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The Group Dynamics of Interorganizational Relationships: Collaborating with Multiple Partners in Innovation Ecosystems

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Abstract

This paper examines how organizations collaborate with multiple partners, such as when they develop innovative and complex product platforms like smartphones, servers, and MRI machines that rely on technologies developed by organizations in three or more sectors. Research on multipartner alliances often treats them as a collection of independent dyads, neglecting the possibility of third-party influence and interference in dyads that can inhibit innovation. Using a multiple-case, inductive study of six groups, each composed of three organizations engaged in technology and product development in the computer industry, I examine the collaborative forms and processes that organizations use to innovate with multiple partners in groups. Groups that used the collaborative forms of independent parallel dyads or single unified triads generated mistrust and conflict that stemmed from expectations about third-party participation and overlapping roles and thus had low innovation performance and weaker ties. Other groups avoided these problems by using a dynamic collaboration process that I call ''group cycling,'' in which managers viewed their triad as a small group, decomposed innovative activities into a series of interlinked dyads between different pairs of partners, and managed third-party interests across time. By temporarily restricting participation to pairs, managers chose which ideas, technologies, and resources to incorporate from third parties into single dyads and ensured that the outputs of multiple dyads were combined into a broader innovative whole.

Keywords: collaborative innovation, organizational innovation, alliances, triads, technology, strategy, network forms, product development, research and development, interorganizational relations, conflict and cooperation, supradyadic mechanisms, ecosystems

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One of organization theory's greatest achievements is a detailed understanding of why organizations form relationships with each other and to what ends. In many industries, such as computing and communications, resources are widely distributed, and companies are compelled to form interorganizational relationships to access the resources they need for innovation (Powell, Koput, and Smith-Doerr, 1996; Ahuja, 2000b; Sytch and Tatarynowicz, 2014a). Prominent examples include the alliances Intel and Microsoft used to develop the Wintel platform and gain control of the PC ecosystem (Bresnahan and Greenstein, 1999; Casadesus-Masanell and Yoffie, 2007). Analysts are quick to note, however, that despite some well-publicized examples, few of the collaborations companies attempt actually produce innovations (Ahuja, 2000a; Stuart, 2000; Davis and Eisenhardt, 2011).

Although collaborative arrangements can occur among any number of organizations, collaborative innovation has mostly been studied in alliances between pairs. Many organizational analysts approach these dyadic alliances from the perspective of social embeddedness (Granovetter, 1985), in which partners with a long history of working together are thought to account for greater output than those without such a history (Gulati, 1995b; Uzzi, 1997). The experience and trust gained in prior ties is said to explain whether future ties are likely to be successful (Gulati, 1995a; Zaheer, McEvily, and Perrone, 1998; Rowley, Behrens, and Krackhardt, 2000). This structural explanation is complemented by rich accounts of alliance governance processes that depend on social embeddedness but explain additional variation (Larson, 1992; Gulati, Khanna, and Nohria, 1994; Doz, 1996), such as a rotating leadership process in which organizations alternate control (Davis and Eisenhardt, 2011). Yet while the consensus around dyads has been solidifying, evidence is emerging that leading firms are collaborating with multiple partners to access better resources and innovate more than their rivals (Ozcan and Eisenhardt, 2008; Lavie and Singh, 2012). Apple's joint development efforts with Qualcomm and Broadcom are an important example, as they produced complex video components that enabled Apple to release the iPhone (Lashinsky, 2012). That period, roughly the 2000s, saw an explosion of collaborative activity and broader, multipartner "ecosystems," which scholarship is only beginning to explore (Adner and Kapoor, 2009; West and Wood, 2013; Bresnahan, Yin, and Davis, 2015).

Some scholars have attempted to extend embeddedness thinking to larger multipartner arrangements by treating these relationships as a portfolio of independent dyads (Khanna and Rivkin, 2006; Ozcan and Eisenhardt, 2008; Lavie and Singh, 2012). This assumes that the social benefits of multiple strong dyadic ties aggregate to a multipartner level of analysis. Some evidence supports this view: for example, dyadic relationships often precede triadic alliances (Nohria and Garcia-Pont, 1991; Rowley et al., 2004) and increase their likelihood of success (Browning, Beyer, and Shetler, 1995; Khanna and Rivkin, 2006). Building on closure theory, research suggests that common linkages to third parties should strengthen the underlying relationships as these dyads create an additional channel with which to exchange information, monitor each other, and sanction opportunistic behavior (Coleman, 1988, 1990). Yet these dyadic models differ from a true multiparty approach in which three or more partners form a supradyadic relationship to pursue common objectives as a group (see Granovetter, 2005 for a discussion). Even closure models, and brokerage models with which they are often contrasted (Burt, 2005), are surprisingly dyadic in

that they conceptualize their core structure—a ''closed triad'' (or a ''structural hole'')—in terms of the presence (or absence) of three dyadic ties.

In principle, participating in multipartner alliances should have a number of advantages over dyads, including a variety of collaborative forms with which to search for innovations. But the few empirical efforts examining multipartner alliances have mostly described their challenges, including an increased likelihood of disagreement and conflict with a large number of partners (Lavie, Lechner, and Singh, 2007; Beckman et al., 2014; Rogan, 2014b), as well as a surprising lack of trust (Browning, Beyer, and Shetler, 1995; Heidl, Steensma, and Phelps, 2014), which is at odds with the assumption that the benefits of social embeddedness will aggregate to the supradyadic level. That is, more partners seem to create more problems. Why?

Network theory about supradyadic relationships dates back to Simmel's (1950) analysis of triads, which informed early research into group dynamics and social network analysis. One challenging aspect of triads (and larger groups) that distinguishes them from dyads is the greater variety of roles and relationships that are enacted as members develop their own idiosyncratic approaches to working with different partners (Simmel, 1955). Simmel (1950) noted how difficult it was for three or more people to speak frankly or become perfectly unified in their views because of the difficulties of enacting multiple partner-specific roles at once. Unlike dyads, groups can address this problem by temporarily decomposing collaborations into subgroups of participants and still maintain the group structure (Hackman and Morris, 1978), but this process can weaken the underlying relationships if excluding members generates conflict and mistrust (Simmel, 1955; Heider, 1958). Members face a constant choice about who participates in each interaction, which has important implications for group dynamics (Wageman, 1995).

Although the dyadic mechanisms underlying social embeddedness do not address the group participation problem, embedded relationships may amplify this challenge (Azoulay, Repenning, and Zuckerman, 2010; Beckman et al., 2014), as more-extensive and idiosyncratic histories between organizations produce stronger expectations of future participation that make it difficult to decompose tasks into subsets of participants. Conflict stemming from the multiplexity of longstanding roles and relationships seems to underlie many of the multipartner-alliance difficulties that strategy and organization scholars have identified (Shipilov et al., 2014), including the inability to resolve product-market rivalries (Gimeno and Woo, 1996; Shipilov and Li, 2010), gain agreement about standards (Browning, Beyer, and Shetler, 1995; Ranganathan and Rosenkopf, 2014), and integrate knowledge across multiple boundaries (Rosenkopf, Metiu, and George, 2001; Rogan, 2014a). Yet despite these common challenges stemming from group structure, and the apparent relevance of third parties in shaping ongoing collaboration, scholars have paid little attention to the network processes that enable organizations to resolve multiparty participation problems and achieve common objectives like innovation.

The purpose of this paper is to explore how organizations innovate collaboratively with multiple partners and extend thinking beyond the common dyadic view of interorganizational relationships in which multiparty interactions are neglected to one in which group dynamics are viewed as endemic, frequent, and central to collaborative innovation in dynamic and interdependent environments. Given limited prior research on multipartner collaborative innovation, I

conducted an inductive, multiple-case study of six triadic groups in the computer industry to develop a better understanding of the collaborative processes organizations use to innovate with multiple partners. The main theoretical contribution is to research on innovation and interorganizational relationships. By reframing multipartner collaboration as group dynamics, this study identifies a unique collaborative process that enables organizations to overcome supradyadic interference and influence by third parties, mitigate internal conflict and mistrust, strengthen multiplex ties, and increase the likelihood of innovation in triads and larger organizational groups.

COLLABORATIVE INNOVATION IN GROUPS AND DYADS

Several scholars have explored collaborative arrangements that involve three or more organizations. For instance, high-tech companies participate in standards bodies to shape technology trajectories (Browning, Beyer, and Shetler, 1995; Rosenkopf, Metiu, and George, 2001; Rysman and Simcoe, 2008; Dokko and Rosenkopf, 2010). Retail and service organizations participate in peer groups to discover best practices and motivate managers (Whitford and Zeitlin, 2004; Zuckerman and Sgourev, 2006). Large business groups are formed to increase market power and consolidate ownership (Ghemawat and Khanna, 1998; Khanna and Rivkin, 2001; Rowley et al., 2004; Perkins, Morck, and Yeung, 2006). And firms increasingly use multipartner alliances—typically, triadic collaborations—for innovation, especially in industries in which activities span more than two sectors (e.g., circuits, hardware, and software), as in information technology (Lavie, Lechner, and Singh, 2007; Heidl, Steensma, and Phelps, 2014).

One reason to form and join groups is to access the diverse resources of multiple partner organizations to achieve complex objectives like innovation (Sakakibara, 1997; Gulati and Westphal, 1999; Baum, Calabrese, and Silverman, 2000; Guillén, 2000). Yet triadic (or larger) groups are relatively rare compared with dyads, suggesting some unique challenges of collaborating with multiple partners in a group, which can include conflict and mistrust related to disagreements or unmet expectations about who participates in collaborative interactions (Browning, Beyer, and Shetler, 1995; Gimeno and Woo, 1996; Casadesus-Masanell and Yoffie, 2007). From a network perspective, the major risk is that competing subgroups will emerge and isolate members (Lau and Murnighan, 1998; Heidl, Steensma, and Phelps, 2014; Sytch and Tatarynowicz, 2014b) who might be useful during innovative development. Members can choose whether to participate in groups (Simmel, 1950), so they may be able to select appropriate participants and mitigate conflict and mistrust, but to date there has not been extensive research about the processes groups of organizations use to shape participation and collaborate over time.

Research about dyadic innovation is an important foundation for this study. In this literature, innovation is viewed as a recombination process that brings together existing elements in new and useful ways (Schumpeter, 1934; Fleming, 2001). Managers use collaborative arrangements to engage in a broader recombinant search that combines their own organization's resources with those of a partner (Ahuja, 2000b; Rosenkopf and Almeida, 2003). Rosenkopf and Nerkar's (2001) research about innovation in the optical disk sector illustrates that the most innovative technologies, like the compact disc

(CD), come from a broad search process that combines partners' different technologies.

Yet achieving broad search collaboratively can be difficult; because most combinations of disparate elements from two organizations are likely to fail, partners tend to mitigate their risk of failure and select combinations with less innovative potential (Eggers, 2012; Piezunka and Dahlander, 2014). When partners engage in recombination together, they may offer their own constraints on technological development but not veto those of their partners. Excessive constraints lead partners to choose the lowest-common-denominator solution that will enable a sufficient—albeit less than innovative—outcome. Davis and Eisenhardt's (2011) study of technology collaborations described one processual solution: some pairs of organizations in their study engaged in broader search by alternating control of technology development across phases of development between partners to ensure that a broader space of innovations was explored.

