4-2014

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DOI: https://doi.org/10.5465/amj.2011.0979

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Published in Academy of Management Journal, 2014 April, 57 (2): 585-613.
http://dx.doi.org/10.5465/amj.2011.0979

* We thank Mark Ebers, Sendil Ethiraj, Mark Newman, Lance Sandelands, and Jim Walsh, as well as the seminar participants at ESMT Berlin, Tilburg University, University of Cologne, University of Michigan, and the 2012 Academy of Management Conference in Boston, MA.

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Abstract

This paper investigates the evolutionary dynamics of a dual social structure encompassing collaboration and conflict among corporate actors. We apply and advance structural balance theory to examine the formation of balanced and unbalanced dyadic and triadic structures, and to explore how these dynamics aggregate to shape the emergence of a global network. Our findings are threefold. First, we find that existing collaborative or conflictual relationships between two companies engender future relationships of the same type, but crowd out relationships of the different type. This results in (1) an increased likelihood of formation of balanced (uniplex) relationships that combine multiple ties of either collaboration or conflict and (2) a reduced likelihood of formation of unbalanced (multiplex) relationships that combine collaboration and conflict between the same two firms. Second, we find that network formation is driven not by a pull toward balanced triads, but rather by a pull away from unbalanced triads. Third, we find that the observed micro-level dynamics of dyads and triads affect the structural segregation of the global network into two separate collaborative and conflictual segments of firms. Our empirical analyses used data on strategic partnerships and patent-infringement and antitrust lawsuits in biotechnology and pharmaceuticals from 1996 to 2006.

INTRODUCTION

A considerable body of research has examined the implications of social structures for actors' behaviors and outcomes. (For a review, see Brass et al., 2004; Kilduff & Brass, 2010.) A more recent and complementary line of inquiry has focused on the dynamics of social structures. This research examines the evolutionary trajectories of networks by looking at the micro-foundations of network dynamics, an approach which calls for understanding the factors driving the "formation, persistence, dissolution, and content of ties in the network" (Ahuja, Soda, & Zaheer, 2012: 437). One notable characteristic of this rapidly growing line of inquiry is that it focuses predominantly on collaborative relationships among actors. In doing so, it thus examines the dynamics of the social structures of work relationships among individual actors and groups (Zaheer & Soda, 2009) and those of investment syndicates and strategic partnerships among corporate actors (e.g., Baum, Shipilov, & Rowley, 2003; Gulati & Gargiulo, 1999; Powell et al., 2005). Although not immune to occasional friction, these relationships generally feature

overlapping goals, cooperative resource exchange, positive affect, and joint action. We depart from this line of research to examine the evolutionary dynamics of a dual social structure that encompasses relationships of both collaboration and conflict.

A focus on the evolutionary dynamics of dual social structures is important for at least two reasons. First, relationships of conflict are endemic to most social systems: alongside collaborative relationships, there is no shortage of long-lasting conflictual relationships that entail "recurring sets of negative judgments, feelings, and behavioral intentions toward others" (Labianca & Brass, 2006: 597). These include relationships of interpersonal antagonism (Labianca, Brass, & Gray, 1998; Morrill, 1991) and enduring interorganizational disputes related to breach of contract, antitrust violations, or infringement of intellectual property (e.g., Agarwal, Ganco, & Ziedonis, 2009; Lumineau & Oxley, 2012; Sytch, 2011). Second, collaborative and conflictual relationships may not simply exist side-by-side within the social space; instead, they may co-determine one another and thus jointly account for the evolutionary dynamics of social systems (Heider, 1946; Sytch, 2011). For these reasons, focusing on the collaborative side of the social structure is likely to produce an incomplete picture of the social order.

This paper focuses on the formation of dyadic and triadic structures as the micro-foundations of networks and explores how the dual structures of collaboration and conflict among corporate actors co-exist and co-evolve. We then explore how these dynamics of tie formation at the level of dyads and triads shape the emergent properties of the global network. Tracing a population of companies in the global biotechnology and pharmaceutical industry from 1996 to 2006, we use interorganizational partnerships as manifestations of collaborative ties and patent-infringement and antitrust litigation cases as manifestations of conflictual ties. To guide our perspective, we employ the theory of structural balance, which differentiates between balanced and unbalanced dyadic and triadic structures in the context of interpersonal ties (Heider, 1946,

1958). This theory suggests that multiplex dyads combining collaborative and conflictual relationships are unsustainable and evolve toward uniplex relationships of either collaboration or conflict, but not both. The theory further differentiates between balanced and unbalanced triads, suggesting that unbalanced triads are also unsustainable and hence either dissolve or evolve toward balanced triads (see Figure 1). Furthermore, the principles of balance theory have also been applied to study the emergent properties of global networks (Harary, 1953), an approach which we extend here to understand the emergent properties of an industry-wide network.

Insert Figure 1 about here

Despite its intuitive appeal, structural balance theory has been challenged in terms of its applicability to real-world empirical settings (Mitchell, 1969) and has received only mixed empirical support (Burt, 2001). Yet the adages of the theory, such as "the enemy of my enemy is my friend," are frequently used in the domains of politics and social interaction and have even been used to impute missing network data (White, 1961). Furthermore, there has been little systematic inquiry into the links between balanced and unbalanced micro-level structures and the emergent properties of global networks. The existing inquiries generally have focused on static network structures and have been applied to a limited set of stylized network configurations, which are rare in real life (Harary, 1953).

In this study, we aim to revisit and expand structural balance theory in three ways. First, we seek to explore to what extent the principles of balance affect the formation of dyadic and triadic network structures, rather than the stability of these structures. Consistent with the central precepts of balance theory, our primary expectation is that we will observe some degree of pull toward the formation of balanced dyadic and triadic structures and away from the formation of unbalanced structures. Second, we aim to establish a firmer foundation for the principles of

balance theory by applying them to the analysis of social structures of corporate actors, and thus extending them beyond their original application to cognitive structures in interpersonal settings. Third, we seek to establish concrete links between the micro-level dynamics of interorganizational dyads and triads that we identify and the emergent properties of the global industry-wide network.

More generally, this study is among the first systematic inquiries into the dynamics of dual networks. It thus aims to extend the study of the social structure of markets (Baker, 1984; Granovetter, 1985; Uzzi, 1999) by combining a focus on its collaborative side with a complementary investigation of its conflictual side. This dual sociostructural perspective represents one salient dimension of the relational pluralism found in numerous social systems in which collaborative and conflictual relationships coexist and can intertwine to determine the actions and outcomes of resident actors. This perspective thus has implications for the studies of network dynamics (Rosenkopf & Padula, 2008; Shipilov & Li, 2011; Zaheer & Soda, 2009), in that conflict and collaboration can jointly shape the evolutionary dynamics of social structure and thus characterize more comprehensively the emergent features of the global network.

This paper also contributes to studies of the connection between the social structure of markets and firm-level outcomes (Beckman & Haunschild, 2002; Lavie, 2007), and to studies of collective dynamics in organizational fields (Davis, 1991; Greve, 2009). By examining previously overlooked interdependencies between conflict and collaboration, this paper enhances our understanding of the antecedents of actors' positions in networks of collaborative relationships. Specifically, it leads to a more precise understanding of the emergent levels of connectivity in collaborative networks and enables us to evaluate more systematically the antecedents of structural gaps between social actors and groups (Salancik, 1995). Both of these implications, in turn, are relevant to theories of private advantage and collective dynamics, and thus provide a tighter link between the properties of network structure and the outcomes it engenders.

THEORY

The concept of dual social structures that encompass both collaboration and conflict has deep theoretical roots in social science. Early in the history of sociometry, scholars recognized that actors' positive and negative emotional choices jointly shape social structure (Moreno, Jennings, & Sargent, 1940). Likewise, Homan's (1950) classic account of a bank's wiring room portrayed the social space in terms of its constitutive collaborative and antagonistic relationships. Conflict was assigned a role comparable to that of exchange in descriptions of the structures of elementary relations (Willer, 1987) and the stability of social structures (Heider, 1946). Similarly, prominent social theorists have noted that collaborative and conflictual relationships "only both together constitute the group as a concrete, living unit" (Simmel, 1955: 20) and that a comprehensive theory of social structure must address both types of relationships (Granovetter, 1973: 1361). From this perspective, social capital has even been characterized as a limiting concept, since the implications of an actor's structural position can be more comprehensively described by a social ledger which tallies both the resources and the liabilities embedded in networks of collaborative and conflictual relationships (Labianca & Brass, 2006).

It is therefore surprising that empirical studies of dual social structures are sparse. Only a handful of studies have focused on establishing a link between dual network configurations and actors' individual behaviors and outcomes. One specific study of the dual social structure of an American monastery analyzed the role structure of its social system and linked it to the monks' subsequent exodus patterns following a crisis (White, Boorman, & Breiger, 1976). Similarly, a study of interpersonal relationships at a university health center found that the number of friendships that an individual had with others who avoided outgroup members was positively related to his or her perceptions of intergroup conflict (Labianca et al., 1998).

The lacuna between recognizing the theoretical importance of dual networks and rigorous empirical inquiry into their dynamics and implications is particularly striking in the study of networks of interorganizational relationships, where the prevailing scholarly focus has been limited to the antecedents and consequences of collaborative ties. Some studies have highlighted the tensions that can permeate collaborative interorganizational ties, such as those related to violations of trust (Uzzi, 1997), divergence of strategic interests (Katila, Rosenberger, & Eisenhardt, 2008; Williamson, 1985), and the appropriation of knowledge for self-gain (Khanna, Gulati, & Nohria, 1998). Yet there has been no systematic study of the interplay between collaboration and conflict in interorganizational settings.

Against this sparse research landscape, balance theory stands out as one of the key theoretical foundations for understanding dual social structures (Cartwright & Harary, 1956; Heider, 1946, 1958). By differentiating between balanced and unbalanced dyads and triads of social actors (see figure 1), this theory makes predictions about the relative stability of these microstructural configurations. Specifically, balanced structures (figures 1a-1d) are hypothesized to be stable, to avoid relational tensions and, hence, to persist over time. Unbalanced structures (figures 1e-1g) are in turn predicted to be unstable because they generate relational tensions among actors. With time, these triads either dissolve or evolve toward a balanced, stable state.

Because the original focus of balance theory was on the stability of cognitive structures among individuals, the role of structural balance in the formation of social relationships has not been explored thoroughly. The focus on relationship formation has been secondary and reflected mostly in the expectation that, notwithstanding the possibility of their complete dissolution, unbalanced structures will tend to evolve toward some form of balance. Not surprisingly, the lack of systematic focus on how network structures form seems to have allowed scholars to recognize only a rather static link between the prevalence of balanced and unbalanced structures and the

structural properties of the global network. Specifically, some early research found that a balanced network of collaborative and conflictual ties[1] can be divided into two subsets, such that only collaborative ties connect the members of each subset while conflictual ties connect the members of different subsets (Harary, 1953, 1955). In addition to representing a static connection between the prevalence of balanced structures and the properties of a global network, this conclusion is of limited empirical value, because balanced dual networks are rare in real life.

In this paper, we address these lacunae in theory and in empirical research by systematically exploring how the principles of balance theory can be used to describe the formation of balanced and unbalanced dyadic and triadic structures. By focusing on the formation of these structures within an interorganizational network, we also explore whether balance theory can be usefully extended beyond its original focus on individual cognition. Furthermore, drawing on our main analysis of firms' tendencies to form balanced and unbalanced dyads and triads, we investigate how these processes can jointly shape the emergent properties of the global network. Below, we first introduce the empirical context of collaboration and conflict in biotechnology and pharmaceuticals, and then explore the role of balance in driving the formation of dyads and triads in this setting.

