishes between no technological distance because two firms are truly similar or because two firms have not authored documents yet.

from −4 quarters pre-filing to +4 quarters post-filing. The matched comparison observations were transformed the same way. The transformation aligns the coauthoring around the timing of the litigation filing. We trimmed the window for litigation filings by eight quarters—from 2006-Q2 to 2011-Q3—so that we could observe at 4 quarters of coauthoring pre- and post-filing. The final transformed panel included: 286 unique firms; 8,438 unique dyads; 16 quarters with filings; 14 working groups; and 257,256 observations. For H1 and H2, we focused on a subset of plaintiff-defendant dyads within the panel, which included 94 dyads and 1,368 observations. (The vast majority of observations in the panel are defendant-other dyads.)

Variables

Dependent variable. Our variable of interest is the number of contribution documents coauthored by a dyad. It is calculated as a simple count of contribution documents by a dyad in a given WG at a given quarter. There are different types of contribution documents (Baron et al, 2015); we only count discussion documents and technical reports and proposals because they best capture new technological collaborations, whereas the other types of documents do not.

Independent variables. Our independent variables include the litigation filing treatment, dyad type, and year pre-post filing. Treated dyads are coded as 1; matched untreated observations are coded as 0. The three dyad types are coded as 1 when an observation belongs to that type; 0 otherwise. A very small percentage of dyads (0.3 percent) are coded as 1 for more than one type because two or more litigation filings occurred in the same WG-quarter. The dyad types for untreated observations are coded the same as their matched treated observations. There is high variability in the level of coauthoring in a WG from quarter to quarter (see Figure 2). To smooth out this variability, we average the coauthoring over the year pre-filing (and include the filing quarter), the year post-filing. Post-filing is set to 1 for quarters +1 to +4; 0 otherwise.

Control variables. We include working group dummies and quarter dummies to account for differences in levels of coauthoring in different technological areas and over time. We include an off-quarter filing control to adjust for multiple treatments over time. For instance, if a dyad was affected by litigation +4 quarters after the focal treatment (because another case was filed), then the dyad off-quarter filing variable would be set to 1 at the +4 quarters observation. This isolates the focal treatment from the effect of other filings that might occur in the observation quarters. We also include the variables used for matching: WG citation-weighted patents, technological distance, and no authoring by dyad member. (Pre-treatment coauthoring is captured by the difference-in-difference estimation using the transformed panel; pre-treatment case filings is captured by the off-quarter filing control.) Finally, we include the total number of 3GPP firms that are listed as litigants in open cases and the number of SEPs listed in open cases within a WG-quarter.

Model Specification

We use a difference-in-difference approach to test our hypotheses. Our response is the coauthoring of dyad d in working group g at filing quarter f and pre- or post-filing t ($t \in \{-4, \dots, 4\}$). To simplify the notation, we represent the combined dgf index simply as index i. We model coauthoring between plaintiffs and defendants as a negative binomial distribution with mean and variance,

$$y_{it} \sim NegBin(\mu_{it}, \mu_{it} + \alpha\mu_{it}^2) ,$$

where α is the dispersion parameter that allows the variance to be greater than the mean. We use a negative binomial model instead of a linear or Poisson model because our response is a non-negative count variable with over-dispersion. The mean μ_{it} is modeled as

$$\ln \mu_{it} = \beta_1 P_t + \beta_2 L_i + \beta_3 P_t L_i + \boldsymbol{X}_{it}\boldsymbol{\theta} + \varepsilon_{it},$$

where:

- β_1 estimates the post-treatment change in coauthoring for all dyads ($P_t = 1$ when $t > 0$),
- β_2 estimates the pre-treatment difference in coauthoring between treated and untreated dyads ($L_i = 1$ when i is a treated dyad),
- β_3 estimates the coauthoring difference-in-difference (when $P_t L_i = 1$),

- $\boldsymbol{\theta}$ is a column vector of parameter estimates for control variables in the row vector $\boldsymbol{X}_{it}$ (including dummy variables for working group and quarter), and
- ε_{it} is the residual.

Unlike a linear model where each term is added to the model, the terms in a negative binomial model enter multiplicitively. This can be seen when we exponentiate the function:

$$\mu_{it} = e^{\beta_1 P_t} \cdot e^{\beta_2 L_i} \cdot e^{\beta_3 P_t L_i} \cdot e^{\boldsymbol{X}_{it}\boldsymbol{\theta}} \cdot e^{\varepsilon_{it}}.$$

For a model such as ours, the average treatment effect of the treated (ATT) would normally be the statistic of interest. The ATT would be appropriate if the average was indicative of the treatment effect across the various dyads. However, the level of participation in coauthoring across the sample of dyads varies widely, and it is likely the treatment effect will differ based on the level of participation. More-active firms will experience a larger effect of litigation, whereas less-active firms will experience a smaller effect of litigation. Thus, we will focus on the average treatment *rate* on the treated instead of the average absolute effect on the treated. The rate estimate will better reflect the effect of the treatment than the absolute value because of the heterogeneous activity in the sample. Assuming a constant rate for the sample allows less-active firms to have smaller absolute treatments and more-active firmst to have greater absolute treatments.

We define the average treatment rate for the treated (τ) as:

$$\tau = \frac{E\left[Y^1 \middle| P_t = 1, L_i = 1, X\right]}{E\left[Y^0 \middle| P_t = 1, L_i = 1, X\right]},$$

where Y^1 and Y^0 are the potential outcomes with and without the treatment, respectively; $E[\cdot]$ is the expectation. The expected outcome when Y is treated is

$$E[Y^1 | P_t = 1, L_i = 1, X] = e^{\beta_1} \cdot e^{\beta_2} \cdot e^{\beta_3} \cdot e^{\boldsymbol{X}_{it}\boldsymbol{\theta}},$$

and the expected outcome when Y is untreated is

$$E[Y^0 | P_t = 1, L_i = 1, X] = e^{\beta_1} \cdot e^{\beta_2} \cdot e^{\boldsymbol{X}_{it}\boldsymbol{\theta}}.$$