Although these broad search processes seem relevant, a number of issues arise in applying them to groups. First, it is not clear that rotating leadership or other dyadic processes would be effective, as alternating control among three or more partners, for example, might dramatically increase the likelihood of selecting an ineffective combination. Moreover, alternating control among multiple partners could take too much time, especially if the order of leadership is contested, a problem that is easier to resolve in dyads, in which non-leading partners are guaranteed to eventually assume control. Moreover, alternation alone does not address a core problem of group collaboration, namely, how groups decide which collaborative form to use, including whether to use the maximal form or a subform and its effects. Simultaneous participation may amplify the tendency of multiple partners to settle on local search.

The second major factor underlying successful collaborative innovation is mobilizing resources for innovation (Allen, 1977; Katz and Tushman, 1981). Research about dyadic innovation suggests that accessing resources depends on managers' active involvement and influence in their organizations (Obstfeld, 2005; Maurer and Ebers, 2006), because the necessary contacts may be deep inside organizational networks and distant from the locus of action (Obstfeld, Borgatti, and Davis, 2013). Consequently, collaborating organizations may rely on dynamic processes to activate boundary-spanning ties and mobilize these distant participants to perform collaborative work. For example, in their study of innovative country music production, Lingo and O'Mahony (2010) found that the most creative producers use a dynamic process in which different collaborative activities are separated in time.

The research about dyads has implications for collaborations in groups. Mobilizing resources in dyads from the group is difficult because non-participating third-party group members may be reluctant to share their resources when they have no influence in a project. Therefore a natural tendency may be to select the maximal form (e.g., a triad in three-member groups, a tetrad in four-member groups) to ensure that each organization actively participates and provides resources. But if mobilizing distant resources requires clear, unilateral control rights, as it often does in dyads, it can be difficult to find the time for each member to take the lead and enable mobilization. A related problem is that the greater interdependencies of resources of multiple partners in groups can also harm effective mobilization (Thompson, 1967). A combination

of two organizations' apparently complementary resources could be ruled out because of a negative (or positive but costly) interdependency with a third party (Beckman et al., 2014; Rogan, 2014a). How multiple partners avoid conflict and choose collaborative forms to manage resource interdependencies is not clear.

The third factor in effective collaborative innovation is maintaining interorganizational trust, the organization-wide expectation that a partner will fulfill obligations, behave predictably, and act with goodwill when it is possible to be opportunistic (Gulati, 1995a; Das and Teng, 1998; Zaheer, McEvily, and Perrone, 1998). Trust is an important foundation for intensive alliances because it enables partners to make commitments and take risky actions without implementing costly safeguards to protect against a partner's betrayal (Gulati, 1995a; Uzzi, 1997). Prior literature suggests that interorganizational trust emerges from a foundation of interpersonal trust between individual boundary-spanning managers and that after many frequent interactions this trust becomes institutionalized (Ring and Van de Ven, 1994; Uzzi, 1997).

Trust can be maintained during periods of alliance inactivity as long as some organizational memory of these trusting interactions persists or no exogenous factors emerge. Trust may be lost, however, if one party acts opportunistically or is perceived to do so (Zaheer, McEvily, and Perrone, 1998). Trust between organizations can also be gained or lost because of the beliefs and actions of individual managers, if subordinates follow their lead (Larson, 1992; Das and Teng, 1998) or if partners are perceived as competitive threats (Burt and Knez, 1995). Graebner's (2009) research on interorganizational trust in acquisitions showed that partners can have asymmetric trust: sellers tend to have more trust in buyers than buyers have in sellers because of disparities in their expectations of the future, with sellers expecting to lose power while buyers expect to gain it (see also Doz, 1998).

Strong dyadic relationships with interorganizational trust can be a foundation for group formation and an antecedent of multipartner alliances, but the role of trust inside group collaborations that focus on innovation has not been substantially explored. Though trust may be a sufficient foundation to launch collaborative forms of all types, whether the collaborative forms themselves generate differential effects on trust has not been examined in detail.

METHODS

To develop a better understanding of multipartner collaboration processes, I conducted an inductive, multiple-case study of six triadic groups of large, established organizations. In this approach, cases are treated as a series of experiments that confirmed or disconfirmed my emerging conceptual insights (Eisenhardt, 1989). I used an embedded design (i.e., multiple levels of analysis) that included the triadic group, dyadic relationships, organizations, divisions/units/functions, labs, teams, and individuals.[1] Established organizations provide a useful context in which to explore interorganizational collaboration, because

[1] This research about innovative organizational groups is part of a larger study of technology collaborations, which initially began by focusing on dyadic technology collaborations between pairs of large, established organizations. I expanded the study's scope to explore triadic collaboration, although many of the advantages of the original sample remain. Although complex, an embedded design permits induction of richer, more reliable models (Yin, 1994).

they are likely to have the basic structural characteristics associated with collaboration performance (e.g., extensive collaborative experience, strong relationships, and dedicated alliance functions), enabling me to focus on collaborative processes without complicating variation. Also, they are likely to have sufficient resources to attract partners and engage in significant R&D, making collaboration probable. Finally, their size is likely to preclude one acquiring another, thus putting the prospect of mergers and acquisitions in the background and making collaboration crucial.

The research setting was organizations in the computing and communications industries, which produce a wide range of information technology products, including semiconductors, laptops, mobile handsets, and Internet software. This organizational field is a particularly appropriate research setting because it is an industry context in which technology collaborations are often used to develop innovations across sector boundaries, such as collaborations among semiconductor, hardware, and software complementor firms (Mowery and Rosenberg, 1998; Bresnahan and Greenstein, 1999). Given the complex nature of information technologies, different resources from three or more firms may be needed to produce innovative products and services, so multipartner interactions around innovation are salient in this context (Bresnahan and Greenstein, 1999; Ranganathan and Rosenkopf, 2014).

Data Collection and Sources

I used several data sources: qualitative and quantitative data from semi-structured interviews; publicly available data from websites, corporate intranets, and business publications; and private data from materials provided by informants. To construct these cases, I conducted over 100 semi-structured interviews of 60 to 90 minutes over seven years. Informants included the executive leads who oversaw the collaborations, strategic alliance directors, product-line general managers, laboratory and technical heads, scientists, and engineers. I also worked for several months as a low-level alliance specialist on R&D collaborations at a large semiconductor company, which I call Macbeth.[2] Taken together, my triangulated, longitudinal data from primary sources in the field provided a rich view of technological collaboration in groups.

I mitigated informant bias in several ways (Golden, 1992; Miller, Cardinal, and Glick, 1997). First, I followed interview guides that focused informants on relating chronologies of objective events, behaviors, and facts of the collaboration. Second, to triangulate the data, I gathered thousands of pages of secondary data both on site and from the media about these collaborations. Third, I collected data in real time from some collaborations and returned multiple times to conduct site visits (Leonard-Barton, 1990). Finally, I promised confidentiality to encourage informants' accuracy (Eisenhardt and Graebner, 2007).

Sample of Triadic Groups

I first identified six pairs of organizations that were engaged in technological collaborations in which each firm also had a previous relationship with Lear, a prominent diversified computing firm with an extensive product line across the

[2] I use the names of Shakespearean characters as pseudonyms for the organizations I studied.

Table 1. Description of Collaborative Groups

Case #: Technology focus	Partners	Partner's relevant capabilities	Focus of previous relationships (partners involved in each type)	Boundary disagreement*
#1: Wireless networks and security	Falstaff	Semiconductors / circuits	Joint sales and marketing (FM,ML,LF), buyer/supplier (FM,ML,LF), standards, R&D consortia (FM,ML,LF), direct competition (LF), technology collaboration (FM,ML,LF)	0%
	Macbeth	Network equipment		
	Lear	Mobile OS / server software		
#2: E-commerce tools and online marketplace	Horatio	OS / software applications	R&D consortia (HM,ML,LH), buyer/supplier (HM,LH), joint sales and marketing (HM,ML,LH), technology collaboration (HM,ML,LH)	17%
	Mercutio	Online marketplaces		
	Lear	Server software / OS		
#3: Server integration and virtualization	Falstaff	Semiconductors / circuits	Joint sales and marketing (FC,CL,LF), buyer/supplier (FC,CL,LF), technology standards (FC,CL,LF), R&D consortia (FC,CL,LF), technology collaboration (FC,CL,LF)	0%
	Claudius	Servers / network systems		
	Lear	Server software / OS		
#4: Spam and instant messaging	Cressida	Internet software	Joint sales and marketing (CA,AL,LC), buyer/supplier (AL,LC), technology standards (CA,AL,LC), technology collaboration (AL,LC)	0%
	Antonio	Internet services		
	Lear	OS / applications		
#5: Mobile e-mail and operating system	Rosalind	Mobile devices / OS	Technology standards (RP,PL,LR), R&D consortia (RP,PL,LR), direct competition (RP,PL,LR), technology collaboration (RP,PL,LR)	0%
	Portia	Mobile devices / Mobile software		
	Lear	Mobile OS / applications		
#6: Middleware and virtualization	Ariel	Network systems	Joint sales and marketing (CL,LA), buyer/supplier (AC,CL,LA), technology standards (AC,CL,LA), technology collaboration (AC,CL,LA)	17%
	Cleopatra	Software applications		
	Lear	OS / applications		

* The measure of boundary disagreement is explained in text below.

(*continued*)

major areas of software (e.g., consumer, enterprise, server, Internet, and mobility). In each case, a pair was considering whether to form a triadic collaboration with Lear, because doing so offered potential value. For a study of how organizations collaborate with multiple partners, this commonality offered the analytical advantage of controlling for the common features of a prominent third. As Simmel (1950) argued, triads are the minimal group structure in which multiparty dynamics are relevant, so focusing on triadic groups gave me a tractable analytical window into organizational group dynamics.

The six triadic groups comprised 12 companies in the computing and communications industries, ranging from semiconductors (Macbeth) to operating systems (Lear, Rosalind) to mobile devices (Rosalind, Portia). Lear was common to all groups, and another firm, Falstaff, was in two groups. Most pairs of partner organizations had extensive prior relationships with each other as complementors, buyer/suppliers, joint sales and marketers, and occasional

Table 1. (continued)

Case #: Technology focus	Initial innovation objective and collaboration duration	Size (employees per firm)	Informant positions and titles	Interviews per firm Total pages
#1: Wireless networks and security	Network circuits and software 34 months	34,000 79,000 55,000	CTO, lab director, VP business unit, VP engineering, group director, technology strategist, program manager, alliance manager, product director, technical lead, PR manager	4 7 6 2900
#2: E-commerce tools and online marketplace	E-commerce software tools 18 months	86,000 3,000 51,000	SVP engineering, director technical marketing, head technical evangelist, BD manager, program manager, alliance manager, product director, technical lead	3 3 5 1800
#3: Server integration and virtualization	Server software and hardware 10 months	38,000 316,000 48,000	CTO, VP wireless division, lab head, BD manager, engineering partnerships manager, program manager, alliance manager, product director	3 3 4 2000
#4: Spam and instant messaging	Security software 21 months	4,000 60,000 55,000	SVP business unit, VP Internet division, director software development, program manager, alliance manager, product director	3 2 4 800
#5: Mobile e-mail and operating system	Mobile e-mail devices and software 42 months	27,000 17,000 55,000	EVP and GM enterprise division, VP strategy enterprise division, director of wireless, lab head, partner licensing director, program manager, alliance manager, product director, PR manager	3 3 5 2500
#6: Middleware and virtualization	Internet-enabled enterprise middleware 45 months	38,000 29,000 48,000	VP business unit, director of software architecture, director technology standards, program manager, alliance manager, product director, technical lead	4 3 5 2600

competitors. Nine organizations were headquartered in the U.S. and three elsewhere, reflecting the global nature of these industries and enhancing generalizability. Table 1 provides details of each triad.