Collaboration and Conflict in Biotechnology and Pharmaceuticals

This study uses interorganizational partnership ties as manifestations of collaborative relationships among companies. Such relationships, which include joint research and development, co-production, and co-marketing agreements, represent influential channels for access to and transfer of information, knowledge, and other resources across organizational

[1] A network is balanced if and only if all cycles have positive signs. A cycle refers to a network path (i) that comprises at least three nodes, (ii) in which all lines are distinct, and (iii) in which all nodes except the beginning and the ending node are distinct. The sign of a cycle is determined as the product of the signs (positive and negative) of the ties comprising the cycle (Wasserman & Faust, 1994: 107-108, 226).

boundaries (Beckman & Haunschild, 2002; Owen-Smith & Powell, 2004). Although interorganizational efforts to collaborate are not immune to occasional relational and competitive frictions (e.g., Katila et al., 2008; Khanna et al., 1998; Williamson, 1985), they are typically built on shared goals, cooperative resource exchange, and a general propensity to work together (Ring & Van de Ven, 1992, 1994; Zaheer & Venkatraman, 1995). The strong influence of interorganizational partnerships on the collaborative fabric of an industry is particularly pronounced in biotechnology and pharmaceuticals, where partnerships and the resulting flows of knowledge and other resources are central to firms' innovation, financial performance, and survival (e.g., Baum, Calabrese, & Silverman, 2000; Powell, Koput, & Smith-Doerr, 1996; Rothaermel & Boeker, 2008).

In contrast, patent infringement and antitrust lawsuits are among the fiercest, most enduring, and most consequential disputes among organizations in biotechnology and pharmaceuticals; they thus exemplify the conflictual side of the social structure (Sytch, 2011). Patent-infringement lawsuits arise from the patentee's claims that the alleged infringer has made, used, sold, or imported into the United States a patented invention without authority during the patent's term (35 U.S.C. §271(a)). Antitrust litigation, in turn, entails allegations that a firm has resorted to unfair competitive practices, including attempts to monopolize the market, fix prices, or engage in price discrimination, or has refused to sell to certain market participants.[2] Patent infringement and antitrust litigation have increased in the United States in recent years. The U.S. Federal District Courts registered about 10,000 antitrust and 29,000 patent infringement cases from 2000 to 2010.

[2] Unfair competitive practices are defined by the Antitrust Acts, which include the Sherman Act of 1890, the Clayton Act of 1914, the Robinson-Patman Act of 1936, and supporting legislation. Antitrust litigation can be brought against a violator by the state, but in recent years corporations, as directly injured parties, have initiated antitrust litigation more frequently than the government has. In fact, our analysis of antitrust filings in the U.S. Federal District Courts using the LexMachina database revealed that filings by the Department of Justice accounted for less than 7% of all antitrust lawsuits from 2000 to 2010.

Both patent infringement and antitrust litigation are highly consequential for the opposing parties. A plaintiff can seek both injunctive relief – to force another company to refrain from injurious acts – and punitive damages up to triple the economic damages sustained. The plaintiffs face risks as well, because lawsuits frequently provoke counterclaims. In patent infringement litigation, moreover, the initiating party risks losing the rights to its intellectual property and thereby opening the floodgates to competition if the court declares its patents invalid or unenforceable. Furthermore, both patent and antitrust litigation are extremely costly (e.g., Somaya, 2003). The cost of litigating patents can reach $5.5 million per lawsuit, excluding damages and royalties (Rea, 2009). For example, Impax Laboratories, a specialty pharmaceutical company based in Hayward, California, incurred costs of patent litigation in 2009 that amounted to more than 8.5% of total R&D expenses.

Because patents in biotechnology and pharmaceuticals are linked closely to actual product portfolios, and because a relatively small number of products typically drive company success, verdicts in patent infringement or antitrust claims can be particularly consequential (cf. Hall and Ziedonis, 2001 for a discussion of semiconductors). For instance, in 2007, GlaxoSmithKline and a group of retailers filed antitrust claims against Abbott Laboratories for attempting to monopolize the AIDS drug market with its Norvir product. The action led to Abbott Laboratories' paying $52 million to settle the case. Likewise, when Transkaryotic Therapies (TKT) was found in 2001 to have infringed Amgen's patent on Epogen (an anemia drug for patients undergoing kidney dialysis and chemotherapy), TKT's stock plunged 17%. In the 2002 patent infringement case between Chiron and Genentech over Genentech's breast cancer drug Herceptin, Chiron sought as much as $300 million in royalties, albeit in vain. It is no wonder that these lawsuits often entail full-fledged conflictual relationships characterized by intensely negative affect and animosity among the executives of the litigating companies (Hewitt, 2005).

It is essential to note that studying patent infringement and antitrust litigation cases jointly is especially beneficial because both forms of legal conflict are often interrelated. For example, the filings and settlements of patent infringement claims can draw antitrust scrutiny (Carrier, 2009). In 1997 Schering-Plough settled its patent infringement suits with Upsher-Smith Laboratories by paying the latter $60 million to postpone until 2001 the sale of Upsher's generic versions of Schering's drug K-Dur, which was used to treat blood pressure and congestive heart failure. This agreement prompted third-party antitrust action that deemed the settlement anticompetitive. Similarly, initiating patent infringement litigation to delay market entry by competitors can also draw antitrust action, as happened when Abbott Laboratories sought to protect the market for its anti-cholesterol drug TriCor, and when GlaxoSmithKline tried to guard the sales of its popular antidepressant Wellbutrin.

While both patent litigation and antitrust disputes are a form of conflict related to competition over scarce resources, it is nevertheless difficult to equate them with competition per se. On the one hand, competition has been traditionally defined as “interaction without social contact” (Park & Burgess, 1921: 278-282). While “sharing an interest in some of the same resources” (Ingram & Yue, 2008: 276), competitors do not have to be (and frequently are not) in direct contact with each other, to be aware of each other, and to develop negative affect and engage in negative behaviors toward each other (see also Deutsch, 1973: 10). On the other hand, many scholars agree that when competition is coupled with social interaction, it frequently does entail conflict (Park & Burgess, 1921; Sherif et al., 1961). In fact, conflict has been described as stemming from “the purposeful interaction of two parties in a competitive setting” (Oberschall, 1978: 291).

Because patent infringement and antitrust disputes offer numerous opportunities for social contact among disputants during both pre-filing discussions and court proceedings, they often

meet the most stringent criteria for conflictual relationships (Schmidt & Kochan, 1972). These criteria include: (1) the *affective* element, manifested in stress, tension, and negative feelings among organizational agents; (2) the *cognitive* element, in that each party is aware of the other's incompatible goals and pursuits; and (3) the *behavioral* element, ranging from passive resistance to overtly aggressive behavior. The negative affect and hostile interactions permeating these confrontations are often inextricably linked to the litigation's high stakes.

In sum, interorganizational partnerships, on the one hand, and patent infringement and antitrust lawsuits, on the other hand, jointly represent the dual facets of social structure in the present context. Due to their immense consequences for companies, these relationships also typically entail a common locus of executive attention at the corporate level that typically involves in-house legal counsel as well as those responsible for business development and alliance management. For example, our fieldwork revealed that the due-diligence process of selecting new partners typically involves analyzing all ongoing and pending litigation by the potential partner. Pre-filing deliberations in litigation, in turn, typically entail a careful analysis of any collaborative activities with the potential litigant, since litigation can affect the revenue stream from such ongoing collaboration and carry an increased likelihood of counterclaims. In this context, it is reasonable to expect that the dynamics of conflict and collaboration will be interrelated. In the following theoretical sections, we examine these interrelated dynamics of collaboration and conflict in greater detail.

Formation of Balanced and Unbalanced Structures

Our theory aims to explore how balanced and unbalanced dyadic and triadic structures are formed in a dual interorganizational network encompassing both collaboration and conflict. This context is characterized by two unique properties. First, empirical research indicates that interorganizational networks are typically only sparsely connected (e.g., Rosenkopf & Schilling,

2007). Consistent with this evidence, we found that the average density of ties in our dual interorganizational network was 0.004, suggesting that the overwhelming majority of dyads remained unconnected. Second, in this context, it would be difficult to deterministically rule out the possibility that any dyad would simultaneously have both collaborative and conflictual ties. In fact, we did observe such multiplex relationships in our data.

These features of our empirical setting indicate that the occurrence of balanced dyads (i.e., any pair of firms that had formed either exclusively collaborative or exclusively conflictual ties with one another) is not necessarily at odds with the occurrence of unbalanced dyads (i.e., any pair of firms that have ongoing collaborative *and* conflictual ties with each other). In a sparse network, balanced dyads could form alongside unbalanced dyads, thus demonstrating the pull toward both kinds of structures. Similarly, the formation of both balanced and unbalanced triads would necessarily be precluded only in a network that (i) does not allow for overlapping relationships of collaboration and conflict between the same two firms, and (ii) is fully connected (i.e., where the number of realized ties equals the number of potential ties).

Since our setting is not only sparsely connected but also allows for multiplex relationships of collaboration and conflict, it is thus beneficial to explore the formation of balanced and unbalanced triads as distinct outcomes. Doing so enables us to capture the entire range of possible network dynamics. For example, in a sparse network such as ours, balanced dyadic and triadic structures among some groups of actors could form alongside unbalanced structures found in other groups of actors. Another possibility is that, in a sparsely connected social system, the pull away from unbalanced triadic structures would not necessarily have to translate into a pull towards balanced triads, since some triads may continue to remain open. In our theory and predictions below, we thus differentiate between the formation of balanced and unbalanced dyadic and triadic structures as distinct outcomes that are not mutually exclusive.

Dyadic Structures

The Formation of Balanced Dyads: Perpetuation of Collaborative and Conflictual Relationships

One way to test the emergence of balanced dyadic structures in networks containing both collaborative and conflictual relationships is through the dynamic of relationship perpetuation. Studies of relational embeddedness offer consistent evidence that existing collaborative relationships tend to drive future collaboration. This effect can be traced to three mechanisms. First, collaborative ties between two firms promote familiarity with each other's resource profiles and expertise, heightening awareness of further opportunities to cooperate that would be difficult to identify without an existing relationship (e.g., Gulati & Gargiulo, 1999; Gulati, Lavie, & Singh, 2009; Zaheer, Hernandez, & Banerjee, 2010). As one manifestation of this trend, in the mid-1990s Chiron, a leading biotechnology company, entered into multiple collaborative relationships with Ribozyme Pharmaceuticals. The initial partnership focused on the joint development of ribozymes for gene therapy, as applied to a series of well-known targets, such as the HIV genome.[3] Two years later, the parties formed a second partnership alongside the first one to identify new targets for therapeutic agents by using ribozymes to examine gene function; this was a new business domain for both companies. Lewis Williams, then president of Chiron, specifically singled out learning through previous collaboration as the key driver behind the new alliance: "Our collaborative work with RPI has given us an appreciation of the utility of ribozymes in assessing gene function… We plan to expand this approach for our discovery program, which is designed to find targets for therapeutic agents" (PR Newswire, 1996).

Second, repeated collaboration and the trust it engenders can reduce the uncertainty associated with future partnerships and the need to rely on formal governance (Gulati, 1995a).

[3] Ribozymes are ribonucleic acid molecules that can serve both as genetic material and as catalysts for biochemical reactions by selectively inhibiting production of proteins. The company Ribozyme was built to design and synthesize such ribozymes, using a cutting-edge technology.

This in turn can reduce transaction costs and make the existing partner a more attractive choice for future collaborations. In addition to the benefits of learning and reducing transaction costs in repeated collaborative ties, a third mechanism that may drive repeated collaboration is simple inertia, where the familiarity of working with a proven partner trumps the economic imperative to consider a broader pool of potential partners (Li & Rowley, 2002).