Thus, the average treatment rate on the treated is simply e raised to the β_3 power:

$$\tau = \frac{e^{\beta_1} \cdot e^{\beta_2} \cdot e^{\beta_3} \cdot e^{X_{it}\boldsymbol{\theta}}}{e^{\beta_1} \cdot e^{\beta_2} \cdot e^{X_{it}\boldsymbol{\theta}}} = e^{\beta_3}.$$

When the moderators (technological distance and defendant centrality) are added to the model, the treatment rate is multiplied by $e^{M_{k_1}\beta_{k_1}} \cdot e^{M_{k_2}\beta_{k_2}}$, where M_k is the value of moderator k and β_k is the parameter for the $M_k P_t L_i$ interaction. For both k, M_k only includes nonnegative values. Thus, when M_{k_1} is zero the treatment rate is $e^{\beta_3} \cdot e^{M_{k_2}\beta_{k_2}}$, holding M_{k_2} constant; when M_{k_1} is greater than zero, then the treatment rate is $e^{\beta_3} \cdot e^{M_{k_1}\beta_{k_1}} \cdot e^{M_{k_2}\beta_{k_2}}$ (again holding M_{k_2} constant), such that the treatment rate will rise or fall depending on whether β_{k_1} is positive or negative, respectively. The effect of the other moderator (k_2) is similarly calculated, holding M_{k_1} constant.

RESULTS

Table 3 presents the descriptive statistics. Figure 2 illustrates the difference-in-difference effect for litigating dyads. The gray lines depict the average quarter-to-quarter coauthoring for litigating and matched non-litigating dyads. The black lines depict the average coauthoring pre- and post- filing. Figure 2 reveals that coauthoring in non-litigating dyads fell in the quarters after a case filing while coauthoring in litigating dyads increased. Thus, the figure suggests that filings had a positive effect on coauthoring between defendants and plaintiffs, which is consonant with H1.

The models in Table 4 test the significance of the result illustrated in Figure 2. Model 1 presents a simple difference-in-difference model with no controls. The results show that a case filing increased coauthoring between defendants and plaintiffs, which supports H1. The average treatment rate for the treated was 4.3 ($\beta_3 = 1.46$; $p < .001$); that is, the average rate of coauthoring increased more than three-fold because of a case filing. Model 2 adds the controls, which adjusts the treatment rate slightly higher to 5.9 ($\beta_3 = 1.77$; $p < .001$); the average rate of coauthoring increased nearly five-fold due to litigation. Prior to litigation, a defendant and plaintiff would average about one document per year (the base rate of coauthoring). The treatment rate indicates that litigation increased coauthoring to about six documents per year, on average.

The moderating effect technological distance and defendant centrality is presented in Model 3. The moderating effect of technological distance was positive and significant (β_k = 0.26; p < .01), which supports H2. When technological distance is low (M_{k_1} = 0.0) and defendant centrality is held constant at its mean (M_{k_2} = 16.4), then the treatment rate is 4.6; when technological distance is high (M_{k_1} = 3.2), the treatment rate rises to 10.8. Thus, the treatment rate for more technologically distant firms is more than double the rate for less distant firms.

The moderating effect of defendant centrality was negative and significant (β_k = −.05, p < .01), which supports H3. When defendant centrality is low (M_{k_2} = 0) and technological distance is held constant at its mean (M_{k_1} = 1.9), then the treatment rate is 16.5; when defendant centrality is high (M_{k_2} = 36), then the treatment rate drops precipitously to 3.0. Thus, the treatment rate for defendants with many other coauthoring ties is about one-fifth the rate for defendants with no ties.

The treatment rate for co-defendant dyads and defendant-other dyads is calculated based on Model 3. The difference-in-difference terms for co-defendant dyads (β = 1.25, p < .01) and defendant-other dyads (β = 0.91, p < .001) were positive and significant, which supports H4a and H4b. The treatment rate for co-defendant dyads was 3.5; the treatment rate for defendant-other dyads was 2.5. Two co-defendants averaged about two coauthored documents per year prior to a case filing. A filing increased coauthoring to about seven documents per year, on average. A defendant coauthored an average 0.8 documents per year with another member of the working group prior to a case filing. Coauthoring with another WG member rose to about two documents per year after a filing. A defendant will, on average, have 75 other WG members they could coauthor with. By multiplying the dyadic average of 0.8 documents per year pre-filing by the average number of defendant-other dyads, we find that a defendant is, on average, authoring about 60 documents per year pre-filing with all other firms in the working group. At the treatment rate of 2.5, the number rises to about 150 documents per year after a case filing.

While the treatment rate is greater for defendant-plaintiff dyads than co-defendant dyads and co-defendant dyads than defendant-other dyads, a χ^2 test revealed that the differences are not significant from one another.

Robustness Checks

One question that arises from this analysis whether the effect of litigation is temporary or whether the effects persist over time. To test this question, we added four more quarters of data so that we had eight quarters of coauthoring post-filing. We then added a new second-year post-filing variable. The variable was 1 for $t \in \{5, .., 8\}$; 0 otherwise. The existing post-filing variable was also coded as 1 for the same quarters. Thus, the existing variable captured the first-year post-filing and the new variable captured the change in coauthoring from the first-year to the second-year post-filing. For defendant-plaintiff dyads, the rate of coauthoring dropped 38% from the first-year to the second-year post-filing (β = -.47; p = *n.s.*), but coauthoring in the second year was still 4.3 times greater than coauthoring pre-filing (p < .01). For co-defendant dyads, the level of coauthoring dropped 46% from the first-year to the second-year post-filing (β = -.61; p = *n.s.*) so that by the second-year post-filing the coauthoring rate was only 81% greater than the pre-filing baseline rate. The second-year rate is neither significantly lower than the first-year rate nor significantly higher than the pre-filing rate. For defendant-other dyads, the level of coauthoring stayed almost the same as in the first-year post-filing, only increasing 3% (β = .02; p = *n.s.*). The rate of coauthoring in the second-year post-filing was 2.3 times greater than pre-filing (p < .001). Overall, the average treatment rate for the treated declined slightly by the second year for defendant-plaintiff dyads, but still remained significant; the treatment rate declined more for co-defendant dyads by the second year such that the treatment rate was no longer significant; and the treatment rate remained the same for defendant-other dyads.