Unit of Analysis

An important question is whether participants consider their organizations to be members of organizational groups. During the interviews, I was struck by the degree to which Lear's managers framed their collaborations as group efforts. One Lear VP said:

> In this industry, you need to think of yourself as being part of a broader group of companies . . . or teams. They are small teams, so we still try to direct them—we have our own goals for each group. But remember: these are big behemoth companies,

> so we may not get our way . . . and some teams will be more successful than others . . . but you still need to think beyond individual partnerships.

Lear's participants saw themselves as having both strong interorganizational relationships, an important focus of prior alliance research, and membership in various organizational groups, which can provide a strong foundation for productive collaboration (Khanna and Rivkin, 2001; Rowley et al., 2004; Granovetter, 2005). Yet, as research about groups of individuals indicates, perceptions of membership and group boundaries can differ among partners. Therefore I assessed whether participants of all three partner organizations perceived themselves as being members of these triadic groups. I adapted Mortensen's (2014) measure of boundary disagreement, which compares partners' perception of group membership. As described in the Online Appendix (http://asq.sagepub.com/supplemental), I found that participants were highly consistent in perceptions of membership and disagreed little about group boundaries.[3] Boundary disagreement never exceeded 17 percent, which increases confidence in the group unit of analysis.

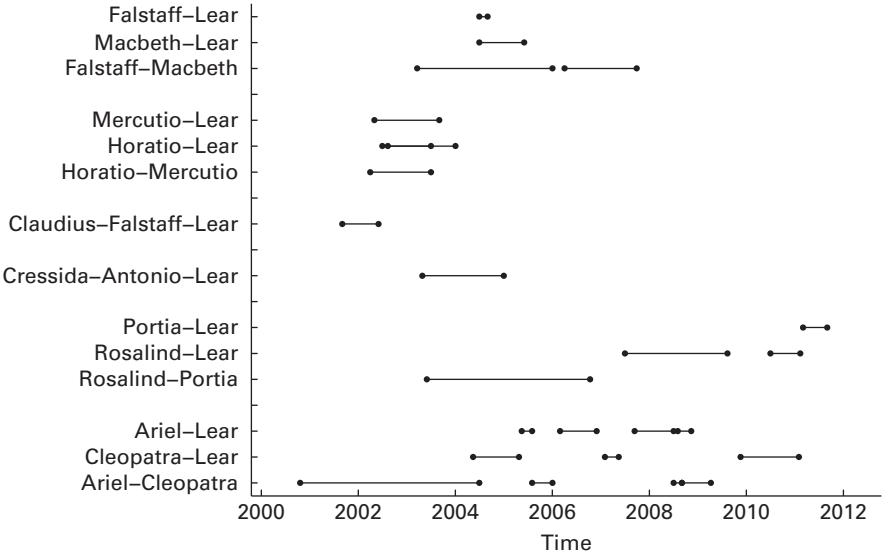
I analyzed all major technology collaborations produced by these groups from 2001 to 2012, naming each group for the focus of its primary technological areas, which spanned many of the relevant categories in which innovations were emerging during this period (e.g., mobile e-mail and operating systems, wireless networks and security, and spam and instant messaging). The six groups produced from one to 11 different collaborations that focused on distinct objectives and lasted anywhere from three months to four years each. By noting who was collaborating and when, I was able to distinguish the triadic group structure of prior relationships from the actual (sub)form(s) used to collaborate, whether it was a triad or a set of dyads, and whether these sets were simultaneous or sequential. In each case, both formal activity (i.e., an alliance contract, financial arrangements) and informal activity (i.e., participation and communication) were indicated, suggesting that true collaboration was occurring.[4] These collaborations are plotted in figure 1, which shows each collaborative form emerging over time.

An advantage of the research design is its focus on groups in which partners had the key antecedents of superior collaboration performance, including extensive collaborating experience and dedicated alliance functions (Gulati, 1995b; Kale, Dyer, and Singh, 2002), and were also strategically interdependent partners in complementary sectors (e.g., hardware/software/Internet, circuits/systems) (Gulati, 1995a). In addition, partners had multiple prior interactions that had created organizational structures and boundary-spanning ties between individuals and workgroups (Tushman, 1977; Uzzi, 1997; Fleming and Waguespack, 2006). All participants dedicated significant resources to joint R&D governed with loose ''memorandums of understanding'' (MoUs) specifying ''broad areas of technology exploration'' (Baker, Gibbons, and Murphy, 2002; Mayer and Argyres, 2004). Finally, these firms were technical and market

[3] The boundary agreement found here may not be representative of the industry. Groups of less-established firms or firms entering new industries (e.g., nanotechnology) may have more disagreement about the membership of their groups.

[4] I thank an anonymous reviewer for suggesting that I note how simultaneous or sequential collaborations were measured.

Figure 1. Group members' technological collaborations from 2001 to 2012.



leaders (i.e., first or second in market share) in their domains and thus desirable partners that shared the common language of the IT industry (Dougherty, 1992; Ahuja, 2000a; Leonardi, 2011). By selecting groups with favorable structural antecedents, I could focus on the collaborative process and its implications for innovation performance.

Measuring Innovation Performance, Conflict, and Trust

Innovation performance is a central outcome variable of this study. I assessed a group's collaborative innovation performance in two ways: the innovation outcomes of the initial collaboration, and any new collaborations that followed from this. In the Online Appendix, I describe a multi-factor measure of the innovation performance of the initial collaborations that is consistent with prior innovation literature (Cohen and Levinthal, 1990; Henderson and Clark, 1990; Ahuja, 2000a; Fleming, 2001; Katila and Ahuja, 2002). It includes five measures: (1) the new technologies generated by the collaboration, (2) codified intellectual property, (3) immediate product-line impact, (4) market acceptance of new technologies, including qualitative evaluations by analysts and immediate financial impact, and (5) participants' perceptions of the overall innovation performance. The number of subsequent collaborations and the participants' perceptions of the overall innovation performance of those collaborations are also included.

During the analysis, interorganizational trust and collaborative conflict emerged as two important mechanisms driving innovation and relational outcomes. As a result, I made efforts to measure both trust and conflict at the beginning of the case, as well as trust and conflict at the end, as detailed in the Online Appendix. Consistent with prior literature, I measured interorganizational trust dyadically (i.e., A may trust B but not C) (Larson, 1992; Gulati, 1995a) and with three main components: fulfilling obligations or commitments, behaving according to expectations, and acting fairly (Zaheer, McEvily, and Perrone,

1998; Graebner, 2009). Collaborative conflict indicates the disagreements or tension among employees in two partner organizations (Pondy, 1967; Ring and Van de Ven, 1994; Doz, 1996; Jehn, 1997). I report averages for both trust and conflict on 10-point Likert scales rounded to the nearest integer.

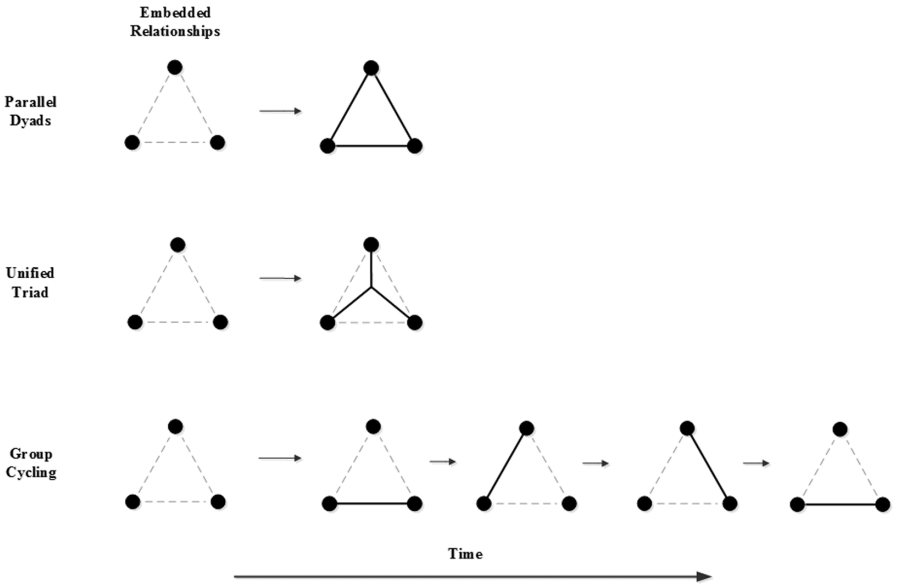
GROUP DYNAMICS AND COLLABORATIVE INNOVATION

Prior literature suggests that organizations select multipartner collaborative forms like triads when each partner can contribute useful resources to a broad recombinant search process and when they are densely interconnected with embedded dyadic relationships that could support trusting collaboration among multiple partners (Gulati, 1995b; Uzzi, 1997). Yet this study's findings reveal that even when partners are densely interconnected, organizational groups use a variety of collaborative forms that may include multipartner alliances like triads, as well as other arrangements of subforms like sets of dyads, to develop innovations. I outline three approaches to group collaboration below, which are depicted schematically in figure 2: parallel dyads, a unified triad, and group cycling, which involves isolating third parties from specific dyads and linking the content of consecutive dyads to form a stream of innovative collaborations.

Parallel Dyads

Two groups in this study organized group innovation in parallel dyads, a collaborative form in which separate collaborations between different pairs of partners are conducted at approximately the same time. As these dyads were

Figure 2. Collaborative forms and process in organizational groups.*



* Dashed lines represent strong-tie embedded relationships; solid lines represent collaborative forms in current alliances.

initiated simultaneously, they overlapped in time for most of their duration, as illustrated in figure 1.

Why multiple partners collaborate in parallel dyads. Group participants form parallel dyads for several reasons. Often, partners use this structure to avoid the potential conflicts that may emerge in multiparty arrangements and to pursue independent projects that will be less constrained by a third party's involvement in a particular dyad. For example, Horatio, Mercutio, and Lear used parallel dyads to collaborate on e-commerce tools and online marketplace technologies (case 2). Horatio, a leading developer of computer hardware, software applications, and operating systems, started discussions with Mercutio, a large Internet commerce company. As Horatio, Mercutio, and Lear already had strong dyadic relationships—having collaborated with each other in the past on many successful dyadic alliances related to Internet and computing technologies—it was natural to consider Lear as a potential third partner. As one Mercutio informant said:

> It seemed that combining Horatio's broad expertise in integrated systems with our skills running online marketplaces would produce valuable innovations. The new XML technologies allowed us to create web pages that update automatically. Bringing in Lear was natural in order to access their deep expertise in server software and other back-office technologies supporting e-commerce. . . . The challenge was how [to do it].

Horatio and Mercutio's managers gave three reasons for choosing parallel dyads with Lear. First, they believed that developing new technologies did not require participation from all three partners in each project and that if resources from third parties became relevant, they could be incorporated at the end of the dyad. Second, there was some concern that all three partners might have difficulty agreeing on strategic objectives, especially related to whether they should emphasize the public relations (PR) value of collaborating or the true R&D efforts. Finally, all parties wished to free each other's managerial attention and resources from unnecessary collaborative efforts to focus on more pressing matters. These technological, strategic, and urgency rationales were common antecedents. Participants believed that separate, parallel dyads would enhance group innovation.