In an intriguing parallel, ongoing conflictual relationships between firms can engender successive conflicts. First, fierce confrontations often follow a spiral path in which patterns of negative affect and aggressive behavior are reciprocated with escalation (Lawler, 1986). In patent infringement litigation, a patentee's claims can invite counterclaims accusing the patentee of overstepping the boundaries of the alleged infringer's intellectual property or of monopolizing the market; the latter claim may then lead to antitrust litigation. Second, ongoing conflict can evoke systematic attribution bias: missteps or unfortunate confluences of external circumstances may be interpreted as the opposing side's willfully advancing the conflict (Argyris, 1990). Research has also suggested that negative information is typically assigned more credence than positive information (Skowronski & Carlston, 1987; Skowronski & Carlston, 1989), further amplifying the bias toward conflict. Thus, if the parties are already involved in a conflict, new confrontations that might otherwise have been overlooked or resolved amicably can escalate into additional, full-fledged conflicts.

Numerous anecdotal examples support this conjecture. For example, between 2001 and 2006, in what some experts described as a "war" (Amiel, 2008), Sanofi-Aventis filed a series of lawsuits against Barr Pharmaceuticals. Likewise, in 1989 the biotechnology company Cetus Corporation and DuPont entered into a dispute over one aspect of a technique in molecular

biology known as polymerase chain reaction.[4] Just two years later, Cetus filed another lawsuit against DuPont involving a new patent unrelated to the ongoing dispute. Similarly, a legal conflict that arose between Genentech and the Welcome Foundation and Welcome Biotechnology over an aspect of recombinant DNA technology eventually resulted in several successive lawsuits.[5]

The Formation of Unbalanced Dyads: Crowding Out of Collaborative and Conflictual Ties

The principles of balance theory would suggest that unbalanced dyadic structures, which combine collaboration and conflict in one multiplex relationship, are less likely to form. If we consider collaboration first, we note that there are several ways in which collaborative ties between firms can crowd out or diminish the likelihood of future conflict. First, existing collaborative relationships can discourage the development of severe conflicts that have a low likelihood of reconciliation, in which one partner strives to invade the technological domain or market niche of the other. This protective function occurs in part because the social relationships that typically accompany an ongoing collaborative link (Larson, 1992; Rosenkopf, Metiu, & George, 2001) can mitigate the influence of economic factors, particularly cut-throat competition (Uzzi, 1997). Ongoing collaborative relationships and the interfirm value they generate may also create an economic disincentive to initiating and escalating conflict, because such conflict could substantially diminish access to the partner's resources and otherwise threaten the continuity of resource exchange.

[4] A polymerase chain reaction is used to amplify a copy of genetic material across several orders of magnitude to produce multiple copies of a particular DNA sequence.

[5] Perpetuating interorganizational conflict via new lawsuits is, of course, not unique to biotechnology and pharmaceuticals. In 2002, when Macromedia, the maker of the popular Web design packages Flash and Dreamweaver, won one of its several ongoing legal disputes against Adobe, the chairman and CEO of Macromedia quipped, "The score is now Adobe one, Macromedia one, customers zero" (Reuters, 2002). Similarly, when General Electric filed two patent infringement lawsuits between 2008 and 2011 against Mitsubishi over wind-energy-related patents, Mitsubishi reciprocated by suing General Electric for infringing one of its wind-energy patents and filed a separate antitrust lawsuit accusing General Electric of an unlawful monopoly in the wind-energy market.

Second, should a dispute nevertheless arise, the extensive social overlay of interorganizational collaboration can make the companies more likely to work out disagreements via extralegal means before they escalate to full-fledged legal conflict (Black, 1973; Lumineau & Oxley, 2012). For example, in his qualitative study of interorganizational relationships, Macaulay (1963) emphasized that instead of engaging legal counsel, executives often relied on social relationships to settle emerging disputes through informal interaction. Mediation represents another, albeit more formal, form of alternative dispute resolution that can enable the parties to stay out of the courtroom. Moreover, if an emergent dispute is related to an existing collaborative agreement, parties can resort to arbitration as yet another way to settle the disagreement.

Turning now to conflict, we note that when conflictual ties exist between companies, those ties can be expected to crowd out or diminish the likelihood of future collaborative relationships. One reason for this is that the negative affect that such conflictual relationships evoke makes it difficult for the disputants to discover, evaluate, and pursue opportunities for collaboration. For example, in her qualitative account of the co-evolution of the pharmaceutical and biotechnology sectors, Higgins (2005: 77-80) described the case of Abbott Laboratories and Baxter International, whose relationship involved several patent lawsuits and was characterized by bitter hostility. The enduring conflictual relationship between Abbott and Baxter imposed substantial constraints on their ability to collaborate with each other. Thus, although both were exceptionally active in pursuing interorganizational partnerships with other companies, Abbott and Baxter refrained from collaborating with each other.[6]

[6] In one instance, when the Food and Drug Administration began to require every blood donation to be tested for hepatitis, Baxter was presented with an economically viable opportunity to collaborate with Abbott: Baxter could contribute a novel design for the plastic blood collection bag and effectively combine it with Abbott's superior expertise in immunology diagnostics. Instead, Baxter chose to pursue the opportunity independently. By its own account, when it entered the uncharted waters of the diagnostics business, it overpaid to acquire the diagnostics company Clinical Assays. In the words of Baxter's CEO at the time, "Look, we do not want to be paying Abbott a nickel for anything, even if we have to; we'll pay anybody else for hepatitis testing" (Higgins, 2005: 80).

Other qualitative accounts of patent infringement and antitrust litigation between companies have documented acrimonious interactions among their senior executives (Hewitt, 2005: 19-23). These hostile interactions are inextricably linked to the high stakes of lawsuits, which can threaten the viability of an entire enterprise. Furthermore, moving the conflict into the legal realm can sometimes be more disruptive to the disputants' relationship than the conflict itself, and can damage any remaining social fabric between them (Black, 1973). Filing a complaint in a federal court can catch the other party off-guard and lead to intensified friction, since the parties will naturally have strikingly different perspectives on the infringement and on the economic value in dispute (Hewitt, 2005).

Another reason why an existing conflictual tie may diminish the likelihood of collaboration in a dyad is related to the increased possibility of unfavorable changes to the dependence status quo between two firms (e.g., Emerson, 1962; Sytch, Tatarynowicz, and Gulati, 2012). These changes can be driven by the unfolding dynamics of interorganizational legal conflict. Specifically, a court's decisions regarding the validity or enforceability of a given patent for the plaintiff, or any injunctions and damages imposed on the infringer, can alter the dependence status quo between the two organizations. This is because such decisions can effectively alter the distribution of control over market opportunities, which are presumably critical enough in those contexts in which both organizations have decided to engage in litigation. Uncertainty surrounding such possible changes in dependence scenarios can translate into uncertainty regarding the attractiveness of future collaboration, particularly with respect to what each partner would contribute to the partnership and the distribution of outcomes, such as revenues or intellectual property rights. Such uncertainty, in turn, can make those organizations that are involved in legal conflict with each other less likely to collaborate in the future.

Finally, legalization of conflict can also impose direct constraints on future collaboration. Legal procedures may limit the exchange of information to admissible evidence and thus exclude or distort information that the parties need in order to fully understand the circumstances surrounding infringement (Macaulay, 1963; Turk, 1976). The risks of disclosing injurious facts, violating collusion rules, or discussing issues that may weaken the case discourage open communication between disputants (Oberschall, 1978; Turk, 1976: 286). Thus, given the considerable threat of significant legal liability, negatively charged interactions, and impoverished communication, it naturally becomes difficult for the disputants to form new collaborative relationships.

There are at least two potential counterarguments that could be made to this account of how present collaboration can crowd out future conflict, and how present conflict can crowd out future collaboration. First, as studies that focus only on collaborative social structures have implicitly assumed, one could expect the dynamics of collaboration and conflict to be independent (i.e., to have a null effect). Information about a firm's partnering and litigation activities does typically aggregate at the top of the corporate hierarchy and thus entails a common locus of executive attention. Yet, organizations are not unitary actors. It is thus unclear to what extent the varying levels of cognitive tensions that different organizational agents experience could aggregate to shape the dynamics of interorganizational collaboration and conflict. As multi-agent and multi-unit entities, organizations could conceivably use a range of interventions that would allow them to contain conflict and separate it from collaboration.

Second, it is also possible that a positive association could exist between the different types of existing and future relationships. This counterargument draws on the view that any form of contact, even collaboration, could propagate future conflict because many relationships entail at least some level of competitive friction (Katila et al., 2008; Khanna et al., 1998). In experimental

settings, for example, scholars have found that conflict and negative sanctions can result from bargaining agreements that have failed (Szmatka et al., 1998). Moreover, violations of trust in collaborative relationships have been linked to particularly acrimonious interorganizational conflict (Uzzi, 1997). On the other hand, existing conflict can also stimulate future collaboration. One way for firms to resolve ongoing conflictual ties is to establish collaborative arrangements that create and distribute joint economic gains. In disputes regarding intellectual property, for example, it is not uncommon for the parties to settle by drafting a licensing deal that enables the alleged infringer to continue manufacturing the product in exchange for a royalty stream.

Taken together, these counterarguments produce a more blurred picture of how collaboration and conflict may co-evolve as dual facets of the same social structure. Our theory, by contrast, suggests that due to their immense economic and organizational consequences, collaborative and conflictual ties (at least those that occur in the form of partnership and litigation ties), are often difficult to keep separate from one another within the same firm. Considering the common locus of executive attention within a firm that involves both collaborative and conflictual ties, we thus anticipate that the patterns of cognitive alignment and tensions among organizational agents will, on average, be consistent with the predictions of balance theory.

Furthermore, our theory is also based on the premise that a sharper distinction can be drawn between relationships of collaboration and conflict, largely due to the extreme nature of firms' legal confrontations. Our predictions, formulated below as Hypotheses 1a and 1b, do not exclude the possibility that companies linked by collaborative ties will also engage in conflict over patent infringement and antitrust issues. We expect, however, that on average these disputes are unlikely to escalate into full-fledged legal confrontations. On the other hand, legal conflicts between companies can sometimes be resolved via private settlements. The relational damage and the associated legal constraints on exploring opportunities for collaboration, however, imply that

these settlements are unlikely to systematically engender collaborative relationships between the disputants.

In summary, we expect collaborative and conflictual relationships between organizations to perpetuate future collaboration and future conflict, respectively. We also expect that collaborative relationships between firms will crowd out subsequent conflict between them, and that conflictual relationships will crowd out subsequent collaboration:

> ***Hypothesis 1a****: The number of current collaborative relationships between two firms will be (1) positively related to their likelihood of entering into a new collaborative relationship and (2) negatively related to their likelihood of initiating a new conflictual relationship.*
>
> ***Hypothesis 1b****: The number of current conflictual relationships between two firms will be (1) positively related to their likelihood of initiating a new conflictual relationship and (2) negatively related to their likelihood of entering into a new collaborative relationship.*

Triadic Structures

The Formation of Balanced Triads

In line with the analysis of dyadic structures, we predict that the evolutionary dynamics of dual social structures will be characterized by a pull toward balanced triads. Two possible balanced triadic structures exist: one in which all three actors are connected to one another by collaborative relationships (figure 1c), and another in which both collaborators are in conflict with the same third party (figure 1d). These structures are considered balanced due to the relative absence of relational tensions between actors. For example, a symmetrical connection to the same third party allows two of the collaborators to avoid possible tensions in their relationship with each other. These two triadic configurations, in turn, present opportunities to analyze three different scenarios of their formation (see figures 2a-2c).

Insert Figure 2 about here

The first scenario is an all-collaborative triad, which emerges when a new collaborative tie forms between two companies that share a common collaborator (figure 2a). This formation dynamic has been investigated previously (Gulati, 1995b; Gulati & Gargiulo, 1999; Shipilov, Rowley, & Aharonson, 2006). Sharing a collaborative tie to a common third party creates a congruent cognitive structure for the executives at both companies and thus avoids the cognitive dissonance that Heider (1946) emphasized. Furthermore, access to the third collaborator allows alters to obtain private information on the credibility and resources of each other. In at least some cases, the presence of a third party in this triad adds a relational structure that mitigates the uncertainty of organizational collaboration. These mechanisms thus suggest that alters' collaborative connections to a common third party will be positively related to the formation of a collaborative tie between the alters, thus creating an all-collaborative triad.