We also noted in the Method section that while the matching process greatly improve the similarity of the treated and untreated groups, it still left some dissimilarities. To test the impact of our matching process, we chose to rerun the analysis using coarsened exact matching (Iacus, King, & Porro, 2009; 2012). Coarsened exact matching (CEM) privileges matching closeness over matching all data. Thus, CEM is willing to throw out treated observations to improve a match. We first used CEM to create “buckets” of treated and untreated observations that were similar on all matching dimensions used previously. We then used the shortest Mahalanobis distance to perform one-to-one matching between treated and untreated observations. While the matching statistics were better—all standardized differences were 0.03 or lower—only 67% of the treated observations were matched. That left only 792 (or 58%) of the defendant-plaintiff observations. Even with the smaller sample, the results were very similar to those presented in Table 4. The treatment rate estimates were very similar to those in Models 1 and 3 for all three types of dyads, and they were significant. The defendant centrality moderator also showed a similar significant impact. However, the technological distance moderator was lower (leading to a 50% increase in the treatment rate when distance was high vs. low instead of more than doubling it), and it was not significant—thus challenging the support for H2a. Still, the moderator was in the direction expected.

DISCUSSION AND CONCLUSIONS

Summary of Results

We study the evolution of cooperation in the face of disagreement about rights to technological assets. We develop a theoretical framework that examines cooperation among firms as repeated interaction on a technological landscape. Evolutionary biology conceptualizes the interplay of cooperation to create and share public goods with competition to gain access to resources through the notion of dear enemy recognition. According to the dear enemy recognition, species will tolerate and work around conflict with competing species when they are familiar, in other words, when they share the resource base on a long-term basis (Jaeger, 1981). Similarly, we hypothesize that repeatedly interacting firms are more tolerant to disagreement with their peers.

Our arguments incorporate role of learning to reduce information-asymmetries and trust-based interests that are known to foster cooperation in repeated game settings (Axelrod & Hamilton, 1981). In other words, organizational actors may continue to cooperate while working through their disagreement and conflicting interests, especially when collective gains need to be balanced with private interests. Moreover, the very disagreement may reveal a discrepancy in understanding and evaluating current and future market conditions between the parties. A litigation conflict may thus motivate the firms to increase their mutual cooperation to address the discrepancies and asymmetries in information and evaluation of the situation.

On the other hand, evolutionary game theory also highlights punishment of aggressors when it potentially creates public goods. Conflict is costly and without a long-term benefit, it only depletes the individual of energy and resources if they engage in it. However, both studies of individuals and organizations creating and maintaining public or collective goods show that subjects often go out of their way to punish aggressors either directly or through ostracism. Similarly in biology, species that face a common enemy may engage in punishment if they can substantially reduce the encroachment of that enemy with counterattacks (Bshary & Bshary, 2010). In that case, individuals create public goods for the whole population facing the common enemy by exerting effort in counterattacking. Furthermore, individuals may activate alternative technological or relational resources in order to hedge themselves from future attacks by the conflict partner.

We thus argue that under repeated and long-term interaction, organizations engaged in territorial competition may be able to sustain or even enhance cooperation even when attacked by a peer. Such aggression, however, may lead to punishment by the group through directing technological resources away from the attacker through cooperation with network alters. In this regard, we find that the broader competitive context moderates the dear-enemy and common-enemy responses. First, if the litigating parties are technologically close and thus provide similar technological components to the broader system, they are close rivals that are likely to respond more aggressively to the attack and reduce cooperation. Technologically similar companies may also have less room to enhance their benefits from the relationship with the attacker by mutual learning. We therefore hypothesized that technological closeness reduces the dear enemy recognition and enhances the likelihood of reduced cooperation and the possibility that the attacked parties develop counter-strategies to punish the attacker through cooperation with others. Second, the cooperative response also depends on whether the attacked party has many outside options within the cooperative network. If they are central and thus have many other possible partners to work with, aggression by one party is less likely to be tolerated and they are more likely to seek alternative partners to work with.

We empirically test our hypotheses in a large standards development organization in the wireless telecommunication industry. The firms in this community repeatedly co-author technological specifications that are new features and other types of inputs into the wireless communication system. Our period of study is 2005-2012 and the cooperative activity continued beyond the study period, thus the “shadow of the future” was persistent until and beyond the last period of our panel.

We utilize a matched sample approach and estimate the effects on cooperation by the incident of patent litigation through a differences-in-differences specification. Our research design can isolate the impact of litigation. While the effect on cooperation between the plaintiff and the defendant may not be exogenous, we argue that there is a high probability that the impact on co-defendants or defendants and others is exogenous.

We find statistically and economically significant support for all the hypothesized effects. If anything, firms subject to a patent lawsuit increase their cooperative activities, as suggested by the dear enemy recognition, and we find that cooperation among co-defendants is particularly greatly increased after the litigation is initiated, as predicted by the common enemy argument. We also find support for the moderating effects of the competitive environment. Technologically distant firms tend to be more tolerant of such disagreements, we argue because they are more likely to be complementary with the plaintiff and therefore dependent on them but not a direct rival in the technological space. Conflict can therefore draw attention to technological similarities and technological differences between contestants, and increase their interests in learning about each other's technologies, especially when there exists a potential for joint gains from complementarities. In addition, firms that have many network alters are likely to enjoy the reputation and trust based advantages which they can activate to achieve their desired technological outcomes, thereby reducing cooperativeness with the plaintiff. Thus, outside options also moderate the cooperative response to disagreement.

Contributions

Our key insight is that the impact of disagreement about rights to technological resources on cooperation is more complex and nuanced in an inter-organizational cooperative network than the dyadic alliance literature would lead us to believe. Alliance studies tend to take cooperation as given and study how to structure the alliance in order to make it last. Then, differing expectations about the future evolution of technology or disagreement about the sharing of payoffs under incomplete contracts or in the absence of trust for instance, are likely to lead to cooperative failure. In contrast, our theory of cooperation on a shared technological territory highlights its long-term and repeated nature. Conflict and disagreement do not necessarily lead to cooperative failure, depending on the competitive relationship between the conflicting firms and their network alters. Cooperation can be better sustained in a repeated setting than alliance theories appear to imply. We thus argue that it is important to study inter-organizational cooperation in many different settings beyond strategic alliances that may not even be a very common occurrence compared to industry associations and technology consortia.