Despite their best intentions, the partners using parallel dyads had low innovation performance. Parallel dyads generated a surprising trust problem among partners that made it difficult to access critical resources from third parties and led to conflict about participation by third parties in ongoing dyads. Although partners agree to parallel dyads with the understanding that access to third-party resources will be restricted, they nonetheless expect that critical resources can be mobilized should they become necessary or that third parties will somehow influence the evolution of dyads in which they are not participating because of their common membership in the group. When third parties are rebuffed, they lose trust in their fellow group members, which leads pairs to distrust this mistrusting partner. As I illustrate below, the degradation of interorganizational trust has a negative impact on the innovation performance of initial dyads and the likelihood of subsequent collaborations.

Degraded trust and resource unavailability. All the groups began with high initial trust, as detailed in table 2. The groups using parallel dyads were

Table 2. Interorganizational Trust, Collaborative Conflict, and Supradyadic Group Dynamics

Case #: Technology focus	Partners	Evolution of trust	Initial trust Final trust	Collaborative conflict	Initial conflict Final conflict
#1: Wireless networks and security	Falstaff–Macbeth–Lear	Lear lost trust in Falstaff and Macbeth when it came to believe that their project would help its competitors. Falstaff and Macbeth lost trust in Lear when it would not give them access to its security professionals or development tools.	9 4	Conflict did not appear to stem from prior roles and relational patterns, perhaps because dyads were separate. Yet some conflict emerged about whether Lear's resources were needed to improve Falstaff and Macbeth's collaboration.	3 6
#2: E-commerce tools and online marketplace	Horatio–Mercutio–Lear	Horatio lost trust in Mercutio and Lear when they disregarded its request to keep the payment technologies open. Lear lost trust in Mercutio and Horatio because they did not honor its request to pause payment and storage system collaborations.	8 5	Conflict did not appear to stem from prior roles and relational patterns, perhaps because dyads were separate. Instead, some conflict emerged around whether third parties could influence or participate in dyads, especially when Horatio lobbied Mercutio and Lear to participate in its payment systems collaboration.	4 6
#3: Server integration and virtualization	Falstaff–Claudius–Lear	Some trust was lost in Lear and Claudius when conflict emerged about whether to defeature the product and reduce salespeople's involvement.	9 6	Falstaff, Claudius, and Lear were conflicted over how partners would mobilize specialists, including the role of salespeople in the process. There was also conflict about how extensively to develop initial prototype products, including what features to include. Conflict emerged over whether Claudius was trying to form a separate alliance with Lear to avoid including Falstaff in difficult decisions in which it had strong interests.	3 8
#4: Spam and instant messaging	Cressida–Antonio–Lear	Cressida lost some trust in Antonio and Lear when disagreement about collaborative activities emerged.	8 6	Cressida, Antonio, and Lear had conflict about who should develop the Internet software platform. Conflict also emerged about how to bond team members, including whether and what types of outside social events to attend. Cressida thought Antonio and Lear were not serious about working, and Antonio thought that Cressida was not committed to the collaboration when its senior executives declined to attend the social events.	4 7
#5: Mobile e-mail and operating system	Rosalind–Portia–Lear	Rosalind, Portia, and Lear maintained high trust during this collaboration.	7 8	Conflict did not appear to stem from prior roles and relational patterns—dyads were separated in time. In fact, Rosalind, Portia, and Lear had very little conflict in their long sequence of collaborations. Even though Rosalind and Portia were former rivals, no significant examples of conflict were noted.	4 4
#6: Middleware and virtualization	Ariel–Cleopatra–Lear	Ariel, Cleopatra, and Lear had similar project and alliance management competencies. Cleopatra and Lear had strongly overlapping technological capabilities in application software; Ariel and Lear had some overlap in systems software.	8 7	Conflict did not appear to stem from prior roles and relational patterns—dyads were separated in time. In fact, Ariel, Cleopatra, and Lear had very little conflict in their long sequence of collaborations. One notable exception was conflict about how Lear could contribute to initial middleware, although this was soon resolved by choosing to isolate Lear from the middleware collaboration altogether.	4 4

(*continued*)

Table 2. (continued)

Case #: Technology focus	Isolating third parties	Linking collaborations
#1: Wireless networks and security	Number of isolations = 0 Although Falstaff, Macbeth, and Lear agreed not to participate in each other's trio of parallel dyadic collaborations, each eventually demanded some involvement and influence in these dyads, leading to acrimony.	Number of dyad–dyad linkages = 0 Outputs from collaborations did not become inputs to other parallel collaborations.
#2: E-commerce tools and online marketplace	Number of isolations = 0 Although Horatio, Mercutio, and Lear agreed not to participate in a trio of parallel dyadic collaborations, eventual interest from the third parties in other collaborations, starting with Horatio, led them to interfere and demand changes in each other's projects.	Number of dyad–dyad linkages = 0 Outputs from collaborations did not become inputs to other parallel collaborations.
#3: Server integration and virtualization	Number of isolations = 0 Falstaff and Claudius invited Lear to join their collaboration to broaden their efforts and leverage its expertise in operating systems, application, and server software. Lear agreed, so there was no isolation.	N/A
#4: Spam and instant messaging	Number of isolations = 0 Agreement to work on a unified triadic collaboration quickly turned acrimonious because an agreement on technology goals and methods could not be reached. All participants stayed involved until the end, so isolation was not achieved.	N/A
#5: Mobile e-mail and operating system	Number of isolations = 4 Unilateral isolation: Rosalind and Portia began mobile e-mail collaboration without Lear's knowledge to reap benefits before engaging with Lear. Unilateral isolation: Lear managers collaborated with Rosalind before Portia to accelerate new mobile versions of Lear's application suite on Rosalind's phone without Portia's participation. Negotiated isolation: Based on two effective prior dyads, Rosalind and Lear negotiated with Portia to forgo participation while they conducted an Internet collaboration. Negotiated isolation: Rosalind agreed to remain isolated from the Portia–Lear collaboration about search functionalities, the fourth and final dyad.	Number of dyad–dyad linkages = 3 Explicit output-to-input linkage: Lear's subsequent collaboration with Rosalind used a modified version of the mobile e-mail to enrich Rosalind's smartphones. Explicit output-to-input linkage: Lear's other collaboration with Rosalind used a modified version of the mobile e-mail to better integrate with Lear's application suite. Tacit-knowledge linkage: Portia's subsequent collaboration with Lear depended on Lear's new capabilities in using the mobile e-mail product on various handsets that was acquired in the previous collaborations with Rosalind.
#6: Middleware and virtualization	Number of isolations = 11 Unilateral/negotiated isolation: Ariel and Cleopatra isolated Lear from an initial collaboration focused on middleware to free themselves from Lear's constraints. Unilateral isolation: Lear conducted second and third dyadic collaborations with Cleopatra and Ariel in which Ariel and Cleopatra, respectively, are isolated. Negotiated isolation: Lear offered to allow Ariel and Cleopatra to collaborate alone to develop their own quick win about adaptive computing in a fourth dyad. Negotiated isolation: Lear negotiated its own two quick-win collaborations with Ariel and Cleopatra about programming languages and consumer content, the fifth and sixth dyads. Negotiated isolation: Ariel, Cleopatra, and Lear orchestrated five collaborations in sequence—the seventh to eleventh dyads—in which respective third parties were isolated to quickly develop integrated virtualization technologies based on prior middleware technologies.	Number of dyad–dyad linkages = 10 Explicit output-to-input linkage: Ariel and Cleopatra outlined their middleware plans for Lear to use in their future collaborations in a series of presentations. Explicit output-to-input linkage: A ''quick win'' collaboration used middleware technologies from the first collaboration to enhance Lear's calendar software with the outputs of Ariel and Cleopatra's first collaboration. Explicit output-to-input linkage: A third collaboration also used middleware technologies to enhance sign-on technologies. Tacit-knowledge linkage: Ariel relied on knowledge about streamlining IT management with Lear's database system learned in prior collaborations in a fourth collaboration between Ariel and Cleopatra. Explicit output-to-input linkages: Ambitious virtualization collaborations between Ariel and Cleopatra used technologies from the first middleware collaboration. A tenth collaboration between Ariel and Cleopatra used prior virtualization technologies to improve Cleopatra's software. Tacit-knowledge linkage: An eleventh collaboration integrated Lear and Cleopatra's enterprise software using deep knowledge of virtualization technologies.

unique in the dramatic deterioration of trust during the collaboration, compared with groups using other collaborative forms and processes. The evolution of trust, as well as conflict, in all cases is detailed in table 2.

During parallel dyads, trust was diminished when third parties rebuffed their partners' requests for access to resources. Although parallel dyads are ostensibly separate, partners often maintained a private expectation that they could access critical resources from third parties if necessary. Because the pair would likely not ask the third party for access unless it was critical, they may interpret the third party's refusal as acting unfairly or even opportunistically. In other cases, trust decreased because third parties demanded changes to a dyad's collaborative content in exchange for access to resources. These demands defied the expectations of predictability and goodwill that underlie trusting relationships.

Diminishing trust is illustrated by case 1, in which Falstaff, Macbeth, and Lear initially agreed to collaborate on wireless networks and security projects in parallel dyads. As large semiconductor and networking equipment companies, Falstaff and Macbeth preferred to develop security technologies independently from Lear, to build platform-independent products that would work with operating systems from both Lear and its competitors. The group began with high initial trust, scoring 9 out of 10. Macbeth's managers considered waiting until the joint security technologies with Falstaff were completed before engaging with Lear about how to use them, but they decided that as changes to semiconductor product development would take a long time, they should begin collaborating with Lear quickly on how to include its security requirements in the circuit firmware. In a third parallel project, Falstaff collaborated with Lear to update its wireless routers to work on Lear's systems. Given their long history of dyadic collaboration on network and computer technologies, the three partners expected that the three simultaneous collaborations could be managed effectively.

Falstaff's and Macbeth's managers soon realized that they needed a more detailed understanding of Lear's security protocols and access to its developer tools to ensure that the new security systems would function properly on Lear's platform. At their request, Lear sent engineers to examine the initial designs. To their surprise, the engineers found that a large part of the schematics was dedicated to working around important startup requirements in Lear's software. Although there were several additional security features as well, Lear's executives came to the conclusion that the main objective of the security project was to provide system control over network-wide security to enterprise software packages from Lear's competitors. Ironically, multiple technical analysts I asked viewed these capabilities as enhancing the value of Lear's software because they gave administrators who were committed to Lear's software a larger set of vendor-independent control points over all systems. Yet Lear's managers would not give up the idea that these technologies were a threat. This was partly because of Macbeth's involvement, as Lear's vice president of engineering explained:

> You'll notice that we've built many platform-independent technologies with Falstaff in the past. Experience has taught us that it can be done with them in ways that benefit us. But when Macbeth's executives talk about platform independence, it means something different. I mean, their CTO [chief technology officer] has publicly stated

> that platform independence is meant to diminish our dominance of middleware. . . . This is why we've never done this sort of thing with them in the past. They're a great collaborator, but we've always done jointly branded products with them that only worked on our platform.

Although it may have been possible for Falstaff's managers to convince Lear to proceed, Macbeth's involvement seemed to preclude this possibility because of Macbeth and Lear's prior relationship.