In contrast, a triad in which a collaborative relationship between two companies is accompanied by their conflictual ties with a common third party (figure 1d) is significantly less studied. Nonetheless, there are reasons to expect that such structures can form. One way in which this triad could come about is through the formation of a conflictual relationship between two parties that are linked by relationships of different types to the same third party (figure 2b). Incongruent perceptions of conflict and collaboration with respect to the third party can result in relational tensions between the collaborating companies' executives. While such tensions could contribute to the emergence and escalation of interorganizational conflict, the third party may even take on a more active role by recruiting its collaborator as an ally in the legal battle against a common adversary. In patent infringement, for example, the technology owner may try to get the parties involved in licensing the technology to join the suit on the company's behalf. For example, in the 2003 patent infringement lawsuit over the imaging technology for early detection of breast cancer, the company iCAD, Inc. – the exclusive licensee of Scanis's imaging patent – took on an

active, visible, and vocal role in litigating alongside plaintiff Scanis against R2 Technology, Inc. Similarly, collaborators may attempt to engage the manufacturers of complementary products, distributors, and other contributors to the value chain to support them in antitrust litigation.

Another way in which the triadic structure depicted in figure 1d can emerge is when a collaborative relationship is formed between two firms sharing a common adversary (figure 2c). Research in sociology, anthropology, psychology, and political science offers evidence that having a common adversary can bring parties closer together (Simmel, 1955; for a review, see Stein, 1976). In the interorganizational context, having common adversaries can blur intergroup boundaries, increase social identification between the employees of both companies, and stimulate resource mobilization. These circumstances can enable parties to discuss opportunities for joint collaboration more openly. Co-identification may also serve as a basis for relational governance, which can reduce reliance on formal governance mechanisms and eliminate concomitant transaction costs (Gulati & Sytch, 2008). Toward this end, existing research offers some evidence that increased levels of co-identification between organizational actors can promote future collaboration between the companies (Baldi, Stern, & Dukerich, 2011).

In addition, the formation of a collaborative relationship between two firms sharing a common adversary can be driven by the need to mobilize resources against a common enemy. Joint product development efforts, for example, can help companies attain a more preferred positioning in the market and hence more effectively combat the unfair competitive practices of an antitrust violator. Alternatively, such joint product development efforts can help collaborators introduce more distance between their inventions and the patent portfolio of the adversary, thus reducing the likelihood of prolonged patent disputes. Based on the above discussion, we predict the following for the emergence of balanced triads:

Hypothesis 2a*: The number of third parties to which both firms hold collaborative ties will be positively related to the likelihood of a new collaborative relationship between the two firms (fig. 2a).*

Hypothesis 2b*: The number of third parties to which one firm holds a collaborative tie and the other one a conflictual tie will be positively related to the likelihood of a new conflictual relationship between the two firms (fig. 2b).*

Hypothesis 2c*: The number of third parties to which both firms hold conflictual ties will be positively related to the likelihood of a new collaborative relationship between the two firms (fig. 2c).*

The Formation of Unbalanced Triads

Research has recognized two types of unbalanced triadic structures: one in which two adversaries are linked to the same third party by collaborative relationships (figure 1f) and one in which all three parties are interlinked by conflictual relationships (figure 1g) (Heider, 1946; Hummon & Doreian, 2003; Szell, Lambiotte, & Thurnera, 2010). These triads are generally deemed unstable due to the relational tensions they produce. Applying the principles of balance theory to the interorganizational context, we expect that such triads will be unlikely to form.

The first type of triad can arise when a conflictual relationship develops between the two firms that share a common collaborator (figure 3a). This dynamic is unlikely for two reasons. First, as predicted by the principles of structural balance, having a common collaborator is likely to generate a strong pull toward collaboration. The tendency to collaborate, in turn, can crowd out emerging conflict. Second, research has suggested that third parties with cross-cutting ties to both alters can act as powerful mediators in disputes, thus attenuating the likelihood of conflict escalation (Black, 1998; Phillips & Cooney, 2005).

Insert Figure 3 about here

The second type of triad emerges when a collaborative relationship is formed between two companies whose relationships to the same third party are of contrasting types (figure 3b). In this situation, however, it is plausible to expect that the asymmetric ties to the same third party will increase the fault lines between the executives of the two companies (Blau, 1974; Lau &

Murnighan, 2005). Reduced levels of co-identification, in turn, may make it more challenging to identify opportunities for collaboration between the two firms. In addition, rather than acting as a mediator or otherwise actively bringing the two companies together, the third party in this situation may act as a *tertius gaudens* and intervene in order to keep the other two companies separated (Simmel, 1950: 154-169; Simmel, [1908] 1971). This could happen if the third party is concerned that its adversary may gain a powerful ally, obtain access to sensitive private information through the collaborator, or lead the collaborator to sever the existing collaborative arrangement (cf. Gargiulo, 1993 on cooptation amidst friction).

Finally, the third type of triad, all-conflictual, is one in which all three parties are linked by conflictual ties (figure 3c). This triad is also generally deemed unbalanced, although in some accounts this holds only under a weakly formulated balance hypothesis (Davis, 1967). The classification of this triad as unbalanced is based on the premise that parties with symmetric relationships to a third party tend to gravitate toward, rather than away from, each other (e.g., White, 1961: 195). According to this logic, the reduced fault lines and increased co-identification between two firms should decrease, rather than increase, the likelihood that both companies will enter into a conflictual relationship. Executives of these companies could be less likely to commit attribution errors and be more open to extralegal means of reconciliation, thus reducing the likelihood of escalating conflict and legal action.

In summary, we predict that the formation of interorganizational relationships will be driven by a pull away from all three types of unbalanced triadic structures:

> ***Hypothesis 3a****: The number of third parties to which both firms hold collaborative ties will be negatively related to the likelihood of a new conflictual relationship between the two firms (fig. 3a).*
>
> ***Hypothesis 3b****: The number of third parties to which one firm holds a collaborative tie and the other one a conflictual tie will be negatively related to the likelihood of a new collaborative relationship between the two firms (fig. 3b).*
>
> ***Hypothesis 3c****: The number of third parties to which both firms hold conflictual ties will be negatively related to the likelihood of a new conflictual relationship between the two firms (fig. 3c).*

Implications for the Global Network Structure

One of the fundamental insights in the study of social and complex systems is that the micro-level behaviors of actors can aggregate to shape the macro-level properties of the whole system (Coleman, 1990; Simon, 1962). Recent work has studied this micro-macro link in diverse fields, including sociology and organization science (e.g., Baum et al., 2003; Doreian & Stokman, 1997; Powell et al., 2005; Rosenkopf & Padula, 2008), economics (e.g., Cowan, Jonard, & Zimmermann, 2007; Jackson & Rogers, 2007), and the physical and biological sciences (e.g., Watts & Strogatz, 1998; Williams & Martinez, 2000). In our context, a key implication of studying dyads and triads as the micro-foundations of social structure is that their formation dynamics can offer insight into the emergent properties of the global network. In other words, we anticipate that the empirically established tendencies of firms to form balanced and unbalanced structures, which we explore above, will shape the emergent properties of the global, industry-wide network.

With respect to the specific relationships between the dynamics of balanced and unbalanced structures and the emergent properties of the global network, our study is inductive for several reasons. First, before understanding how the dynamics of balanced and unbalanced structures can aggregate into the industry-wide network, we need to establish statistically whether and to what extent the principles of balance apply to the formation of interorganizational relationships. Second, because dual network structures have not yet been widely studied in interorganizational settings, it is not immediately clear what global network properties would most comprehensively describe them. Finally, formulating concrete predictions about how the micro-level dynamics of tie formation might influence the emergent global network is challenging because it is difficult to anticipate both the complex interdependencies across the behaviors of numerous actors and the resulting aggregation effects. Thus, rather than formulating such

predictions *ex ante*, we follow the recommendations of prior research (Davis, Eisenhardt, & Bingham, 2007) and use agent-based modeling to evaluate the link between the dynamics of relationship formation and the emergent global networks. We discuss the design of the analytic model and its results below.

METHODS

Data

For our empirical analyses, we used data on interorganizational partnerships and on patent infringement and antitrust lawsuits among firms in the global pharmaceutical and biotechnology industry between 1996 and 2006. Networks of interorganizational partnerships offer a rich and representative domain for studying the embeddedness of economic action and have therefore been explored extensively in prior research (e.g., Gulati & Gargiulo, 1999; Kogut & Walker, 2001; Powell et al., 1996; Uzzi, 1996). We obtained partnership data from the MERIT-CATI and BioScan databases. These two databases provide comprehensive coverage of partnerships in biotechnology and pharmaceuticals and have been used extensively in prior studies (e.g., Gomes-Casseres, Hagedoorn, & Jaffe, 2006; Gulati, 1995b; Powell et al., 1996; Rothaermel & Deeds, 2004).

We considered only those partnerships in which at least one of the partners was a biotechnology firm or a pharmaceutical firm, based on its three-digit SIC code or other available description of its business activities. Relying on the description of each partnership in the data, we also ensured that the objectives of the partnerships were broadly related to the firms' core business activities. These criteria produced a population of 2,200 companies. For precision in matching the partnerships to firms, we manually verified each database entry. We then extracted complete patent infringement and antitrust litigation records for the companies from the U.S. Federal District Courts using the Lex Machina and PACER (Public Access to Court Electronic Records)

databases, which are increasingly used in finance, economics, and legal studies (e.g., Haslem, 2005; Lowry & Shu, 2002). All litigation records were collected manually and cross-verified for accuracy. The two databases provided comprehensive coverage of all 93 U.S. Federal District Courts and of our subject companies' litigation records.[7]

In constructing the evolving dual network of collaborative and conflictual relationships, we took steps to ensure that our procedures were consistent with prior research. First, we treated any two firms that formed a partnership or litigated against each other as directly linked through a dyadic collaborative or conflictual tie. If more than two firms had formed a joint partnership or litigated against one another as counterparties in the same lawsuit, they were subdivided into sets of collaborating and litigating dyads; these were then mapped into the network as dyadic ties (Stuart, 1998). Second, we treated ties of patent infringement and antitrust litigation as lasting from the year when the legal complaint was filed in a U.S. Federal District Court until the year it was adjudicated by a district court or, if applicable, an appellate court. Because partnership terminations are rarely reported, we followed prior research and modeled a five-year duration window (e.g., Gulati & Gargiulo, 1999; Kogut, 1988; Lavie & Rosenkopf, 2006; Stuart, 2000). Given the five-year moving window and the fact that our partnership data began in 1996, we modeled the evolution of the dual network in one-year increments from 2000 to 2006. In a given year, a typical network comprised 1,826 collaborative ties and 332 conflictual ties among 1,074 firms. An average firm in this network held 3.4 ongoing collaborative and 0.6 ongoing conflictual ties.

We constructed the full risk set over all potential and realized collaborative and conflictual ties in the population of firms. To account for firms' unobserved heterogeneity in forming new

[7] Patent infringement lawsuits are generally filed in the U.S. Federal District Courts, and our data provide complete coverage of this litigation. Antitrust lawsuits, by contrast, can be brought in either federal or state courts. Since there is no systematic way of aggregating antitrust records across all state courts, our data include only those antitrust lawsuits that were filed in the U.S. Federal District Courts.

relationships, the full risk for a given year included those firms that either already had an ongoing relationship of any kind or had formed at least one new relationship in that year. After eliminating observations that had missing data, we retained a total of 760,250 dyad-years in the sample. As in many other network studies, the formation of a collaborative or conflictual tie was a rare event: In our sample, only 1,318 of the year-dyads registered at least one newly formed collaborative or conflictual relationship.