Our study is among the first within strategic management focusing on conflict or disagreement between organizations and its subsequent implications for cooperation. While disagreement is natural and frequent in economic and social life, there are few instances where it is explicitly documented. Litigation is an important sphere of conflict and its strategic implications have been previously analyzed (e.g. Clarkson & Toh, 2010). However, what happens to the cooperative and productive interactions among the parties post-litigation has rarely been studied.

We cast our investigation of patent litigation conflict in a framework of evolutionary game theory and focus on how conflict and cooperation evolve over time. In our context, cooperation occurs very commonly—firms participate in standard setting to cooperatively create specifications for the communication system. However, conflict is also relatively frequent, and patent litigation regularly afflicts cooperative innovation in wireless telecommunication. We view patent litigation as an aggressive strategy to defend technological territory. Many of the participating firms hold intellectual property rights that allow them to monopolize key technologies. They have a strong interest in keeping rivals from encroaching that territory, to the point that they may risk subsequent cooperation in related areas. Our basic research question asks, how do firms respond to such territorial aggression in the technological landscape?

Our empirical setting allows us to analyze the process to develop wireless telecom standard specifications as a network of "co-authoring" behavior among firm representatives. Firms collaboratively propose and develop technological features for the communication system, and we analyze a complete archive of this activity over an eight-year period. We can thus longitudinally observe network evolution and strategic response to disturbance. While strategic networks have been extensively studied, they are rarely studied in a dynamic framework. In other words, network evolution, and in particular, its causal drivers, are difficult to observe and analyze. Our setting allows us to follow a panel of firms over a long period of time and compare similar firms operating in similar circumstances, except for the disturbance that affects only the treated group. Therefore, we have an unusually good opportunity to identify causal factors behind cooperative behavior of firms in a network. Most prior network research is entirely descriptive, and while description has been very fruitful, our research design allows us to go a step further to highlight implications of strategic disagreement for subsequent network evolution.

Our setting is also unique in that it offers a window into repeated interaction over a long period of time. Repeated games are an important area of theoretical work in competitive strategy, but they are rarely empirically analyzed. While the insights from repeated games and, in particular, relational contracts, are rather clear, we are not aware of studies with long panels of cooperative activity interspersed with disagreement and potential cooperative failure. Thus, one of our contributions is to analyze both the short-term and long-term response to changes in the payoff structures of the firms competing in the technological landscape.

Managerial Implications

This study provides insights for managers of high-technology firms innovating and competing on densely populated technological landscapes. Technological disagreement drains resources, and firms need to be cognizant of when to engage in conflict and when to tolerate or even accommodate aggression. For example, engaging in drawn out patent wars or standards wars can be extremely costly and counterproductive from a long-term performance perspective. However, when in conflict, firms that have cultivated technological and relational alternatives are more likely to be able to strategically respond by undermining the aggressor either through direct attack or counterattack, or through diverting the technological development away from the conflict partner and towards less contested territory. Overall, such strategic disagreements can be viewed not as devastating incidents of cooperative failure but as instances of competition where expectations about future payoffs have changed, and where, under significant uncertainty and asymmetric information, firms need to renegotiate their relationships. Occasionally those negotiations fail and firms end up in court. However, the optimal strategic response is rarely to cut off cooperative activity but to assess whether in the long term it is more advantageous to continue the existing arrangement or divert the efforts and investments into a new area or a new cooperative arrangement.

REFERENCES

3GPP.org. Release 15. Accessed Jan. 2018. http://www.3gpp.org/release-15

Abbott, K., & Snidal, D. 1998. Why States Act through Formal International Organizations. ***Journal of Conflict Resolution***, *42*(1), 3-32.

Ahmadjian, C.L. & Oxley, J.E. 2011. Vertical relationships, hostages, and supplier performance: Evidence from the Japanese automotive industry. ***Journal of Law, Economics, & Organization***, *29*(3), pp.485-512.

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

Arino, A. & De La Torre, J. 1998. Learning from failure: Towards an evolutionary model of collaborative ventures. ***Organization Science***, *9*(3), 306-325.

Anderson, P. & Tushman, M. 1990. Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change. ***Administrative Science Quarterly***, 35(4): 604-633.

Axelrod, R. 1984. ***The evolution of cooperation***. New York: Basic Books.

Axelrod, R., & Hamilton, W.D. 1981. The evolution of cooperation. ***Science***, *211*(4489), 1390-1396.

Baj, P. 2015. Apple and Samsung’s complicated relationship. ***Nasdaq***. Posted 28 Dec. 2015. http://fortune.com/2012/07/30/apple-v-samsung-the-patent-trial-of-the-century-starts-today/

Baker, G., Gibbons, R., & Murphy K. J. 2002. Relational Contracts and the Theory of the Firm. ***Quarterly Journal of Economics***, 117 (1): 39-84.

Bar, T. & Leiponen, A. 2014. Committee composition and networking in standard setting: The case of wireless telecommunications. ***Journal of Economics & Management Strategy***, 23(1): 1-23.

Baron, D.P. 1995. Integrated Strategy: Market and Nonmarket Components. ***California Management Review***, 37(2): 47-65.

Baron, J., Gupta, K., & Roberts, B. 2015. Unpacking 3GPP standards. Working paper.

Baron, J. & Spulber, D.F. 2015. Technology standards and standards organizations: Introduction to the Searle Center Database. Working paper.

Baum, J.A., & Haveman, H.A. 1997. Love thy neighbor? Differentiation and agglomeration in the Manhattan hotel industry, 1898-1990. ***Administrative Science Quarterly***, 304-338.

Bercovitz, J., Jap, S.D., & Nickerson J.A. 2006. The Antecedents and Performance Implications of Cooperative Exchange Norms. ***Organization Science***, 17(6): 724-740.

Bies, R.J., & Tripp, T.M. 1996. Beyond distrust. ***Trust in organizations***, 246-260.