Ultimately, Lear refused to provide additional access to its security professionals or developer tools for the security project. As Falstaff and Macbeth were making some progress on basic prototypes, they continued to work on their security technologies without Lear's input, although participants feared that because of Lear's absence the product would underperform on important dimensions like reaction, uptime, and the number of features. As one manager at Macbeth said,

> Maybe it sounds entitled, but we thought we could count on our partner [Lear] to help us outside of the narrow wireless project. I mean, we're all allies, and we've shared a common vision for security for quite some time. They're willing to do this sort of work with Falstaff, why not with us? I fear we should have involved Lear from the beginning; maybe we could have convinced them to join us if we let them drive it for a while, but now they won't even listen to our side.

It appears that a disagreement about technological features triggered Lear's initial mistrust of Falstaff and Macbeth, and then Lear's refusal to provide access to resources created lasting distrust in them. In turn, this second-order distrust of Lear by Falstaff and Macbeth strained their dyads with Lear. Although most of the mistrust was attributed to Lear, all pairs lost trust in each other, with a final trust score of 4 out of 10 for this group. Macbeth and Lear continued to collaborate on wireless router technologies, but the more-frequent interactions were curtailed, leading to a less-than-innovative product that met minimal objectives. One Macbeth manager explained, ''We were shocked at Lear's behavior. Our project with Falstaff was in desperate need, and they let us down. It wouldn't have taken much on their part, so we felt burned. But we had to keep working with them on [wireless routers], so we had to grin and bear it.'' Participants gave this collaboration an average innovation performance rating of 5 out of 10. The parallel security dyad and one subsequent one were even less innovative, receiving 3 out of 10.

Even though the trust problems that emerge in parallel dyads have such a damaging impact on resource mobilization, partners may feel trapped in this collaborative form. For instance, Horatio, Mercutio, and Lear's e-commerce tools and online marketplace collaborations (case 2) lacked key resources like engineering know-how, prototype products, schematics, and marketing plans from third parties that could have been useful in separate dyads. All parties recognized this, but the mistrust was difficult to repair. This group ended with a final trust score of 5 out of 10. As one informant said, ''What a mistake! We should have just worked together in a three-way alliance. Then we could have used all the technologies we needed. But now there are a few individuals who are so angry that we can't fix it.''

Degraded trust and contested participation. Diminishing trust can also arise from the unmet expectations of third parties. Although each partner agreed to forgo participation in its partner's other dyad, simultaneous engagement with these partners in other collaborations generated interest in their projects and a sense that they were missing out on innovation opportunities by not participating or attempting to influence outcomes. Ironically, partners demanded non-interference from third parties in their own dyads but became interested in participating in the other dyads themselves. Many partners believed that membership in the broader triadic group entailed some rights to participate in or have some influence over all of the group's collaborations. The expression of interest took multiple forms, from requesting frequent information updates to demanding approval over key features and aspects of the innovation process itself. Ultimately, being refused entry into each other's collaborations led to lasting distrust and ongoing disagreements about participation.

The e-commerce tools and online marketplace collaborations (case 2) illustrate disagreement about participation. The partners agreed to separate, parallel dyads between Horatio and Mercutio (an online store selling integrated hardware systems), Horatio and Lear (advanced storage systems to support data-intensive e-commerce), and Mercutio and Lear (tools linking Lear's applications to Mercutio's e-commerce payment technologies). The group began with high initial trust (8 out of 10). As the projects got underway, Horatio started to express interest in Mercutio and Lear's payment collaboration. It began as a trickle of questions from Horatio's alliance managers about how development was progressing. A project manager at Mercutio supplied occasional updates over e-mail and during coffee meetings with mid-level Horatio managers. These were reported to Horatio's top managers, who pressed for further information: they were concerned that the payment interfacing tools Mercutio and Lear were developing would not be applicable to the online store they were developing with Mercutio. Over three months, Horatio's managers began to exert stronger pressure on Mercutio's managers to monitor and modify the payment system designs in Mercutio and Lear's collaboration.

Mercutio and Lear resisted. Mercutio's managers preferred to stick to the original agreement to separate collaborations and to worry about modifying the software to satisfy Horatio later if necessary. Lear's managers tried a different angle: they had become interested in Horatio and Mercutio's online store and offered a trade in which they would have some influence over website design and, presumably, a share of the profits. As a Lear vice president said, ''Horatio tried to play in our project with Mercutio, but honestly we thought it was better for us to join [Horatio and Mercutio's] website project.''

Some participants argued that a series of meetings was necessary to negotiate the details of cross-collaboration involvement. But limited time made it difficult to get the right executives together, and after seven months of back-and-forth over e-mail and phone, only one face-to-face meeting was scheduled. Negotiations finally began with a series of conference calls, but some executives relied on their trusted lieutenants to attend the calls, and these managers lacked decision-making authority. Sometimes information flowed between pairs of companies—typically through e-mail—but not among all three at once. For example, Horatio's managers pleaded with Mercutio's managers to keep the payment technologies ''open,'' without agreeing to include Lear in the

online store collaboration. Yet Mercutio's executive felt that doing so would be in bad faith, now that the issue was on the table. Consequently, Mercutio and Lear agreed to freeze the collaboration until the negotiations were complete. When the three executives finally met, they couldn't agree on how to structure three-way participation. The disagreement became tense, with a final conflict rating of 6 out of 10. Deadlines were approaching and they were at an impasse, so they simply agreed to continue with independent collaborations.

The impact of contested participation was striking. As they had stopped working together, Mercutio and Lear were months behind schedule with the online payment collaboration. Lear's vice president in charge of commerce argued that the dyad had gone on too long and that the two companies should lower their aspirations to develop a minor XML integration between two of Lear's simplest applications and Mercutio's e-commerce technologies. Although these changes would diminish the value for customers, Lear pressed Mercutio to agree, and it eventually relented. As Lear's vice president said, ''We could salvage this thing—those changes could be marketed as a quick win and good PR.''

Horatio and Lear were farther along in their collaboration because Horatio's head engineer had ignored Lear's request to pause the payment and storage system development. This engineer did not trust that Lear would be willing to continue if his organization had paused. But without Lear's direct involvement, critical mistakes had been made: Lear's engineers discovered multiple new features that did not fit its server protocols and would need to be reworked. These repetitions seemed too costly, and by this point the projects were so far behind schedule that participants decided to simply end this collaboration without producing any new products.

Horatio and Mercutio had the most disagreement in their dyad, and tension between the managers led them to scale back their own aspirations. Mercutio's executive said he ''gave up on Horatio'' and tried to exit the collaboration as quickly as possible to focus on efforts with Lear. The group's final trust declined to 5 out of 10. Instead of designing a general-purpose online store selling integrated hardware from all manufacturers, because of time and budget pressures they focused on a rudimentary website that did not use XML richly and sold only Horatio's hardware system. This system fulfilled the letter of Horatio and Mercutio's written agreement and allowed them to exit the collaboration gracefully.

So only two of the three parallel dyads produced new products, and none was viewed as highly innovative by analysts or participants. Participants gave Horatio and Mercutio's dyadic collaboration an innovation performance rating of 2 out of 10, with one of them claiming, ''These projects were a tangled mess.'' The group's other two collaborations received an innovation performance rating of 5 out of 10. There is some evidence that ties dissolved as a result of these mistrusting parallel dyads, because no subsequent collaborations occurred between these partners in the timeframe I studied.

There are two views of how trust works in groups using parallel dyads. Third parties may appear responsible for mistrust, as simple misunderstandings or disagreements can lead them to distrust their two partners, and if they refuse access to resources, this can lead the two partners to mistrust the third. From the third party's perspective, the two collaborators are responsible for mistrust because they have refused the third party's entry into the partnership. These

two negative feedback loops amplify each other and may generate some conflict as well. The evidence suggests that all parties lose trust. The two views are complicated by the fact that each organization is both a third party and a collaborator in two ongoing dyads, which provides a rich channel for indirect communication that amplifies mistrust. Misunderstandings can fester because there is no basis for resolution in the triad itself, leading to delays that diminish innovation performance and subsequent dyads.

Unified Triads

As the parallel dyad cases illustrate, group members expect to participate in collaborations with other partners, despite having agreed otherwise when deciding on that collaborative form. One might assume that collaborating in a true multiparty arrangement could allow organizations to mobilize resources and avoid the participation disagreements that emerge in parallel dyads. Two groups in my study used a collaborative form I call "unified triads," in which representatives from three organizations agree to conduct a single collaboration with common objectives and joint governance provided by all participants. Representatives from all three companies attend most meetings to ensure that different organizational interests are represented in collaborative decision making and that the most appropriate resources from partners will be available during joint work.

Why multiple partners collaborate in unified triads. Existing literature emphasizes the importance of prior dyadic relationships as a factor in forming new multipartner collaborations. Consistent with this view, my data indicate that partners form unified triads because they believe that potentially innovative combinations of knowledge, technologies, and resources are most likely to emerge from an inclusive collaborative process. Participants emphasized the importance of quick access to technologies and knowledge as an important motivation for choosing this collaborative form. And group members using unified triads expressed a belief that strong relationships entail some rights to participate in any collaboration organized in the group context. Thus organizations may be eager to maintain the sense of group solidarity and include partners that express even minor or moderate interest in emerging collaborations.

Falstaff, Claudius, and Lear's server integration and virtualization collaboration (case 3) illustrates a typical rationale for collaborating in a unified triad. Executives at Falstaff and Claudius believed that IT systems in large enterprises were becoming too complex, due to their reliance on different proprietary product platforms, and planned to develop interface technologies that would enable Claudius's servers to interface seamlessly with other vendors' enterprise products. Lear's management was eager to be involved, while Falstaff and Claudius's managers believed that Lear could accelerate and broaden their efforts to include rich server integration and virtualization. One vice president at Falstaff explained:

> We worked it out in three directions. We wanted to use our dynamic circuit technology in a product for large enterprises. Lear wanted to access virtualization technologies that improve their server software and make it easy to connect to their apps.

> And Claudius could become the first-to-market provider of integrated server products.

These partners enjoyed strong prior relationships and recent innovative dyads, and participants in each organization believed that these conditions were ideal for collective innovation. The combination of these structural factors and the eagerness of third parties to participate is a common antecedent of unified triads. But I found that groups working in a unified triad actually had low innovation performance because of conflicts about roles and relationships.

Collaborative conflict and overlapping roles. A critical problem in multipartner collaborations is that multiple partners may prefer to perform the same roles or to perform different roles that conflict. Roles are the activities, interactions, and communication patterns that single organizations perform to complete work objectives in a collaborative context. Prior qualitative research has noted that organizations assume differentiated roles in effective alliances (Doz, 1996; Bechky, 2006)—e.g., one partner takes responsibility for software, the other for hardware; one partner assumes project management responsibilities (scheduling, calling meetings, etc.), the other develops initial prototypes, etc. In this study, unified triads developed a uniquely high level of conflict concerning the proper roles of partners. Collaborative conflict is detailed in table 2, above. In unified triads, conflicts arose because different members expected a single partner to assume two distinct roles or because two partners enacted roles that were unsuitable to a third party. Conflict challenged partners' expectations and increased the costs of coordinating activities, ultimately affecting innovation.