Statistical Analysis of Network Dynamics

A common issue in network studies is the nonindependence of observations, which can produce a downward bias in estimating standard errors. To address this issue, we used a three-pronged methodological approach. First, instead of running our analyses on the full risk-set of all dyads, we created a matched sample in which the 1,318 materialized relationships were randomly matched with the nonmaterialized relationships using a 1:5 ratio.[8] (For a similar approach, see Jensen, 2003; Sorenson & Stuart, 2001.) The resulting subsample consisted of 7,908 year-dyads. In the full risk set, an average firm would enter the sample 172 times in a given year; in the matched sample, this rate fell to about three times per year. We subsequently utilized the rare-events logit estimation approach. This approach provided for an unbiased estimation of the coefficients by accounting for the rate at which the collaborative and conflictual ties would form in the population as opposed to the matched sample (King & Zeng, 2001).

Second, following Lincoln (1984), we modeled a dyad-level autocorrelation process to account for the dependencies stemming from the presence of a common actor across multiple dyads. To this end, we specified the following variable: $\boldsymbol{y}_{ij,t+1} = \boldsymbol{\rho W}^{ij}_{kl}\boldsymbol{y}_{kl,t} + \boldsymbol{x\beta} + \boldsymbol{\varepsilon}$, where W^{ij}_{kl} is the vector of dependencies between dyad *ij* and all other dyads in the network, such that $W^{ij}_{kl} = 1$ if

[8] The ratio of 1:5 is considered to optimize the efficiency of estimation (King & Zeng, 2001). Using alternative ratios of 1:3, 1:7, and 1:10 produced similar results.

$k = i,j$ or if $l = i,j$, and 0 otherwise; and $\boldsymbol{y}_{kl}$ is the corresponding lagged dependent action of dyad *kl* (see also Marsden & Friedkin, 1993). This approach has been shown to be effective in accounting for common-actor dependencies across dyadic observations and in producing accurate estimates of the variables of substantive interest (e.g., Baum et al., 2005; Gulati, Sytch, & Tatarynowicz, 2012). To account for the formation of collaborative and conflictual relationships, we modeled two separate forms of network autocorrelation: *Network Autcorrelation Collaboration*, for which the lagged dependent action was $\boldsymbol{y}_{kl,t} = 1$ if dyad *kl* formed a new partnership in year *t*, and 0 otherwise; and *Network Autcorrelation Conflict*, for which the lagged dependent action was $\boldsymbol{y}_{kl,t} = 1$ if firms *k* and *l* initiated a new lawsuit in year *t*, and 0 otherwise.

Third, we conducted a computational analysis of the formation of balanced and unbalanced dyads and triads in our data. This analysis complemented the rare-events logit model in two ways. First, to evaluate the *expected* rate of formation of a given type of dyad or triad from year *t* to *t+1*, we simulated a random network with the same size and degree distribution as the observed network in year *t+1* (Szell et al., 2010). Replicating the size and degree distribution of the real network helped us account for a variety of unobserved factors that could affect firms' propensity to enter into collaborative and conflictual ties with one another. Second, by utilizing a large number of random realizations of the dual network, we also provided an alternative solution to the issue of dyadic interdependence in our data (Krackhardt, 1988).[9]

Specifically, to randomize the network in year *t+1*, we applied the *configuration model* (Newman, Strogatz, & Watts, 2001). In this model, the collaborative and conflictual ties were

[9] Longitudinal network data can also be analyzed statistically using the stochastic actor-oriented models for network dynamics implemented in SIENA (Snijders, Van de Bunt, & Steglich, 2010). This approach, however, turned out to be less tractable in our case for a number of reasons. First, while SIENA is best suited to analyzing actor-level predictors of relationship formation, our focus was on modeling the formation of a new collaborative or conflictual relationship as a dyad-level outcome. Second, while the actor-centric models in SIENA require distinguishing between outgoing and incoming ties, due to the nature of our data we were unable to make such a distinction empirically (see also footnote 9). Finally, estimating a co-evolutionary SIENA model using a dual network of our size proved to be technically challenging, due to the limited capacity of SIENA in handling large dual networks.

distributed randomly across firms while accounting for firms' centralities in the collaborative and conflictual segments of the observed network, respectively. Formally, the probability of receiving a particular type of tie for any pair of firms *i* and *j* was equal to $Pk_ik_j / (2m-1)$. Depending on whether this rule was used to estimate the likelihood of a collaborative or conflictual tie between *i* and *j*, *P* reflected the observed fraction of collaborative ties (85%) or conflictual ties (15%) in the data, respectively. Correspondingly, k_i and k_j denoted the observed centralities of firms *i* and *j* in the collaborative or conflictual segment, and *m* denoted the total number of ties in the given segment and year. To mitigate the stochastic variation of the random network baseline, we applied the configuration model 1,000 times.

In our analysis, we first estimated the actual rate of formation of a given type of dyad or triad in the observed network from year *t* to *t+1*, and then compared it with the average *expected* rate of formation of the same type of dyad or triad measured across all 1,000 random cases. We decomposed more complex triads—those with overlapping collaborative or conflictual ties— into more basic, uniplex triads (see figures 2a-2c and 3a-3c), and counted the latter separately. Dyad formation was defined as the process by which an existing connected dyad (i.e., one with an ongoing collaborative or conflictual tie in year *t*) would form a new collaborative or conflictual tie in year *t+1*. Triad formation, in turn, involved a situation where an existing open triad (i.e., one comprising two, rather than three, ongoing ties in year *t*) would be closed by a new collaborative or conflictual tie in year *t+1*. We compared the counts of such dyads and triads across the real and random cases statistically using z-scores (Szell et al., 2010). For any type of dyad or triad, $z = [N_{D/T} - E(N_{D/T})] / \sigma_{D/T}$, where $N_{D/T}$ was the observed count of that specific dyad or triad in the real network, $E(N_{D/T})$ was its average *expected* count, and $\sigma_{D/T}$ was the standard deviation from $E(N_{D/T})$ measured across all 1,000 realizations of the random network in year *t+1*.

Measures

Dependent and Independent Variables

To measure firms' tendencies to enter into a collaborative or conflictual relationship in a given dyad *ij*, we used binary measures for conflict and collaboration. These variables took on 1 if firms *i* and *j* had entered into at least one partnership or initiated at least one lawsuit against each other in year $t+1$, and 0 otherwise.[10] This binary specification and the rare-events logit model enabled us to empirically estimate the likelihood of future collaboration (p_{coll}) or conflict (p_{conf}) for a given dyad. The residual probabilistic outcome ($1-p_{coll}-p_{conf}$) is the likelihood of no tie forming in the dyad. Modeling the emergence of collaboration and conflict in the same dyad allowed us to evaluate the formation likelihoods for the entire range of balanced and unbalanced structures, since they do not have to be mutually exclusive in sparse networks and those networks that have concurrent relationships of conflict and collaboration in the same dyad.

To test Hypotheses 1a and 1b regarding the effects of relationship perpetuation and crowding out, for each dyad *ij* we modeled the *Number of Current Collaborative Ties* as the number of joint partnerships firms *i* and *j* held in year *t*. Similarly, we modeled the *Number of Current Conflictual Ties* as the number of active patent infringement and antitrust lawsuits between firms *i* and *j* in year *t*. To test Hypotheses 2a-2c and 3a-3c regarding the formation of balanced and unbalanced triads, respectively, among firms, we used the following three predictors: (1) *Number of Collaborative Third Parties*, which indicated the count of third parties to which

[10] An alternative network-analytic approach is to consider litigation relationships as asymmetric network ties, treating plaintiffs as the initiators and defendants as the targets of conflict. In the context of patent infringement and antitrust litigation, however, it is difficult to make these assumptions. First, in both instances, legal action can follow an aggressive maneuver by the infringer, who has a reasonable expectation of legal recourse. Thus, the parties' roles with respect to initiating conflict can reverse, such that the infringer rather than the patentee becomes the initiator of the conflictual relationship. Second, in some infringement cases, the alleged infringer takes the case to court by demanding declaratory relief. Such action is typically possible only after receiving a credible threat from the patentee in the form of a "cease and desist" letter or an invitation to license. In this case, both parties can be viewed as initiators of the legal action, which again makes it difficult to operationalize lawsuits as asymmetric ties.

firms *i* and *j* were both linked through collaborative relationships in year *t*; (2) *Number of Conflictual Third Parties*, which indicated the count of third parties to which firms *i* and *j* were both linked through conflictual relationships in year *t*; and (3) *Number of Mixed Third Parties*, which indicated the count of third parties to which firms *i* and *j* were linked through relationships of different types (i.e., a collaborative tie for *i* and a conflictual tie for *j*, or vice versa). We subsequently logged all count variables to mitigate their skewed distribution across firms. Since in this network the relationships of collaboration and conflict could overlap within the same dyads, this design allowed us to decompose the complex structure of the multiplex triads into more basic, uniplex triads, and to analyze their additive effects.

Control Variables

To ensure the robustness of our results, we controlled for the focal firm's and the partner's *Assets* and *Long-Term Debt*, measured in thousands of U.S. dollars and logged to mitigate skewness. We also controlled for each firm's *Profit* using the ratio of EBITD to sales. The variable *Number of Patents* controlled for each firm's patent stock, measured as the count of its successful patent applications filed before year *t*. *Joint Patent Citations*, in turn, measured the technological proximity of firms *i* and *j* as the extent to which they had cited each other's patents. Specifically, the measure was defined as the sum of *j*'s patents cited by *i*'s patents and *i*'s patents cited by *j*'s patents, relative to the number of all patents cited by the patents that firms *i* and *j* owned in year *t*. This measure allows us to control for the competitive proximity of the two companies in the market space. All patent measures were logged to reduce skewness.

We also controlled for the baseline propensity of both firms to engage in collaborative and conflictual relationships using logged measures of *Collaboration Experience* and *Conflict Experience*, respectively. These measures captured the numbers of each firm's unique collaborators and unique adversaries from the beginning of the observation period until *t-1*. At the

dyad level, we also controlled for the logged *Number of Past Collaborative Ties* and *Number of Past Conflictual Ties* between the two firms from the beginning of the observation period until *t-1*, excluding current relationships. The logic behind these controls is that the imprint of past relationships can shape subsequent relationships beyond the firms' current interactions. All the models included year fixed effects.

RESULTS

The Dynamics of Dyads and Triads

Table 1 displays the means, standard deviations, and bivariate correlations for all our predictors and control variables. Table 2 reports the results of our statistical analyses. Across all our models, the condition indices remained low, thus indicating that multicollinearity did not pose any significant threat to estimation (Belsey, Kuh, & Welsch, 1980). In Models 1-6 (table 2), we estimated the binary outcomes of collaboration and conflict using rare-events logit models. The results in Models 1 and 2 support Hypotheses 1a and 1b. We find, first, that two firms maintaining a collaborative or conflictual relationship with each other are more likely to perpetuate the same type of relationship in the future. In other words, conditional on the presence of a collaborative tie in the dyad, the likelihood of a future collaborative tie goes up. Similarly, conditional on the presence of a conflictual tie in the dyad, the likelihood of a future conflictual tie increases. Specifically, a one-standard-deviation increase in the number of current collaborative relationships between two firms increases the probability of a new collaborative relationship between both firms in the following year by 27.1% (Model 1). Similarly, a one-standard-deviation increase in the number of current conflictual relationships between two firms increases the likelihood of a new conflictual relationship between them in the following year by 14.9% (Model 2).

Insert Tables 1 & 2 about here

Our statistical evidence also confirms that current conflictual relationships between firms crowd out future collaboration: a one-standard-deviation increase in the number of conflictual relationships between two firms reduces the probability that they will form a collaborative relationship in the future by 10.5% (Model 1). Furthermore, in Model 2, a one-standard deviation increase in the number of current collaborative ties reduces the probability that the firms will initiate a conflictual relationship in the subsequent year by 13.9%.