Bradfield, M., & Aquino, K. 1999. The effects of blame attributions and offender likableness on forgiveness and revenge in the workplace. ***Journal of Management***, *25*(5), 607-631.

Bshary, A., & Bshary, R. 2010. Self-serving punishment of a common enemy creates a public good in reef fishes. ***Current Biology***, *20*(22), pp.2032-2035.

Burt, R. S. 1982. ***Toward a structural theory of action***. New York: Academic Press

Buston, P. M., & Balshine, S. 2007. Cooperating in the face of uncertainty: a consistent framework for understanding the evolution of cooperation. ***Behavioural Processes***, *76*(2), 152-159.

Clarkson, G., & Toh, P. K. 2010. ‘Keep out’signs: the role of deterrence in the competition for resources. ***Strategic Management Journal,*** 31(11), 1202-1225.

Cohen, W.M., & Levinthal, D.A. 1989. Innovation and learning: the two faces of R & D. ***Economic Journal***, *99*(397), pp.569-596.

Clutton-Brock, T. 2002. Breeding together: kin selection and mutualism in cooperative vertebrates. ***Science***, *296*(5565), 69-72.

Das T. K., & Teng, B.S. 1998. Between Trust and Control: Developing Confidence in Partner Cooperation in Alliances. ***Academy of Management Review***, 23(3): 491-512.

Dirks, K.T., Lewicki, R.J., & Zaheer, A. 2009. Reparing relationships within and between organizations: building a conceptual foundation. ***Academy of Management Review***, *34*(1), pp.68-84.

Doz, Y.L. 1996. The evolution of cooperation in strategic alliances: Initial conditions or learning processes?. ***Strategic Management Journal***, *17*(S1), pp.55-83.

Dyer, J. H., & Singh, H. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. ***Academy of Management Review***, *23*(4), 660-679.

The Economist. October, 2010. The Great Patent Battle. http://www.economist.com/node/17309237

Elmer-Dewitt, P. 2012. Apple v. Samsung: The patent trial of the century starts today. ***Fortune***. Posted 30 July 2012. http://fortune.com/2012/07/30/apple-v-samsung-the-patent-trial-of-the-century-starts-today/

Farrell J. and Saloner G. 1988. Coordination through Committees and Markets. ***RAND Journal of Economics***, 19(2): 235-252.

Freeman, L.C., Romney, A.K., & Freeman, S.C. 1987. Cognitive structure and informant accuracy. ***American Anthropologist***, *89*(2), pp.310-325.

Graham, S. & Vishnubhakat, S. 2013. Of smart phone wars and software patents. ***Journal of Economic Perspectives***, 27(1): 67-85.

Gardner, R., Ostrom, E., & Walker, J.M. 1990. The nature of common-pool resource problems. ***Rationality and Society***, 2(3), 335-358.

Greve, H.R., Baum, J.A., Mitsuhashi, H., & Rowley, T.J. 2010. Built to last but falling apart: Cohesion, friction, and withdrawal from interfirm alliances. ***Academy of Management Journal***, *53*(2), 302-322.

Griffin, A.S., West, S.A., & Buckling, A. 2004. Cooperation and competition in pathogenic bacteria. ***Nature***, *430*(7003), 1024-1027.

Gulati R. 1995. Social Structure and Alliance Formation Patterns: A Longitudinal Analysis. ***Administrative Science Quarterly***, 40: 619-652.

Gulati, R. & Gargiulo, M. 1999. Where do interorganizational networks come from? ***American Journal of Sociology***, *104*(5), pp.1439-1493.

Gulati, R. & Nickerson, J.A. 2008. Interorganizational Trust, Governance Choice, and Exchange Performance. ***Organization Science***.

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.

Gulati, R., & Sytch, M. 2008. Does familiarity breed trust? Revisiting the antecedents of trust. ***Managerial and Decision Economics***, *29*(2- 3), pp.165-190.

Garud, R., Jain, S., & Kumaraswamy, A. 2002. Institutional entrepreneurship in the sponsorship of common technological standards: The case of Sun Microsystems and Java. ***Academy of Management Journal***, *45*(1), pp.196-214.

Hamilton, W.D. 1964. The genetical evolution of social behaviour. II. ***Journal of Theoretical Biology***, *7*(1), 17-52.

Hargrave, T.J. & Van de Ven, A.H., 2006. A collective action model of institutional innovation. ***Academy of Management Review***, *31*(4), pp.864-888.

Harrigan, K.R., Contractor F., Lorange, P. 1988. Strategic alliances and partner asymmetries. ***Cooperative Strategies in International Business***. Lexington Books, Lexington, MA.

Heide, J. B., & Miner, A. S. 1992. The shadow of the future: Effects of anticipated interaction and frequency of contact on buyer-seller cooperation. ***Academy of Management Journal***, *35*(2), 265-291.

Heinze, J., Foitzik, S., Hippert, A., & Hölldobler, B. 1996. Apparent dear-enemy phenomenon and environment-based recognition cues in the ant *Leptothorax nylanderi*. ***Ethology***, 102: 510–522.

Helfat, C.E. 1994. Evolutionary trajectories in petroleum firm R&D. ***Management Science***, *40*(12), pp.1720-1747.

Hirshleifer, J. 1991. The Technology of Conflict as an Economic Activity. ***American Economic Review*** (Papers and Proceedings) 81(2): 130-134.

Hirshleifer, D. & Rasmusen, E. 1989. Cooperation in a repeated prisoners' dilemma with ostracism. ***Journal of Economic Behavior & Organization***, *12*(1), pp.87-106.

Iacus, S.M., King, G., & Porro, G. 2009. CEM: software for coarsened exact matching. ***Journal of Statistical Software***, *30*(13), pp.1-27.

Iacus, S.M., King, G., & Porro, G., 2012. Causal inference without balance checking: Coarsened exact matching. ***Political Analysis***, *20*(1), pp.1-24.

Ibarra, H. 1993. Network centrality, power, and innovation involvement: Determinants of technical and administrative roles. ***Academy of Management Journal***, *36*(3), pp.471-501.