Usually conflict emerged over which group member would address a given problem. Nearly all of the complex organizations in these groups have some partially overlapping capabilities, so such disagreements were not surprising. For example, Cressida, Antonio, and Lear had some conflict over which firm would develop a software platform to develop anti-spam and secure instant messaging services (case 4). This group had high trust (8 out of 10) and low conflict (4 out of 10) at the beginning of their collaboration. As leading firms in different sectors of the computing industry—Cressida in online media, Antonio in Internet services, and Lear in software—each had cutting-edge Internet software capabilities and argued that it should develop the platform. This conflict consumed several months and delayed development, during which time a different competitor released its own new anti-spam and instant messaging products. The group's final conflict rating was 7 out of 10.

Partners also have conflict about who will provide basic project management functions, including scheduling meetings, determining offline communication patterns, and mobilizing individuals to participate at different times. This is complicated by the fact that some organizations tend to allocate these roles in different ways with specific partners, which can conflict in multipartner alliances. For example, in Claudius, Falstaff, and Lear's server integration and virtualization collaboration (case 3), there was conflict about how partners should mobilize business and technology specialists to participate. In the past, Falstaff and Lear had engaged in collaborations from the perspective of technology strategy: the company's CTOs led most of these collaborations and called on

individuals in their different R&D organizations to participate. By contrast, to ensure that joint sales objectives were also met, Claudius and Lear would engage in technology collaboration with involvement from their sales organizations, so that executive and senior vice presidents of sales from both companies played an important leadership role in their collaborations. Conflict emerged when Claudius and Lear wanted strong involvement from their sales organizations but Falstaff's managers did not, fearing that two different sales managers with two sets of demands would micromanage innovation efforts.

To resolve this disagreement, the partners agreed to change the process by which the alliance would be evaluated so that sales managers would participate only in the final progress reviews. But this compromise proved unsatisfactory. Although Falstaff's managers could seemingly work without sales managers' involvement, alliance managers at Claudius and Lear had difficulty making joint decisions without advice from their sales colleagues. Ultimately, this lack of involvement from salespeople made it difficult to resolve ongoing debates concerning which features should be included or excluded. The group ended with a final conflict rating of 8 out of 10.

Collaborative conflict and incommensurable content. The second major problem in unified triads is that the incommensurable content that stems from prior relationships makes it difficult to reach agreement on joint innovation objectives or methods. Content is the objectives, interactions, and common activities inside collaborations, often embedded in routines or other taken-for-granted practices developed in prior relationships. This problem with incommensurable content is linked to the first problem, because the content of relationships is strongly related to the roles that two partners divide between themselves, as case 3 illustrates. In prior dyadic collaborations, Claudius and Falstaff developed ''quick and dirty'' products that they brought to market quickly, while Falstaff and Lear developed complex products that were tested extensively before release. Before Lear joined their collaboration, Claudius and Falstaff had planned to develop a ''defeatured'' version of server virtualization technologies that gave customers limited ability to modify the system but would accelerate the product to market. After Lear joined, Claudius was surprised to learn that Falstaff's managers had come to prefer richly featured technologies that would provide more value. Underlying Claudius's preference for a defeatured product was the desire to beat rival ''Viola'' to market. As one informant said, ''We were looking to dig a deep moat around this advantage. Maybe it would take Viola two or three years to catch up.'' Lear and Falstaff had less competitive interactions with Viola, and although their partnerships with Claudius were strong, they were not particularly interested in hurting Viola's position. Instead, Falstaff's interest was to drive adoption of its new virtualization technologies, while Lear's desire to offer a richly featured product stemmed from a wish to demonstrate how each of its different applications could take advantage of virtualization technologies.

To mollify Claudius, the group removed features to accelerate development, which proved unsatisfactory: although they agreed in principle to defeature the product, doing so proved difficult in practice. Many ideas for new features continually emerged during engineering, and Lear's executives abided by the letter of the agreement by instructing their engineers to ''codify'' and ''document''

these new ideas so they could return to them in the future. Their engineers' excitement proved infectious, however, and soon Falstaff's and even Claudius's engineers were working on new feature ''side projects'' that were not sanctioned by the collaboration's managers.

Problems with incommensurable content in the spam and instant messaging collaboration (case 4) were more social than technical. Lear and Antonio's managers had established a pattern of engaging participants around elaborate sporting events and dinners, which family members could attend, that solidified informal work relationships. But Cressida's managers preferred to bond with their partners through marathon work sessions that developed camaraderie naturally—they maintained their startup roots, disdaining expensive events and dinners. Both Lear and Antonio had adapted to Cressida's unique style before, having individual employees in each organization who were former startup founders and could ''speak Cressida's language.'' But in this unified triad, there was overwhelming pressure on Cressida to attend outside social events. As one Cressida manager described,

> We finally got the impression that they were collaborating just to skim their expense accounts. We needed this project to work for the sake of our company, and they just didn't seem committed. . . . They harped on us to attend those stupid dinners, so we just started sending Ryan and Jake to entertain them while we would stay back and get the work done. Ryan's a joker, and Jake's pretty funny too.

Jake had a different view. ''Their kids loved me, but the senior Lear people gave me a hard time for why my bosses didn't show up, especially when Antonio's managers always made it from out of state. I think they felt disrespected by my bosses. I saw the alliance blow up before any of them did.'' The personal nature of this conflict may account for why this group had the highest final conflict rating in this study, 8 out of 10. This disagreement about basic collaborative roles generated acrimony that carried through this triadic collaboration, leading the partners to abandon the projects before completion. The triad produced no new technologies, and participants ranked its innovation performance rating at 2 out of 10. The group produced no subsequent collaborations.

The combination of overlapping roles and incommensurable content is especially pernicious, as case 3 illustrates. Claudius's managers became frustrated because despite agreeing to drop several of their preferred features from the roadmap, their partners had completed several ''optional'' features. The resulting outputs were a few prototype server integration technologies that were never incorporated into products. Customers were forced to develop their own legacy software to integrate Claudius and Lear's server systems and software, and Falstaff and Claudius would forgo opportunities to embrace virtualization at the moment it was becoming an important technological trend.

This example is particularly interesting because Falstaff and Claudius likely could have achieved some level of server integration and virtualization innovation had Lear not been involved. After the failure, however, Falstaff and Claudius expressed no further interest in dyadic collaboration, suggesting that the interactions with Lear had generated irreversible misunderstandings, negative emotions, and resource expenditures that closed off options for innovation that might have existed before. There is some evidence that tie strength weakened after the unified triad. An executive vice president at Falstaff explained:

> We spent months trying to make the ultimate triad alliance: the best hardware company, the best systems company, and the best operating systems company . . . coming together to create tighter integration of our server hardware, software, and networking equipment. What could go wrong? Well, we spent months trying to hammer out an agreement, and at every meeting we'd either find a market where two of us compete with the other, or an area where one of us would want to join the other two but one partner would object. Ugh. At some point this got acrimonious, so we just gave up. I think this created lasting distrust.

In these two cases, unified triads appeared to overly constrain innovation because of conflicting roles and many competing demands that stemmed from different incommensurable relationships. Although it may be possible to resolve these conflicts, attempting to do so requires extra investments in coordination and communication (e.g., meetings, formalized and repeated presentations to multiple stakeholders), decelerations in development (e.g., rework, make-work, stop-gap projects), and/or changes to project objectives (e.g., deciding on lower-performing technologies, addressing fewer customer segments). Because the typical solutions to conflict suggested by the group dynamics literature are not available in these organizational triadic groups—superordinate goals or a high-power external monitor—this intragroup conflict is maintained (Sherif et al., 1961; Jehn, 1995). As the Falstaff vice president indicated, there may be some effect of unified triads on diminishing trust too, but the trust measures indicated that this may be only minimal: case 3 has an average reduction in trust (i.e., final minus initial) of 1 unit, whereas case 4 has an average trust reduction of 2 units. It is perhaps not surprising that although conflict is rampant, trust is not severely diminished, because there was no strong perception of unfairness, hidden opportunism, or shirking obligations in unified triads as interactions are out in the open. Even so, the moderately trusting foundation did not compensate for the negative effect of high conflict on innovation.

Group Cycling

Parallel dyads and unified triads are collaborative forms that generate different multipartner collaboration problems. Two groups in this study took a different approach: by isolating third parties from specific dyads and linking the content of consecutive dyads, these groups generated an extended sequence of dyads with high innovation performance. In this process, the active dyads appear to ''cycle'' around the edges of their triadic relational structure over time, which inspired the name of this process: group cycling.

Why multiple partners cycle through collaborations in groups. Typically, partners engage in group cycling because they wish to minimize conflict and misunderstandings that can occur when all members are present in a single collaboration, while ensuring that resources from multiple group members can be combined in innovative ways over time. A good example is Rosalind, Portia, and Lear's collaborations about mobile e-mail and operating systems (case 5). A key concern of each partner was accessing resources and ensuring participation while minimizing conflict. As leading mobile applications, operating systems, and device companies, Rosalind, Portia, and Lear had overlapping and

distinct competencies. Consequently, they foresaw potential conflicts (e.g., use of open vs. closed software, distinct product marketing strategies, and different approaches to managing R&D) that were related to prior roles and relationship patterns. To mitigate this risk, they conducted four distinct dyadic collaborations that were sequenced in time, including an initial collaboration focused on new mobile e-mail technologies (Rosalind and Portia) and three subsequent collaborations that made use of these technologies to enhance productivity applications (Rosalind and Lear), Internet browsing (Rosalind and Lear), and search functionalities (Portia and Lear). Generating an effective cycle of dyadic collaborations depended on two key mechanisms: third-party isolation and dyadic linking.

Third-party isolation and dyadic independence. Third-party isolation occurs when two parties collaborate without the participation of the third party. I recorded instances of isolation conservatively as occurring only when a third party was left inactive relative to two parties who were actively engaged in a technological collaboration. Of course, the third party continues its own activities and may communicate with the other two parties, but during isolation it does not participate in meetings, decision making, or informal interactions about the content of the joint technological development in the dyad. Isolation is also distinguished from parallel dyads because third parties who are isolated do not participate in other dyads with the two parties simultaneously. Of course, isolated third parties often need to be convinced that isolation is in their interest, such as by learning the potential outcomes of future collaborations. Isolation enables partners to alleviate the constraints and conflicts that emanate from third-party members and enables the two partners to maximize their joint capacity to innovate without interference.

Ariel, Cleopatra, and Lear's highly innovative middleware and virtualization collaborations (case 6) are good examples of how partners can effectively isolate third parties. The collaboration began when Ariel and Cleopatra identified a large opportunity to transform enterprise software to interface richly with the Internet. Ariel, a software and hardware systems company, had an open architecture and a set of tools for writing Internet-enabled software. Cleopatra was an enterprise software firm that sold traditional client- and server-based software like billing, supply chain, and sales management products to large enterprises. Together, the firms came up with the idea to use Ariel's tools to develop new middleware that would allow Cleopatra's software to access the Internet and would then be used to create virtual machines that would run independently of a user's current desktop or the Internet systems he or she would access. The collaboration would help Ariel by promoting its Internet software tools and server products that leveraged these tools. It would help Cleopatra by enabling its enterprise software to access the Internet in a rich fashion.