In Models 3 and 4, we explicitly accounted for the presence of current multiplex relationships. One possibility is that, in multiplex ties, current conflict may have a particularly pronounced effect in terms of perpetuating future conflict and crowding out future collaboration. Extant work suggests that while legal action is less likely to occur between relationally close principals (Black, 1976: 40-48), when such conflict does occur, it is likely to be particularly acute. For example, Uzzi (1997: 59) notes that escalating conflict among relationally close actors can engender a breach of trust and be akin to vendettas and feuds. Similarly, experimental evidence indicates that defections from established collaborative ties often have a more negative emotional and interpersonal impact, compared to one-shot games (Bottom et al., 2002). We find that the interaction between the *Number of Current Collaborative Ties* and the *Number of Current Conflictual Ties* has no effect on whether two firms will form a new collaborative or a new conflictual tie. These results thus suggest that the additive model of current collaborative and current conflictual ties adequately reflects the dynamics of new relationship formation.

In Models 5 and 6, we tested Hypotheses 2a-2c and 3a-3c, which predicted the formation of balanced and unbalanced triads. Our findings do not support Hypotheses 2a-2c. Specifically, Model 5 indicates that the number of third parties to which both firms are connected through collaborative ties, as well as the number of third parties to which they are connected through conflictual ties, has no effect on the formation of a collaborative relationship between the firms.

Similarly, Model 6 suggests that the number of third parties to which the firms are linked through ties of different types has no effect on the formation of a new conflictual relationship. In sum, our statistical results do not support the prediction of a pull toward balanced triads as a driving force behind new interorganizational relationships.

The results do confirm, however, our predictions regarding the strong pull away from unbalanced triads (Hypotheses 3a-3c). A one-standard-deviation increase in the number of third parties to which both firms are tied through relationships of different types reduces the likelihood of a new collaborative tie between the firms by 9.8 percent (Model 5). Similarly, a one-standard-deviation increase in the number of third parties to which the firms are tied through either collaborative or conflictual relationships reduces the likelihood of a conflictual tie between the firms by 16.3 percent and 15.8 percent, respectively (Model 6).

Our computational analyses provided consistent results. Specifically, we found (i) a stronger-than-expected perpetuation of collaborative ties ($z=13.73$, $p<0.001$) and conflictual ties ($z=28.61$, $p<0.001$), as well as (ii) a stronger-than-expected crowding out of future conflictual ties by current collaboration ($z=-2.19$, $p<0.1$) and also of future collaborative ties by current conflict ($z=-3.92$, $p<0.001$). In addition, we found a weaker-than-expected formation of unbalanced triads. This effect was supported with respect to (i) an open triad with two existing asymmetric ties being closed by a newly formed collaborative tie ($z=-8.06$, $p<0.001$), or (ii) an open triad with two existing collaborative ties being closed by a future conflictual tie ($z=-3.36$, $p<0.001$). The occurrence of an all-conflictual unbalanced triad was statistically indistinguishable from the random case.[11]

[11] This result is partly explained by the overall sparseness of the conflictual network segment (where k = 0.6), which makes encountering such triads either in real life or in a random network very unlikely. Consequently, the comparisons across both cases are likely to be accompanied by a high degree of statistical error.

Taken together, these results point to three conclusions. First, firms tend to form balanced dyadic structures by perpetuating both collaborative and conflictual relationships. Second, the dynamics by which conflict and collaboration crowd each other out reduce firms' propensity to create unbalanced dyadic structures of ongoing collaboration and conflict. Third, although network dynamics are not driven by the pull toward balanced triadic structures, they are characterized by the pull away from unbalanced triads.

The Emergent Properties of the Global Interorganizational Network

In the final set of analyses, we explored to what extent the observed micro-level dynamics of relationship formation could account for the properties of the global, industry-wide network. Qualitative examinations of the network map in figure 4 suggest that the global network is separated to a significant degree into two distinct collaborative and conflictual segments of firms. The dense collaborative segment is visible on the left side of the network map, while a dense conflictual segment is separated from it and is located on the right side of the map.

To assess this salient feature of the global network analytically, we used a statistical index of network segregation, defined as $S = \rho(i \in G_1, i \in G_2)$. This index captured the correlation between firms' participation in the collaborative segment (G_1) and the conflictual segment (G_2) of the dual network at the same time. Specifically, $i \in G_1$ was defined as 1 if firm *i* participated in the collaborative segment, and 0 otherwise. Similarly, $i \in G_2$ was defined as 1 if *i* participated in the conflictual segment, and 0 otherwise. The value of $S = -1$ would indicate a highly segregated network that consists of two completely nonoverlapping collaborative and conflictual segments, while $S = 1$ describes a uniformly mixed network in which every firm participates in both networks simultaneously. The average segregation of the real network over time was $S = -0.520$,

confirming the presence of two distinct segments of firms engaged in either collaborative or conflictual relationships with one another.

Insert Figure 4 about here

Our expectation was that the degree of network segregation could be closely related to the coevolutionary dynamics of conflict and collaboration, representing an aggregate product of the empirically established dyad- and triad-level formation dynamics. The dyadic processes of relationship perpetuation and crowding out could lead firms to stick to their pre-existing relational trajectories in dyads, while reducing their likelihood of mixing collaborative and conflictual ties in any given dyad. These processes could thus jointly aggregate across dyads to produce the segregated structure of the global network. By the same token, the empirically confirmed triadic processes of pulling away from unbalanced triads in Figures 3a and 3b could be also expected to reduce the mixing of firms across the segments of collaboration and conflict. Due to these dynamics, firms with collaborative ties in a triad would be less likely to add a conflictual tie to actors in that triad and vice versa.

Notwithstanding these relationships, it was hard to predict exactly how these micro-level processes would aggregate across multiple dyads and triads to shape the segregation of the global network. For example, it was possible that some firms could organize their collaborative and conflictual interactions across different dyads and triads, thus participating in both segments of the network simultaneously. To examine the cumulative effects of dyadic and triadic processes of network formation, we therefore followed prior research (Davis et al., 2007) and utilized an agent-based simulation model. (For a technical discussion of the model, see the online appendix.)

The agent-based model incorporated the entire set of dyadic and triadic processes of network formation that had received empirical support in our earlier statistical analyses.

Specifically, we modeled both sets of the statistically significant effects of relationship perpetuation and crowding out (H1a-H1b), as well as the statistically significant effect of the pull away from unbalanced triads (H3a-H3c). To ensure further concordance with the empirical reality, we modeled a range of other network parameters using their real values averaged across our seven-year period. Those included network size ($N = 1{,}000$), the mean number of ties per firm ($k = 4.0$), and the random fraction of firms forming and dissolving ties in each period (estimated at 20%). To produce the initial network, we applied the *configuration model* which assigned the collaborative and conflictual ties randomly to firms while approximating their actual distributions (Newman et al., 2001). To maintain our focus on the formation, rather than the stability, of balanced and unbalanced structures, past ties dissolved at random. Finally, to mitigate the effects of change in key network parameters, we ensured that the size, density, and degree distribution of the simulated network would remain constant over time (see also pp. 1-2 in the Online Appendix available at ftp://research.3utilities.com/dualnets).

We applied this abstract model to test a number of different scenarios for network formation (see Table 3 in the online appendix). Our first scenario (Test 1) used the empirically estimated levels of relationship perpetuation, crowding out, and pull away from unbalanced triads to replicate the dynamics of the observed network. The remaining seven scenarios (Tests 2-8), in contrast, tested a range of alternative scenarios by using other parameter values. Our expectation was that Test 1 would more closely reproduce the segregation of the real network, and thus provide a better fit to the data, than Tests 2-8. We ran each simulation for 1,000 time steps and repeated each test 1,000 times to mitigate the stochastic variability and to ensure stable outcomes (Baum, Cowan, & Jonard, 2010). To compare the results of the simulations with the empirical results on network segregation, we conducted a series of statistical tests utilizing standard z-scores. Formally, $z = [S - E(S)] / \sigma$, where $E(S)$ denotes the average segregation of the simulated

network, and σ is the standard deviation from $E(S)$ measured across all the simulation runs for a given test.

As expected, Test 1 provides the best fit to the data [$E(S) = -0.507;\ z = -0.359$]. Furthermore, Test 2, in which we modeled a significantly weaker pull away from unbalanced triads than in Test 1, also provides a good fit [$E(S) = -0.506;\ z = -0.403$]. These consistent results suggest that the dyadic processes of relationship perpetuation and crowding out are more consequential for the segregation of the global network than is the pull away from unbalanced triads. By contrast, the remaining six tests all produce statistically different, and lower, scores [$-0.015 \leq E(S) \leq 0.053$]. Taken together, these results support our claim that balanced and unbalanced dyadic structures play a key role in shaping the segregation of the global, industry-wide network.[12]

Robustness Tests and Supplementary Analyses

To validate our statistical results, we performed a series of additional tests. First, we explored the possibility that the crowding out of collaborative and conflictual relationships could be driven by a small group of firms initiating only conflictual relationships with other firms. Although "patent trolls" are extremely rare in biotechnology and pharmaceuticals, some companies could nevertheless be classified as aggressive litigators. To test the validity of this alternative explanation, we eliminated from the sample all those firms that had entered exclusively into conflictual relationships over the entire observation period. We then reestimated our statistical models and found that the results remained unchanged. Second, our short observation period and limited variance within dyads prevented us from modeling fixed effects at the dyad level.

[12] See the Online Appendix (ftp://research.3utilities.com/dualnets) for a detailed discussion of the agent-based model, its input parameters, results across the alternative scenarios of network formation, and the tests measuring sensitivity to various starting conditions and parameters.

Nonetheless, we reestimated our logit models using dyad-level random effects and found that the results also remained consistent.

In addition, we conducted a series of supplementary analyses to test more precisely the theoretical mechanisms that could explain the formation of balanced and unbalanced structures in the interorganizational setting. These mechanisms included (i) the potential role of cognitive alignment and tensions among executives in facilitating interorganizational collaboration and conflict, respectively; (ii) the intervention by the third party; and (iii) the dynamics of coalition formation. First, we anticipated that if the cognitive mechanisms cited in (i) played any role in our data, their effects would be weaker for larger firms. This is because in a larger firm with a more complex organizational structure, the control of interorganizational relationships is likely to be distributed across a greater number of units; since this would dilute the common locus of executive attention, we would also expect it to reduce the role of cognitive alignment and tensions. In line with this expectation, we found that for larger companies in a dyadic relationship, the effects of perpetuating collaborative and conflictual ties were attenuated. This finding, in turn, is consistent with the role of cognitive forces in driving the formation of balanced dyads among organizations.

Second, our theoretical argument suggested that a third party with asymmetric ties to two firms might act as *tertius gaudens* and actively keep both firms apart (Simmel, 1950:154-162). Depending on the extent to which the third party is connected to one of the alters by a strong collaborative tie, the way that this mechanism could manifest empirically would be by providing the third party with a wider channel of influence over that alter and thereby making it more susceptible to the third party's influence (e.g., Rogers, 2003). A strong tie and the concomitant wider channel of exchange with a collaborator could simultaneously make the third party more vulnerable to the formation of a collaborative tie between the collaborator and the adversary, since

sensitive information might leak to the adversary. This circumstance could in turn provide the third party with a stronger incentive to intervene to preclude the formation of such a tie.