Jaeger, R. G. 1981. Dear enemy recognition and the costs of aggression between salamanders. ***The American Naturalist***, *117*(6), 962-974.

Johnston, J.S. & Waldfogel, J. (2002). Does repeat play elicit cooperation? Evidence from federal civil litigation. ***The Journal of Legal Studies***, *31*(1), 39-60.

Katila R., Rosenberger J.D., & Eisenhardt K.M. 2008. Swimming with Sharks: Technology Ventures, Defense Mechanisms, and Corporate Relationships. ***Administrative Science Quarterly***, 53: 295-332.

Krackhardt, D. 1990. Assessing the political landscape: Structure, cognition, and power in organizations. ***Administrative Science Quarterly***, pp.342-369.

Kramer, R.M. & Lewicki, R.J. 2010. Repairing and enhancing trust: Approaches to reducing organizational trust deficits. ***Academy of Management Annals***, *4*(1), pp.245-277.

Lanjouw, J., & Schankerman, M. 2001. Characteristics of Patent Litigation: A Window on Competition. ***RAND Journal of Economics*** *32*(1): 129-151.

Lounsbury, M., 2002. Institutional transformation and status mobility: The professionalization of the field of finance. ***Academy of Management Journal***, *45*(1), pp.255-266.

Lount Jr, R. B., Zhong, C. B., Sivanathan, N., & Murnighan, J. K. 2008. Getting off on the wrong foot: The timing of a breach and the restoration of trust. ***Personality and Social Psychology Bulletin***, *34*(12), 1601-1612.

Nelson, R.R. & Winter, S.G., 2005. Winter. 1982. ***An evolutionary theory of economic change.*** Cambridge, MA: Harvard University Press.

Ostrom, E. 2000. Collective action and the evolution of social norms. ***Journal of Exonomic Perspectives***, 14(3), 137-158.

Ostrom, E., Walker, J., & Gardner, R. 1992. Covenants with and without a sword: Self-governance is possible. ***American Political Science Review***, *86*(2), 404-17.

Oxley, J.E. 1997. Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach. ***Journal of Law, Economics, and Organization***, 13: 387-409.

Park, S.H. & Ungson, G.R.. 2001. Interfirm Rivalry and Managerial Complexity: A Conceptual Framework of Alliance Failure. ***Organization Science***, 12(1): 37-53.

Pfeffer, J. 1981. ***Power in organizations*** (Vol. 33). Marshfield, MA: Pitman.

Phelps, C.C. 2007. Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation. ***Academy of Management Journal***, 53(4): 890-913.

Polidoro, F. & Toh, P.K. 2011. Letting rivals come close or warding them off? The effects of substitution threat on imitation deterrence. ***Academy of Management Journal***, *54*(2), pp.369-392.

Poppo L. & Zenger, T. R. 2002. Do Formal Contracts and Relational Governance Function as Substitutes or Complements? ***Strategic Management Journal***, 23(8): 707-725.

Powell W. W., Koput K. W., & Smith-Doerr, L. 1996. Interorganizational Cooperation and the Locus of Innovation: Networks of Learning in Biotechnology. ***Administrative Science Quarterly***, 41(1): 116-145.

Ring, P.S. & Van de Ven, A.H. 1994. Developmental processes of cooperative interorganizational relationships. ***Academy of Management Review***, *19*(1), pp.90-118.

Roberts, G. 2005. Cooperation through interdependence. ***Animal Behaviour***, 70(4), 901-908.

Robinson, D.T., & Stuart, T.E. 2007. Financial contracting in biotech strategic alliances. ***Journal of Law and Economics***, *50*(3), pp.559-596.

Rosenkopf, L., Metiu, A., & George, V.P. 2001. From the bottom up? Technical committee activity and alliance formation. ***Administrative Science Quarterly***, *46*(4), pp.748-772.

Simcoe T.S., Graham S.J.H., & Feldman, M.P. 2009. Competing on Standards? Entrepreneurship, Intellectual Property, and Platform Technologies. ***Journal of Economics and Management Strategy*** 18(3): 775-816.

Skaperdas, S. & Syropoulos, C. 1996. Can the shadow of the future harm cooperation? ***Journal of Economic Behavior &*** *Organization*, *29*(3), pp.355-372.

Somaya D. 2003. Strategic Determinants of Decisions not to Settle Patent Litigation**.** ***Strategic Management Journal***, 24(1): 17-38.

Stuart, E.A. 2010. Matching methods for causal inference: A review and a look forward. ***Statistical Science***, *25*(1), p.1.

Stuart, T.E. & Podolny, J.M. 1996. Local search and the evolution of technological capabilities. ***Strategic Management Journal***, *17*(S1), pp.21-38.

Temeles, E. J. (1994). The role of neighbours in territorial systems: when are they'dear enemies'? ***Animal Behaviour***, *47*(2), 339-350.

Tushman, M. & Rosenkopf, L. 1998. The Coevolution of Community Networks and Technology: Lessons from the Flight Simulation Industry. ***Industrial and Corporate Change***, 7(2): 311-336.

Van de Ven, A.H. 2005. Running in packs to develop knowledge-intensive technologies. ***MIS Quarterly***, 365-377.

Vasudeva, G., Alexander, E.A., & Jones, S.L. 2014. Institutional logics and interorganizational learning in technological arenas: Evidence from standard-setting organizations in the mobile handset industry. ***Organization Science***, 26(3), 830-846.

Vasudeva, G., Spencer, J.W., & Teegen, H.J. 2013. Bringing the institutional context back in: A cross-national comparison of alliance partner selection and knowledge acquisition. ***Organization Science***, *24*(2), pp.319-338.

Williamson, O.E. 1991. Comparative economic organization: The analysis of discrete structural alternatives. ***Administrative Science Quarterly***, *36*(2), 269-296.

Zaheer, A., McEvily, B., & Perrone, V. 1998. Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. ***Organization Science***, *9*(2), pp.141-159.