Ariel and Cleopatra considered inviting Lear into this initial collaboration because it could provide necessary technical expertise about virtualization for consumer software—linking with Lear's enterprise software and operating system platform would broaden the reach of any technologies they designed. The prior history of dyadic collaborations among the three partners gave them some confidence that a three-way collaboration could be successful; for example, the three had pursued multiple procurement contracts, technology standards, joint

sales and marketing initiatives, and technology collaborations together in the past. Like other groups in this sample, this group began with high initial trust (8 out of 10) and low initial conflict (4 out of 10). Ultimately, Ariel and Cleopatra decided to pursue a group cycling approach because they wanted to isolate Lear from the initial collaboration while preserving the option to collaborate with it later. An Ariel executive explained,

> We worried that Lear would demand huge changes to any middleware to favor their [product set]. But this would kill the virtualization dream and platform independence. Keeping them out of the first project would let us achieve this dream . . . and [I was] sure [they'd] eventually want to work with these technologies.

Managers wanted to avoid the surreptitious third-party involvement observed in the parallel dyads cases described above and maintain trust. To effectively isolate Lear from the initial collaboration while preserving the opportunity to collaborate with it later, managers from Ariel and Cleopatra contacted managers at Lear to let them know about their middleware plans. Although future collaborations were not planned in detail, the team presented its vision of a general-purpose middleware that Lear and other firms could use to access the Internet. Lear's managers had heard rumors about Ariel and Cleopatra's collaboration, so they were satisfied to be thought of as future partners.

Without Lear's involvement in the initial collaboration, Ariel and Cleopatra were free to design Internet-enabled middleware for enterprise software without having to consider Lear's preferences. Although many projects were possible, they envisioned a particularly robust Internet-based middleware that could support three of Cleopatra's most important enterprise applications. The advantage of beginning with Cleopatra's applications was that it would reveal some general problems that any software provider would encounter. Yet the middleware would also be tailored enough that Cleopatra could produce some quick enhancements to its products. Had Lear been involved, it would have probably demanded interfacing with its applications as well, which would have doubled the work.

Isolation can be either unilateral or negotiated. During unilateral isolation, two parties collaborate without the third party's knowledge or agreement, whereas negotiation involves some third-party consent. For example, Rosalind and Portia (case 5) began with unilateral isolation in their mobile e-mail technologies, while later collaborations about Internet browsing and search were negotiated. In Ariel and Cleopatra's first collaboration (case 6), isolation began unilaterally and only later required some negotiation as Lear's managers learned about the project. Yet Ariel and Cleopatra resisted Lear's attempts to join by conducting a series of presentations at Lear's headquarters in which they convinced Lear to stay out of the project. Despite this rejection, the group maintained trust, with a final trust rating of 7 out of 10. A critical question is why Lear agreed to be temporarily isolated and why trust issues did not arise as they did in the parallel dyad cases. I address this below.

Sequential linking and dyadic interdependence. Isolation achieves a degree of independence for two collaborators from third-party interference. By contrast, linking creates interdependence across dyads. The goal of linking is to

enable future collaborations with the third party to benefit from prior collaborations in which it did not participate. Linking can be achieved in a variety of ways, such as planning for the outputs of prior collaborations (e.g., materials, knowledge, technologies, products) to become inputs for future collaborations. Future collaborations can also benefit unexpectedly, such as from knowledge acquired in the prior dyads. In both cases, linking is an active process that imposes constraints and occupies managerial attention to tailor the innovation process to support the third party's technologies or understandings and to allow the third party to make effective use of prior outputs. The key point is that the two parties decide whether and how to reflect the third party's technologies and interests in the present collaboration. As implied above, isolation and sequential linking are related, because future collaborations may induce third parties to be isolated in the present.

In negotiating the collaborations in case 6, Lear asked to be involved with Ariel and Cleopatra in what would have been a unified triadic alliance. Ariel and Cleopatra turned down Lear's requests, instead proposing a set of possible dyadic collaborations with either Ariel or Cleopatra that would use the newly developed middleware technologies in some way once their initial middleware collaboration was complete. They also argued that the initial collaboration's focus on enterprise software (as opposed to consumer applications, which Lear focused on) would actually benefit Lear. Ariel and Cleopatra suggested that Lear could begin collaborating by modifying its enterprise software to reach the Internet with this new enterprise-focused middleware. After this ''quick win,'' more-ambitious collaborations could focus on Lear's consumer applications. Lear's top executive was persuaded by these arguments.

With Lear's isolation preserved, Ariel and Cleopatra extensively developed their middleware over the next two and a half years. Lear was updated on their progress twice in this period, which allowed Lear to prepare for its own collaborations with the two firms and adjust its product roadmap accordingly. Ariel and Cleopatra voluntarily made technical modifications to the middleware to make it easier to interface with Lear's products and saved these changes as a surprise for Lear, even joking that they were ''a reward'' for ''keeping out of our playpen.''

As the initial collaboration was ending, Lear's alliance team presented Ariel and Cleopatra with a proposal for new collaborations. After waiting over three years, it wanted immediate and tangible value from these subsequent collaborations. It proposed a second collaboration that would integrate Cleopatra's enterprise applications with Lear's calendar software using the new middleware, cutting down on time wasted switching windows and copying and pasting between applications. A third collaboration would create a single sign-on for Lear and Ariel's platforms that would truly integrate the user's experience across platforms. Lear had grander plans for a more-ambitious effort to connect all its applications to the Internet, but because that would be similar to the virtualization efforts that Ariel and Cleopatra envisioned, it left that project open for a future collaboration.

The group worked quickly on the second collaboration (Lear and Cleopatra's calendar project) and then the third collaboration (Lear and Ariel's sign-on project), which were streamlined because the middleware modifications by Ariel and Cleopatra made changes to Lear's codebase simple. This seemed to create goodwill in Lear—it was a tangible example of how technologies can be

modified in minor ways to anticipate future collaborations. As one Lear informant said, ''We really appreciated that—it made us think about the future of these projects and how they were connected.'' In response, Lear and Ariel made some modifications to their sign-on technologies to be of some use to Cleopatra's sign-on system as well. Both collaborations were highly successful in producing their intended innovations, and partners were able to maintain relatively low conflict by avoiding disagreement about participation. The group's conflict rating was low from start to finish, at 4 out of 10.

Linking can be either explicitly negotiated—so that outputs of prior collaborations become inputs to future collaborations—or rely on partners' tacit knowledge built up through prior collaborative experience and embedded in routines. In fact, not all future collaborations need to be planned. For example, Rosalind, Portia, and Lear (case 5) planned to cycle through only two dyadic collaborations focused on mobile e-mail and productivity applications but ended up collaborating on two additional projects related to mobile Internet and search that emerged only when the original two were completed. These emergent collaborations seemed to strengthen the already strong relationships among partners. In fact, some analysts argued that the two follow-on technologies from these emergent collaborations were the most innovative of all, with the subsequent collaborations receiving a subjective innovation performance rating of 8 out of 10.

Typically, partners plan only one or two collaborations ahead in the cycle because they would like to benefit from whatever serendipitous collaborative innovation ideas emerge. For example, the output of Ariel and Lear's fifth collaboration in case 6 about programming languages formed a surprisingly useful framework for using the middleware with Lear's software in the sixth collaboration with Cleopatra. With Ariel's help, Lear used the middleware to encode the application's data to its own format, in effect ''fooling'' a computer into accessing an ''Internet database that was actually just application data on the same computer,'' as one Lear manager described. This development paved the way for complete virtualization of middleware and applications in the seventh collaboration. A long cycle of four additional collaborations ended when participants agreed that all the major opportunities in middleware and virtualization had been exhausted.

Ariel, Cleopatra, and Lear's 11 collaborations enabled each company to change its technology roadmap and strategic trajectories. Based on the middleware and virtualized version, the companies created or revised programming languages, server software, applications, and websites in ways that provided great utility for customers seeking to connect these products to the Internet. Ariel and Cleopatra's participants in the initial middleware-focused collaboration gave it a 9 out of 10 average on innovation performance, and the subsequent 10 collaborations each received an average of 8 out of 10 from participants. Moreover, there is some evidence that group cycling strengthened already strong ties, as multiple participants hoped that their companies would launch future collaborations in different areas.

It is useful to compare the isolation and linking mechanisms producing group cycling to the other collaborative forms, parallel dyads and unified triads. In the groups using parallel dyads, partners attempted to isolate third parties by conducting multiple unlinked dyads at the same time, but third parties refused to remain isolated and reasserted themselves to influence the other dyads.

Problematic concurrent linkages emerged between collaborations that diminished trust. In the groups using unified triads, partners tried to avoid isolation by including all three partners in collaboration, but productive sequential linkages were never made because conflicting roles and relational content discouraged the emergence of new collaborations. Only with group cycling was the true isolation of third parties achieved, because partners could provide a credible story about how successive linkages would emerge between current collaborations and future collaborations, which motivated these third parties to remain isolated during others' dyadic collaborations.

DISCUSSION

Although most prior literature about collaborative innovation focuses on dyads, there is evidence that some leading firms use collaborations with multiple partners to create broader and more influential innovations (Powell et al., 2005; Ranganathan and Rosenkopf, 2014; Sytch and Tatarynowicz, 2014a). Existing literature tends to view multiparty relationships as decomposable into a set of independent dyads, yet neglects the possibility of third-party influence and interference in dyads or the difficulties of determining participation in true multipartner arrangements like triads, quadrads, or other forms in which multiple partners collaborate in a single alliance with common objectives. Using an inductive multiple-case study of triadic groups in the computer industry, I sought to develop a better understanding of the collaborative forms and processes organizations use to develop innovations with multiple partners.

Multiparty Collaboration as Group Dynamics

A better understanding of collaborative innovation may be possible by reframing multiparty collaboration as group dynamics, if we view interconnected organizations as members of distinct groups with their own unique processes that are not reducible to prior dyadic network structure. Groups encounter unique problems associated with multiparty interactions that are not adequately explained by thinking of collaborative relationships as multiple independent subforms (parallel dyads) or a maximal multipartner relationship (unified triad). I found that collaboration in larger multipartner forms like unified triads is at high risk of conflict that stems from overlapping roles and incommensurable prior relationships, while decomposing interactions into independent and simultaneous subforms like parallel dyads can generate trust problems and mismatched expectations about resource availability from third parties. The scores in table 3 illustrate the impact. These conflict and trust problems suggest that interorganizational collaboration can suffer from distinct coordination and cooperation challenges (Gulati, Wohlgezogen, and Zhelyazkov, 2012) in groups. To address these problems, organizations can employ supradyadic mechanisms at the group level, such as isolation and linking. The first mechanism, isolating third parties, gives pairs full control over dyadic collaborations and temporary independence from intragroup constraints and third-party interference. Isolation mitigates conflict that is associated with the presence of third parties, allowing parties to use well-established role allocations and relational patterns that are tailored to a given dyadic relationship (Davis and Eisenhardt, 2011). The second