To test this argument about a third party acting as a *tertius gaudens*, we used a weighted count of third parties in asymmetric triads, adjusting the collaborative tie by either (i) the duration of the partnership in years, or (ii) the strength of the partnership as measured by Contractor & Lorange's (1988: 6) scale of organizational interdependence (see also Nohria & Garcia-Pont, 1991: 117). Our findings indicated that accounting for the possible influence of a third party resulted in a statistical effect of up to 15% stronger, in terms of explaining the *reduced* likelihood of a collaborative relationship forming between two firms. Interestingly, we also found that this effect extends beyond pure coercion by the third party: when we adjusted for the degree of influence stemming from the power of the third party relative to the alter (using either relative substitutability of exchange partners or differences in company size), this produced significant effects in the expected direction, but these effects weakened. We conclude from this that the third party plays a more complex role, which cannot be explained by power advantage alone but may also be driven by the alter's susceptibility to influence and commitment to the third party. Taken together, these results advance the influential discussion of two-step leverage in social structures (Gargiulo, 1993). Although actors might be inclined to pursue indirect cooptation of an adversary by forming two-step collaborative ties to that adversary, the adversary's active *tertius gaudens* role and the cognitive tensions permeating unbalanced triads could emerge as significant constraints when forming these structures.

Third, even though our results did not support Hypothesis 2c (which predicted that two firms sharing a common adversary could be pulled towards a joint collaborative relationship), we conducted additional tests to explore the potential role of coalition formation in this process. Our intuition was that such dynamics would be more likely to exist between those firms that not only

faced a common adversary but also occupied close positions in the technological or social space. This intuition rested on the argument that coalitions often form as a response to a common threat (Simmel, 1955), and that technological or social proximity can accentuate the perceived commonality of the threat. To test the validity of this argument, we interacted the count of conflictual ties to the same third party with (i) the firms' overlapping patent citations, measured as the degree to which both firms cited the same patents (e.g., Stuart & Podolny, 1996), and (ii) the firms' structural equivalence (Burt, 1987), measured as the degree to which both firms connected to the same collaborators. None of these additional variables produced a significant positive effect on the likelihood of a new collaborative tie between both firms, thus providing no support for the role of coalition formation in this context.

Finally, our research design relied on an additive approach to modeling the formation of triads, in that we decomposed more complex, overlapping structures into sets of basic triadic configurations. These configurations involved (i) two alters with collaborative ties to the same third party, (ii) two alters with conflictual ties to the same third party, or (iii) two alters with asymmetric ties to the same third party. In additional analyses, we also experimented with a range of alternative designs by including a set of two-way interactions as well as a three-way interaction across the different configurations of ties between the alters and the third party. These multiplicative models failed to produce a better fit to the data, indicating that the additive model provided an adequate description of the dynamics of collaboration and conflict in our setting.

DISCUSSION

This study is among the first to examine the co-evolutionary dynamics of collaboration and conflict in an interorganizational system. It has produced three key findings. First, our results document the formation dynamics of balanced dyadic structures, where current collaboration or conflict between two companies and the accompanying relational dynamics promote new

relationships of the same type. In contrast, we find that unbalanced dyads, which involve multiplex relationships of ongoing collaboration and conflict, are significantly less likely to form. This is because collaboration and conflict tend to crowd each other out. Our theory proposed that interorganizational partnerships and the social fabric they create diminish the likelihood and severity of subsequent disputes, while also offering channels for extralegal reconciliation. These factors effectively lower the prospects of future legal confrontation. In a parallel fashion, the disruptions to the social fabric and the relational animosity that litigation introduces among organizational agents diminish the likelihood of future interorganizational partnerships.

Second, we find that network dynamics are characterized not by a pull toward balanced triadic structures, but rather by a pull away from unbalanced structures. One interesting implication is that while the relationships to, and interventions of, a third party may not always result in alters' entering into a collaborative or conflictual relationship, they can be sufficient to disrupt the formation of such a relationship. Furthermore, avoiding unbalanced structures is consistent with the previously described tendency among social actors to systematically overweight negative information (e.g., Skowronski & Carlston, 1989).

Finally, our results indicate that the dyadic and triadic processes of relationship formation among firms aggregate in significant ways to shape some of the key properties of the industry-wide network. Specifically, we find that the formation of balanced dyads and the pull away from unbalanced dyads can drive the emergence of a segregated global network with two distinct segments: a collaborative one and a conflictual one.

Taken together, these findings lead us to extend and reconfigure existing theories of action. Fundamentally, our results indicate that collaborative and conflictual relationships may be interdependent in determining the nature of subsequent interorganizational interaction. This study thus suggests that the relationships of collaboration and conflict, which can be viewed as the most

salient dimensions of relational pluralism, are most accurately conceived not as two separate elements of social structure but rather as key elements of a single social space.

This study makes several additional contributions. First, it demonstrates that theories exploring the link between structural action in networks and network genesis and dynamics (Gulati & Gargiulo, 1999; Gulati, Sytch, & Tatarynowicz, 2012; Shipilov & Li, 2011; Zaheer & Soda, 2009) can be advanced to account for the co-evolutionary dynamics of collaboration and conflict. Moreover, we have shown that these dynamics are influential in shaping the emergent features of the global network architecture. For example, we conceptualize and offer evidence of a link between the low occurrence of multiplex relationships in interorganizational networks and the segregation of these networks into distinct structural regions. This finding indicates that identifying global network properties can, and arguably should, incorporate relationships of both collaboration and conflict.

Our second contribution relates to the rich body of research on how the characteristics of social structures affect actors' behaviors and outcomes, as well as the collective dynamics of social systems. Gaps in the connectivity of collaborative social structures have been used to build theories of private advantage (e.g., Burt, 1992; McEvily & Zaheer, 1999) and to understand the rate at which new knowledge and resources diffuse through the broader social space (e.g., Abrahamson & Rosenkopf, 1997; Greve, 2009). In these lines of research, scholars have often made assumptions about the origins of structural gaps (Salancik, 1995) by relating the absence of connectivity to a possible lack of interest in collaboration, lack of awareness of potential partners, or limited opportunities to collaborate. In contrast, our findings indicate that the absence of connectivity in the collaborative space could mask a full-fledged conflictual relationship between the actors.

Building on these results, future research could conceivably differentiate between the brokerage positions held by a mediator between two conflicting parties and the position of spanning two unconnected parties. The *tertius gaudens* role identified by Simmel (1950:154-162), for example, is based on the explicit assumption of an emerging or existing conflict between two bridged parties. The starting point of the classic brokerage perspective, in contrast, is that competition for the benefits of social relationships can result in tension between the competing actors (Burt, 1992: 5-6). Differentiating these positions more clearly can illuminate the mechanisms by which a third party can claim the broker advantage.

An additional benefit of applying the dual-network perspective is that it helps us understand collective dynamics in organizational fields more comprehensively (Davis & Greve, 1997; Westphal, Gulati, & Shortell, 1997). For example, networks in many individual and organizational settings have been found to take on small-world properties, typified by cohesive, collaborative communities of actors linked into a global network architecture by sparse collaborative bridging relationships. Our findings allow us to conjecture that, in some cases, otherwise cohesive communities of collaborators may be separated by conflictual relationships. The small-world topology, when conceptualized in terms of exclusively collaborative relationships, has been theorized to be particularly conducive to free flows of knowledge and resources. However, considering the boundaries of network communities through the lens of relational conflict and enmity can improve our understanding of how knowledge and resources flow *across* network communities in a small-world system, which can in turn affect a range of individual and collective outcomes.

Finally, this study suggests several extensions to the original formulation of balance theory. The first is related to expanding the theoretical scope of balance theory to include not just the stability of social structures, but also their formation. Thus far, balance theory has been applied

to understand the stability of structures without first recognizing where these structures originate. The second involves extending balance theory to understand the formation of balanced and unbalanced structures in interorganizational settings. While this study offers some evidence for the role that cognitive alignment and tensions among organizational agents play in explaining the formation of balanced and unbalanced structures, these dynamics in interorganizational settings could not be linked to the role of cognitive dissonance only.

One of the more promising extensions would be to recognize and carefully evaluate the role of a common third party in the formation of triadic structures. For example, this study provides evidence that in some situations, common third parties could play an active role in keeping the alters away from forming a collaborative relationship. This is in stark contrast to the original balance theory, which did not explicitly distinguish between the third party as an object or as an actor, thus bypassing its possible agency (Heider, 1946). Thus, a triad in which two actors like the same book and do not get along would be equivalent in balance terms to a triad in which two actors like the same person but do not get along.

Future research could also extend the work reported here on how the micro-dynamics of collaboration and conflict in social systems aggregate to shape the emergent properties of the global network. First, future studies could investigate the effects of the dyadic and triadic processes of tie formation on a broader set of global network properties beyond network segregation. Our focus on this single global network property leaves open a wide range of questions regarding the impact of these processes on other network properties, such as the network's small-world property or its core-periphery structure. Second, subsequent research could extend our evolutionary model of a dual network by exploring not only the micro-to-macro link, but also the possibility of a reciprocal link from the characteristics of the global system or the firms' institutional environment to the micro-dynamics of tie formation. For example, the

landmark decision by the United States Supreme Court in *Medimmune, Inc. v. Genentech, Inc., 549 U.S. 118 (2007)* created a more favorable legal climate for the licensees to try to invalidate the licensors' patents covering the licensed product. It is possible that these legal changes could lead to the licensees' behaving more aggressively in terms of managing the overlaps between their products and the licensed intellectual property. If these dynamics would then stimulate the licensors to sue their licensees more frequently for patent infringement, the result might be a significant reduction in the degree to which collaboration crowds out conflict in the network.

One limitation of this study is that we are unable to evaluate directly just how generalizable our findings will be to a broader range of social systems. Focusing on the extreme forms of firms' legal conflicts over patent infringement and antitrust issues allowed us to discretely separate interorganizational conflict from collaboration in this study. In addition, interorganizational conflict in this setting is often emotionally charged, can be highly consequential for both parties, and entails a common locus of managerial control with collaborative relationships. Yet the features of interorganizational conflict will unquestionably vary across different empirical settings, and it remains to be seen how these variations can affect the dynamics documented in this study. Future work could also extend our theory to a broader spectrum of relationships, where conflict and collaboration might prove to be more closely intertwined, at least over a short period of time. Such relationships could, for example, characterize the early stages of the interactions between venture capital firms and target companies, or the interactions between acquirers and acquisition targets in hostile takeovers (Walsh, 1989). In these situations, conflict over purging the managerial ranks of the target company could paradoxically stem from, and be closely related to, the original desire to create an effective collaborative relationship.

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Tables and Figures

Table 1. Descriptive statistics and correlation matrix.