Figure 1. Components of the 3GPP mobile broadband standard (3G) Universal Mobile Telecommunications System (UMTS). The Radio Access Network (RAN) includes the protocols to connect user equipment (UE; a mobile phone) to node Bs (a base station or cell tower) and Radio Network Controllers (RNCs). Uu, IuB, and IuR are interface protocols between aspects of the RAN. The Core Network manages packet switching protocols (for connecting to the Internet) and circuit switching protocols (for connecting into other communication networks). The interface protocols between the RAN and the Core Network are IuCS (for circuit switching) and IuPS (for packet switching).

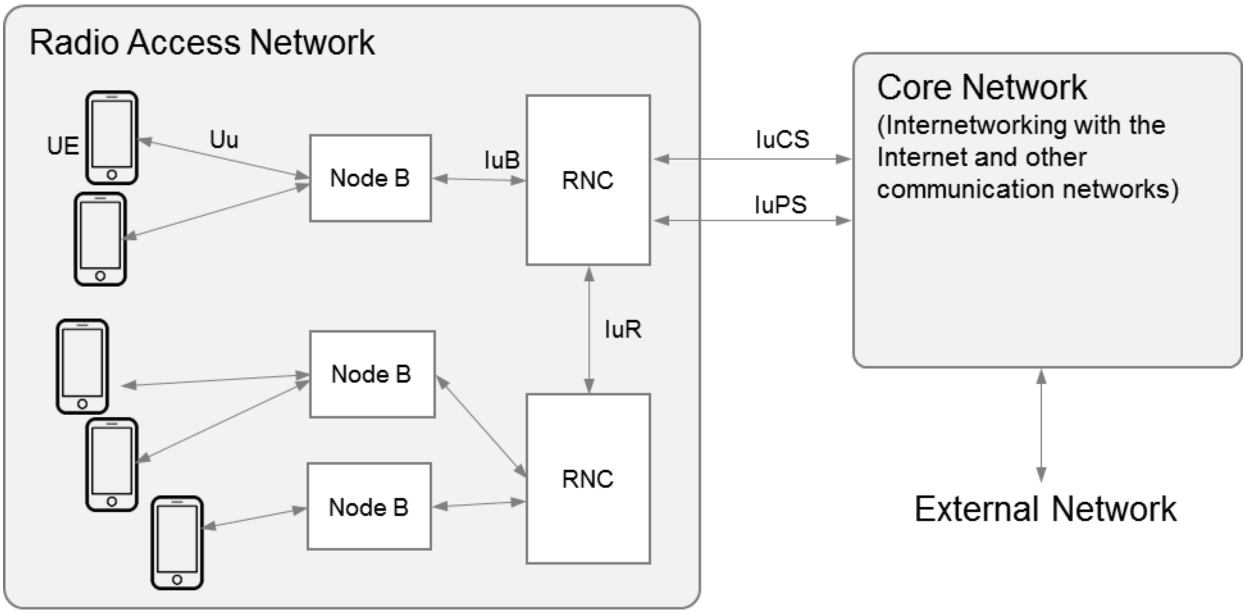

Figure 2. Technical document coauthoring pre- and post-filing for defendant-plaintiff dyads. Gray lines depict quarter-by-quarter coauthoring; black lines depict average coauthoring pre- and post-filing. Solid lines depict coauthoring among litigating (or treated) dyads; dashed lines depict coauthoring among non-litigating (or untreated) dyads.

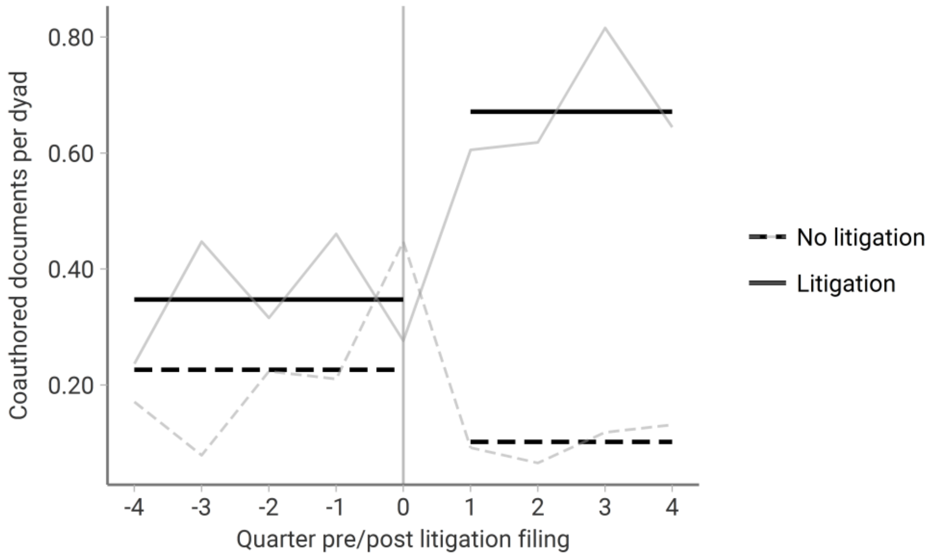

Table 1

Summary of 3GPP Data

Working Group	Technology Domain	Contributors		Litigation		
		Firms	Documents	Filings	Litigants	SEPs
Core Network & Terminals (CT)						
CT1	Specifications for interfaces between Radio Access Network and Core Network (Iu-CS, Iu-PS)	74	2,761	4	9	10
CT3	Specifications for interfaces between Core Network and external networks	45	948	0	0	0
CT4	Specifications for Core Network	55	2,234	2	6	3
CT6	Smart card applications	45	208	0	0	0
Radio Access Network (RAN)						
RAN1	Specifications for interface between User Equipment and Node B (Uu)	105	10,273	46	49	83
RAN2	Architecture for User Equipment to Node B interface	107	12,488	35	40	64
RAN3	Specifications for interfaces between Node B and Radio Network Controller (RNC) and between RNCs (IuB, IuR)	79	6,218	10	14	14
RAN4	Radio frequency aspects, repeaters, and radio performance	120	13,084	6	19	12
RAN5	Specifications for conformance testing of the User Equipment interface	80	8,696	0	0	0
Service and System Aspects (SA)						
SA1	Requirements for services and features of the system	104	2,808	10	10	10
SA2	System architecture (except for RAN)	107	3,777	11	14	17
SA3	Requirements and architecture for system security	67	1,248	8	15	8
SA4	Specifications for audio and video codecs	64	604	11	17	21
SA5	Requirements and architecture for overall system management	42	1,884	1	8	2

Notes. Observation window is 2005-Q2 to 2012-Q3. Technical reports and discussion documents are included in the document count; change requests, liaison requests, and withdrawn or unknown documents are excluded. SEPs = standard essential patents.