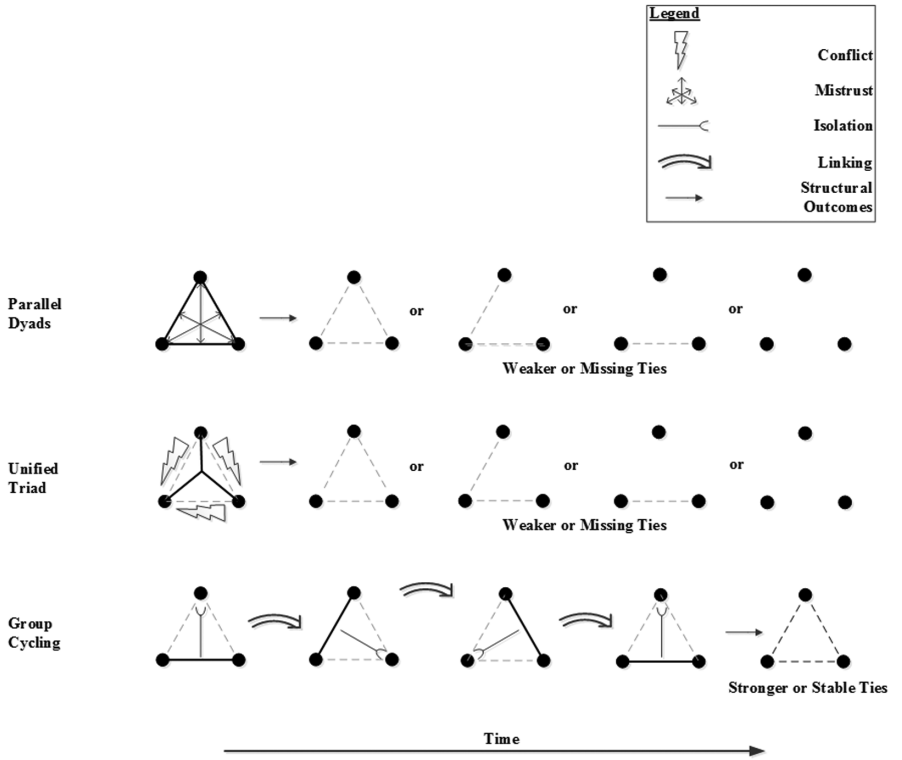
Table 3. Summary of Evidence Linking Group Dynamics and Innovation Performance

Technology focus	Partners	Collaborative form or process	Innovation Performance		
			Initial collaboration's performance	Other concurrent / subsequent collaborations	Other collaborations' performance
#1: Wireless networks and security	Falstaff–Macbeth–Lear	Parallel dyads	Low (5 out of 10)	2 / 1	Low (3 out of 10)
#2: E-commerce tools and online marketplace	Horatio–Mercutio-Lear	Parallel dyads	Medium (4 out of 10)	2 / 0	Medium (6 out of 10)
#3: Server integration and virtualization	Falstaff–Claudius–Lear	Unified triad	Low (3 out of 10)	0 / 0	N/A
#4: Spam and instant messaging	Cressida–Antonio–Lear	Unified triad	Low (2 out of 10)	0 / 0	N/A
#5: Mobile e-mail and operating system	Rosalind–Portia–Lear	Group cycling	High (7 out of 10)	0 / 3	High (8 out of 10)
#6: Middleware and virtualization	Ariel–Cleopatra–Lear	Group cycling	High (9 out of 10)	0 / 10	High (8 out of 10)

mechanism, linking subsequent collaborations, creates a useful interdependence across dyads that uses the outputs of prior collaborations as inputs to new collaborations, thus enabling more complex combinations to be constructed. Linking mitigates the trust problems associated with inactive third parties that maintain indirect relationships with both partners (Burt and Knez, 1995). Isolation and linking are complementary because their combined use ensures that partners can generate a lengthy cycle of dyads that makes effective use of third-party contributions.

A group dynamics perspective is also useful for reframing the broader interorganizational networks in which innovating organizations are embedded. The most influential alliance research generally conceives of interorganizational networks as a collection of independent relationships between pairs of partners (Powell, Koput, and Smith-Doerr, 1996; Gulati and Gargiulo, 1999; Ahuja, 2000a). Using the provocative imagery of E. A. Abbott (1884), it can be said that organizational theorists have so far restricted themselves to the ''flatland'' of two-member interorganizational relationships. Yet relationships with three, four, or more members defined by common objectives and interactions that are projecting ''out of the page'' could have an outsized influence on the performance outcomes of collaborations. As Simmel (1950) pointed out, it is difficult to conceive of fully independent dyads in the broader context of triads and larger groups if they change their character in the presence of others. For this reason, network scholars have largely ignored these supradyadic interactions (cf. Zuckerman, 2010, for a discussion of commensuration in social network analysis). A key insight of my study is that group-embedded dyads are fundamentally different from the isolated dyads that are the unit of analysis in most alliance research because of the influence of supradyadic conflict and trust on

Figure 3. Mechanisms and structural outcomes in organizational groups.



the combinatorial potential of groups. An implication is that some prior alliance research may reflect omitted variable bias if the sample of successful dyads is embedded in unmeasured group structures that shape interdependence and actually determine performance. Research that combines network and group measures may offer a more powerful and complementary explanation of innovative relations than networks alone (see also Granovetter, 2005).

Despite their differences from dyadic networks, these small group structures may depend on dyadic relationships. In my sample, all groups began with longstanding dyadic relationships, which may be necessary for these complex group processes, as prior literature has indicated (Baum, Shipilov, and Rowley, 2003; Rowley et al., 2004; Khanna and Rivkin, 2006). The findings suggest that dyads are an essential combinatorial unit in organizational groups that can best be understood in relation to other dyads through linking relational content. My study adds some unique implications for understanding the strength of long-term dyadic relationships in groups. The data indicate that group dynamics may be an antecedent of tie strength, as depicted in figure 3. All the organizations using unified triads and parallel dyads in my study have had no subsequent collaborations since those failed interactions. The mistrust and conflict that stem from these collaborative forms seem to diminish both cooperation and coordination (Gulati, Wohlgezogen, and Zhelyazkov, 2012), suggesting that the underlying interorganizational relationships may weaken beyond repair. Ironically, partners undertaking the most cohesive collaborative form, a unified triad,

appeared to have the strongest conviction to ''never collaborate again'' and ''avoid those guys like the plague,'' perhaps because the conflict engendered there effectively dissolved these relationships. By contrast, a few partners have conducted non-technology-focused alliances and even a merger following group cycling, suggesting that effective group processes can maintain or even strengthen underlying interorganizational relationships.

Finally, the broader contribution is to research on how organizations innovate in the interdependent technology ecosystems in which collaborative groups are most often observed (Bresnahan and Greenstein, 1999; Adner and Kapoor, 2009). A key problem that innovation and organization theorists address is how multiple contributors break down and reassemble components to build complex innovations (Simon, 1962), such as a computing platform. The modularity of modern information technologies undoubtedly aids in decomposition and cumulative innovation on platforms (Baldwin and Clark, 2000), but modularity alone is not enough to ensure that groups successfully innovate in these interdependent environments, particularly if innovation requires collaboration among multiple partners. Group innovation processes may be necessary antecedents of complex innovation in interdependent industry ecosystems (Adner and Kapoor, 2009). Future research could compare the group dynamics of different platforms (e.g., iPhone vs. Android) to explore further.

Alternative Explanations and Boundary Conditions

Differences in innovation objectives may possibly account for differences in performance if they shape the aspirations of collaborators (Greve, 1998).[5] Yet this explanation seems unlikely in my study, because the initial objectives of the collaborations indicate comparably high aspiration levels and similar desires for both upstream and downstream benefits of innovation across cases. All collaborations initially pursued here ultimately became important markets in the computer industry, with significant investment in these alliances.

Another possibility is that differences in technology types could be responsible for differences in innovation.[6] For instance, there may be differences in interdependence across technologies (Thompson, 1967), and certain pairs of capabilities are inherently more complementary than others (Milgrom and Roberts, 1995). To some extent, the existence of strong dyadic relationships and the common inclusion of Lear controls for these factors, but these could underlie differences in innovative potential or the match of processes and projects. For example, group cycling would seem better suited to sequentially independent tasks than pooled or reciprocal interdependence, in which parallel dyads and unified triads might be more appropriate, respectively. Also, software is sometimes thought to be more flexible than semiconductor projects

[5] The concern is that some objectives may be less ambitious to start and easier to achieve. Or perhaps some partners desire only upstream benefits of innovation like patents while others desire only downstream benefits like revenue. These differences could account for differential motivations of partners that could shape the innovation performance of groups. I appreciate the suggestions of two anonymous reviewers to consider whether differing aspirations and objectives could be determining differences in group innovation performance.

[6] I appreciate the suggestion of a reviewer to consider this alternative explanation. Innovative potential and task interdependence are important issues that are known to shape outcomes but do not vary substantially in my sample.

(Cusumano, 1995). But these explanations are unlikely here, because similar capabilities and technologies were involved in both more and less innovative collaborations. All collaborations brought together well-known bases of complementarity in this industry (e.g., circuits/systems, middleware/applications) (Mitsuhashi and Greve, 2009). IT sectors are characterized by moderate-to-high interdependence, but the modular interfaces and specialized layers of the computer industry let participants choose whether complex innovation is managed in a sequential, pooled, or reciprocal manner (Bresnahan and Greenstein, 1999; Baldwin and Clark, 2000). Other inducements for dyadic collaboration—firm size, uncertainty, and rivalry—are likely to promote group collaboration as well (Ahuja, 2000b; Hoang and Rothaermel, 2005; Schilling and Phelps, 2007; Schilling, 2015). Finally, elements of software, systems, and circuits appeared in all cases, and representative collaborations in which the dominant focus was one of these had both high and low innovation performance, suggesting that a technologically determined explanation is not consistent with these data.

Another alternative explanation is that relational differences in combinations of partners account for innovation. For instance, high initial trust and strong relationships may be a boundary condition of group cycling's effectiveness.[7] Moreover, if different pairs of partners have differential needs for Lear's contributions, this could mediate innovative success (Katila, Rosenberger, and Eisenhardt, 2008; Rogan and Greve, 2015).[8] Yet in reanalyzing the data, I discovered no major asymmetries in resource needs or the usefulness of Lear—these organizations are best characterized as being in a state of mutual dependence (Casciaro and Piskorski, 2005; Gulati and Sytch, 2007). Lear was prominent in multiple markets at the turn of the millennium, and each partner could see the utility of collaborating with it. Yet this does suggest that mutual dependence may be a boundary condition for this theory and an antecedent of group cycling's success. Without mutual dependence, group members could conceivably isolate third parties, avoid multiparty collaborations, and collaborate in parallel dyads if expectations of third-party contributions could be kept to a minimum. This suggests that a more-thorough exploration of the relational antecedents of group dynamics should be undertaken. This study highlights the variability of processes and outcomes when groups begin with seemingly beneficial structural conditions. By relaxing the selection criteria of this study (strong relationships, high trust, low conflict, symmetric power relations, and complementary capabilities), researchers could explore the viable configurations of structure and processes in a larger sample.

This study takes some first steps toward exploring how groups of organizations innovate collaboratively, moving beyond dyads to see multipartner innovation efforts as involving group dynamics in which a variety of collaborative forms and processes can be used to complement a network of socially embedded relationships. Future studies could explore other collaboration

[7] I appreciate the suggestion of an anonymous reviewer about antecedent conditions like trust and symmetric power. Though I am limited in my ability to make strong inferences beyond these sample selection criteria, it is possible that group cycling and other processes have use in cases of low initial trust or asymmetric power, as suggested by the reviewer, or that trust and symmetric power are substitute antecedents of group cycling.

[8] I appreciate the suggestions of two anonymous reviewers to consider whether resource dependence or Lear's usefulness might shape outcomes. The distinction between asymmetric dependence and mutual dependence is useful in these cases.

mechanisms at the group level of analysis, as interdependent ecosystems become more prominent and innovation in groups becomes more central. If the emergent theory presented here survives empirical test, it could broaden our perspective of how organizations innovate collaboratively from an independent dyadic view to one that includes organizational groups.

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