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
DV1	*Collaboration*	0.125	0.331											
DV2	*Conflict*	0.042	0.202											
1	*Assets Firm 1*	6.777	2.954	-										
2	*Assets Firm 2*	5.823	2.786	0.071	-									
3	*Long Term Debt Firm 1*	3.885	3.416	0.789	0.071	-								
4	*Long Term Debt Firm 2*	2.786	2.999	0.059	0.728	0.054	-							
5	*Profit Firm 1*	-12.471	133.611	0.127	0.011	0.092	0.012	-						
6	*Profit Firm 2*	-12.360	113.234	0.018	0.112	0.012	0.080	0.002	-					
7	*No. of Patents Firm 1*	0.437	1.015	0.155	0.021	0.149	0.009	0.023	0.016	-				
8	*No. of Patents Firm 2*	0.345	0.815	0.020	0.142	0.019	0.124	0.015	0.031	0.167	-			
9	*Joint Patent Citations*	0.009	0.041	0.042	0.024	0.036	-0.003	0.011	-0.004	0.144	0.131	-		
10	*Collab. Experience Firm 1*	1.716	1.288	0.534	0.067	0.522	0.046	0.064	0.021	0.145	0.055	0.035	-	
11	*Collab. Experience Firm 2*	1.184	0.812	0.150	0.299	0.140	0.261	0.027	0.047	0.088	0.110	0.020	0.187	-
12	*Conflict. Experience Firm 1*	0.516	0.881	0.505	0.070	0.502	0.047	0.046	0.018	0.124	0.034	0.009	0.668	0.159
13	*Conflict. Experience Firm 2*	0.286	0.657	0.111	0.352	0.104	0.311	0.021	0.041	0.042	0.042	0.016	0.130	0.393
14	*No. of Past Collab. Ties*	0.002	0.039	0.037	0.020	0.044	0.024	0.004	0.004	-0.010	-0.018	-0.009	0.076	0.068
15	*No. of Past Conflict. Ties*	0.004	0.062	0.073	0.081	0.056	0.091	0.007	0.008	0.014	-0.012	0.027	0.095	0.142
16	*Network Autocorr. Collab.*	1.076	1.085	0.456	0.162	0.437	0.133	0.052	0.033	0.222	0.156	0.017	0.782	0.475
17	*Network Autocorr. Conflict*	0.412	0.710	0.385	0.203	0.371	0.154	0.038	0.041	0.185	0.119	0.005	0.530	0.311
18	*No. of Current Collab. Ties*	0.029	0.166	0.179	0.073	0.185	0.064	0.016	0.014	0.038	0.028	0.015	0.312	0.245
19	*No. of Current Confl. Ties*	0.009	0.085	0.091	0.076	0.091	0.058	0.010	0.011	0.038	0.008	-0.006	0.113	0.061
20	*No. of Collab. Third Parties*	0.178	0.408	0.240	0.151	0.234	0.131	0.029	0.031	0.111	0.056	0.052	0.450	0.522
21	*No. of Confl. Third Parties*	0.028	0.187	0.164	0.160	0.161	0.129	0.014	0.015	0.048	0.008	0.010	0.231	0.261
22	*No. of Mixed Third Parties*	0.062	0.236	0.203	0.153	0.203	0.124	0.024	0.024	0.089	0.051	0.007	0.306	0.297

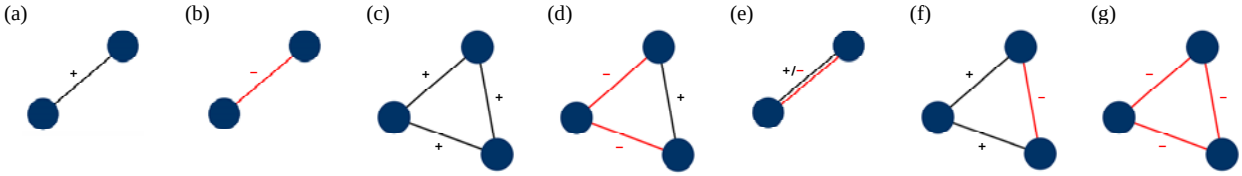
		12	13	14	15	16	17	18	19	20	21	22
12	*Conflict. Experience Firm 1*	-										
13	*Conflict. Experience Firm 2*	0.146	-									
14	*No. of Past Collab. Ties*	0.055	0.042	-								
15	*No. of Past Conflict. Ties*	0.125	0.177	0.037	-							
16	*Network Autocorr. Collab.*	0.554	0.248	0.070	0.109	-						
17	*Network Autocorr. Conflict*	0.704	0.523	0.025	0.102	0.575	-					
18	*No. of Current Collab. Ties*	0.259	0.123	0.191	0.121	0.312	0.221	-				
19	*No. of Current Conflict.Ties*	0.188	0.260	-0.004	0.146	0.113	0.199	0.073	-			
20	*No. of Collab. Third Parties*	0.327	0.241	0.081	0.158	0.451	0.320	0.260	0.076	-		
21	*No. of Confl. Third Parties*	0.295	0.398	0.080	0.217	0.229	0.314	0.187	0.237	0.334	-	
22	*No. of Mixed Third Parties*	0.410	0.453	0.042	0.183	0.313	0.463	0.192	0.232	0.355	0.431	-

Table 2. Rare-events logit models of the formation of new collaborative and conflictual ties by firms.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	Collaboration	*Conflict*	*Collaboration*	*Conflict*	*Collaboration*	*Conflict*
Constant	-11.635***	-9.812***	-11.633***	-9.824***	-11.827***	-10.440***
	(0.335)	(0.396)	(0.334)	(0.399)	(0.351)	(0.449)
Assets Firm 1	0.070*	0.106**	0.071*	0.105**	0.068	0.117***
	(0.041)	(0.042)	(0.041)	(0.043)	(0.042)	(0.045)
Assets Firm 2	-0.084**	0.158***	-0.084**	0.159***	-0.087**	0.160***
	(0.040)	(0.030)	(0.040)	(0.030)	(0.041)	(0.031)
Long Term Debt Firm 1	-0.009	-0.028	-0.011	-0.026	-0.010	-0.064*
	(0.032)	(0.036)	(0.032)	(0.037)	(0.033)	(0.037)
Long Term Debt Firm 2	-0.011	-0.068**	-0.010	-0.069**	-0.017	-0.063**
	(0.034)	(0.030)	(0.034)	(0.030)	(0.034)	(0.030)
Profit Firm 1	0.032	0.866**	0.032	0.860**	0.029	0.792**
	(0.027)	(0.339)	(0.027)	(0.338)	(0.026)	(0.334)
Profit Firm 2	0.001	0.055	0.001	0.057	0.001	0.046
	(0.001)	(0.066)	(0.001)	(0.069)	(0.001)	(0.057)
No. of Patents Firm 1	-0.047	0.033	-0.047	0.045	-0.032	0.063
	(0.033)	(0.042)	(0.033)	(0.043)	(0.033)	(0.043)
No. of Patents Firm 2	0.129***	0.134***	0.127***	0.130***	0.134***	0.143***
	(0.045)	(0.050)	(0.045)	(0.050)	(0.045)	(0.050)
Joint Patent Citations	-3.373	-10.212	-3.294	-10.459	-3.445	-12.645*
	(3.416)	(6.282)	(3.411)	(6.381)	(3.448)	(6.889)
Collab. Experience Firm 1	0.448***	0.090	0.444***	0.065	0.518***	0.335***
	(0.103)	(0.114)	(0.103)	(0.116)	(0.108)	(0.127)
Collab. Experience Firm 2	0.459***	-0.018	0.460***	-0.022	0.566***	0.244**
	(0.081)	(0.093)	(0.082)	(0.095)	(0.099)	(0.124)
Conflict. Experience Firm 1	-0.349***	0.664***	-0.353***	0.645***	-0.294**	1.038***
	(0.120)	(0.126)	(0.121)	(0.127)	(0.120)	(0.137)
Conflict. Experience Firm 2	-0.371***	0.889***	-0.385***	0.871***	-0.263**	1.271***
	(0.122)	(0.120)	(0.124)	(0.124)	(0.128)	(0.136)
No. of Past Collab. Ties	-1.211	2.066**	-1.240	1.816*	-0.741	1.797*
	(1.118)	(0.929)	(1.127)	(0.943)	(1.195)	(0.917)
No. of Past Conflict. Ties	0.177	1.295**	0.145	1.325**	0.410	1.796***
	(0.534)	(0.616)	(0.539)	(0.606)	(0.515)	(0.619)
Network Autocorr. Collab.	1.270***	-0.199	1.276***	-0.183	1.189***	-0.410***
	(0.140)	(0.140)	(0.141)	(0.143)	(0.137)	(0.138)
Network Autocorr. Conflict	0.113	0.068	0.114	0.110	0.144	-0.169
	(0.142)	(0.139)	(0.143)	(0.144)	(0.144)	(0.138)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
No. of Current Collab. Ties	1.446***	-0.895**	1.499***	-0.588*	1.454***	-0.663**
	(0.263)	(0.384)	(0.282)	(0.344)	(0.260)	(0.303)
No. of Current Conflict. Ties	-1.298**	1.636***	-0.798	1.775***	-1.250**	1.775***
	(0.539)	(0.506)	(0.637)	(0.552)	(0.547)	(0.515)
No. of Current Collab. Ties × No. of Current Conflict. Ties			-1.062	-1.488	-	-
			(0.777)	(1.581)		
No. of Collab. Third Parties					-0.136	-0.436**
					(0.143)	(0.209)
No. of Conflict. Third Parties					-0.186	-0.920***
					(0.264)	(0.272)
No. of Mixed Third Parties					-0.438**	-0.403
					(0.220)	(0.259)
Observations	7908	7908	7908	7908	7908	7908

*Robust standard errors in parentheses; Two-tailed tests, ***p<.01, **p<.05, *p<.10*

Figure 1. Balanced (a-d) and unbalanced (e-g) dyadic and triadic structures.



Collaborative ties are marked black, conflictual - blue.

Figure 2. Formation of balanced triads (H2a-H2c).

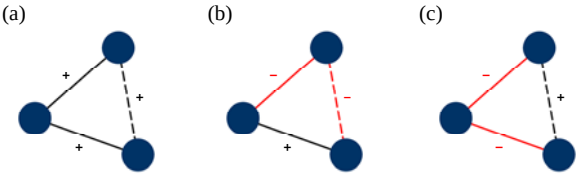
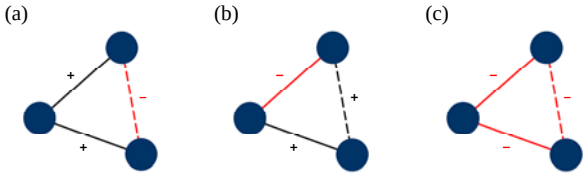
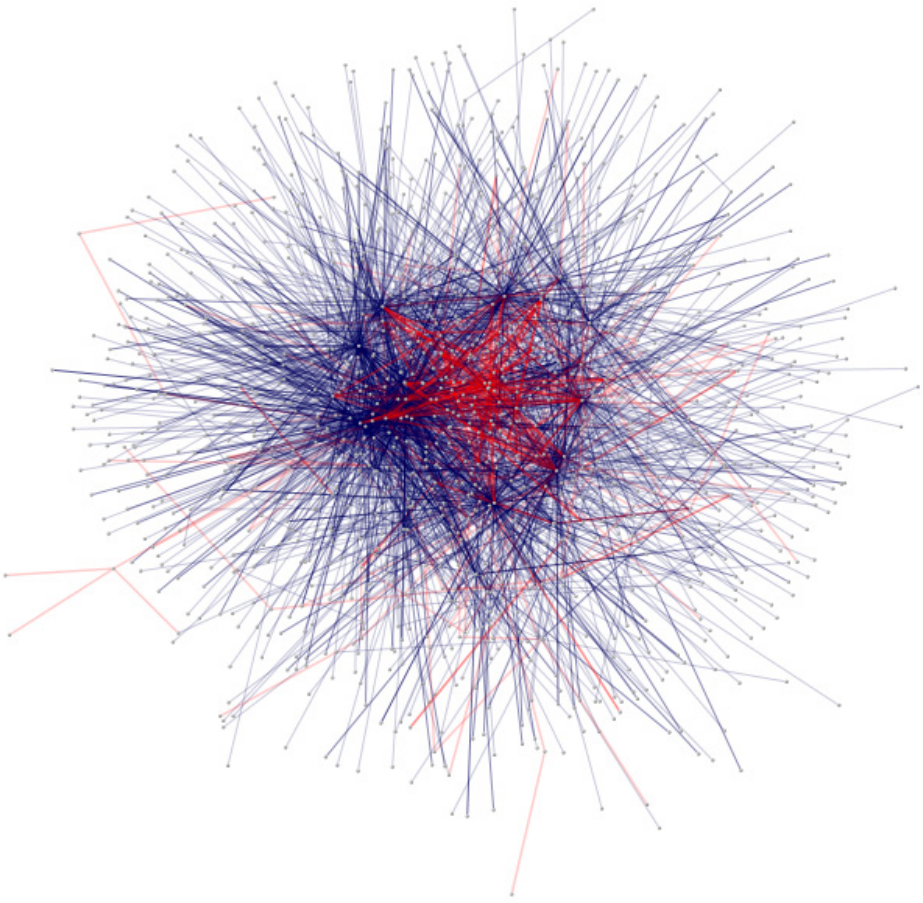


Figure 3. Formation of unbalanced triads (H3a-H3c).



Solid lines mark existing ties, dashed - new ties.

Figure 4. Segregation of the global network into two segments of collaboration (blue) and conflict (red).



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