Table 2

Treated/Untreated Matching Statistics

	Untreated Mean	Treated Mean	Standardized Difference
All data			
Pre-treatment coauthoring	0.20	1.25	0.18
Pre-treatment case filings	0.05	0.64	0.50
WG citation-weighted patents	0.29	1.90	0.40
Technological distance	1.62	1.57	0.01
No authoring by dyad member	0.74	0.65	0.18
Matched data			
Pre-treatment coauthoring	0.87	1.25	0.07
Pre-treatment case filings	0.24	0.64	0.34
WG citation-weighted patents	0.98	1.90	0.23
Technological distance	1.77	1.57	0.04
No authoring by dyad member	0.63	0.65	0.04

Note. All 14,292 treated dyads were matched one-to-one from a pool of 713,520 untreated dyads.

Table 3

Descriptive Statistics

		Mean	S.D.	(1)	(2)	(3)	(4)	(5)
(1)	Document coauthoring	0.22	1.45					
(2)	Defendant-plaintiff dyad	0.01	0.07	0.01				
(3)	Co-defendant dyad	0.02	0.14	0.04	0.00			
(4)	Defendant-other dyad	0.98	0.15	-0.03	-0.43	-0.84		
(5)	Post-filing	0.44	0.50	0.01	0.00	0.00	0.00	
(6)	Litigating dyad	0.50	0.50	0.05	0.00	0.00	0.00	0.00
(7)	Litigants in open cases	9.47	10.56	0.08	-0.01	0.04	-0.03	0.12
(8)	SEPs in open cases	7.38	6.80	0.05	-0.01	0.02	-0.01	0.07
(9)	Off-quarter filing	0.06	0.25	0.00	0.00	0.02	-0.01	0.04
(10)	Combined citation-weighted patents	1.44	3.24	0.06	0.03	0.00	-0.01	0.00
(11)	No authoring by dyad member	0.79	0.68	-0.15	-0.04	0.02	0.00	0.00
(12)	Technological distance	2.09	5.02	0.05	0.00	-0.03	0.03	0.00
(13)	Defendant coauthoring centrality	7.36	13.82	0.18	0.00	0.00	-0.01	0.00

		(6)	(7)	(8)	(9)	(10)	(11)	(12)
(7)	Litigants in open cases	0.53						
(8)	SEPs in open cases	0.58	0.89					
(9)	Off-quarter filing	0.15	0.26	0.24				
(10)	Combined citation-weighted patents	0.14	0.09	0.13	0.04			
(11)	No authoring by dyad member	0.04	0.11	0.09	0.05	-0.07		
(12)	Technological distance	-0.04	-0.11	-0.10	-0.03	0.00	-0.36	
(13)	Defendant coauthoring centrality	0.53	0.38	0.37	0.05	0.20	-0.22	0.09

Total observations = 257,256; defendant-plaintiff dyads = 1,368; Co-defendant dyads = 4,860; defendant-other dyads = 251,712.

Table 4

Effect of Litigation on Coauthoring

	Model 1		Model 2		Model 3		Model 4	
	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
Defendant-Plaintiff dyad								
Baseline	-1.49***	(0.26)					-0.07	(0.35)
Post-filing (β_1)	-0.80*	(0.36)	-1.46***	(0.44)	-1.02+	(0.53)	-1.13**	(0.43)
Litigating dyad (β_2)	0.43	(0.31)	-1.66***	(0.37)	-2.00***	(0.40)	-0.58*	(0.29)
Post-filing * Litigating dyad (β_3)	1.46***	(0.39)	1.77***	(0.50)	2.31**	(0.85)	1.92**	(0.59)
Technological distance moderator								
Tech. distance * Post-filing					-0.16**	(0.05)		
Tech. distance * Litigating dyad					-0.18***	(0.03)		
Tech. distance * Post-filing * Litigating dyad (β_{k_1})					0.26**	(0.08)		
Defendant centrality moderator								
Defendant centrality * Litigating dyad					0.05***	(0.01)		
Defendant centrality * Post-filing * Litigating dyad (β_{k_2})					-0.05**	(0.02)		
Co-defendant dyad								
Baseline							0.78***	(0.22)
Post-filing							-1.05**	(0.34)
Litigating dyad							-1.08+	(0.55)
Post-filing * Litigating dyad							1.25**	(0.46)
Defendant-other dyad								
Baseline							-0.11	(0.21)
Post-filing							-0.39***	(0.11)
Litigating dyad							-0.80***	(0.12)
Post-filing * Litigating dyad							0.91***	(0.10)
Controls								
Litigants in open cases			-0.09*	(0.04)	-0.08*	(0.03)	0.01	(0.01)
SEPs in open cases			0.05	(0.07)	0.05	(0.06)	-0.08***	(0.02)
Off-quarter filing			-0.68+	(0.39)	-0.69+	(0.39)	-0.28	(0.19)
Combined citation-weighted patents			0.05+	(0.03)	0.05+	(0.03)	0.04***	(0.01)
No authoring by dyad member			-3.07***	(0.33)	-2.95***	(0.29)	-2.73***	(0.16)
Technological distance			0.03	(0.04)	0.10***	(0.02)	-0.01	(0.01)
Quarter dummies			Included		Included		Included	
Working group dummies			Included		Included		Included	
Akaike Information Criterion (AIC)	1,606.4		1,418.0		1,410.3		155,981.5	
Observations	1,368		1,368		1,368		257,256	

Note. The effects of the moderators are the same whether they are modeled separately or together, so we only present Model 2 with the moderators together. Defendant centrality only applies to treated dyads, so there is no defendant centrality * post-filing interaction.

+ p < .10; * p < .05; ** p < .01; *** p < .001; two-tailed tests with cluster-robust standard errors clustered on firm and partner.