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Group Dynamics and Interorganizational Relationships: Supradyadic Innovation in Collaborative Ecosystems

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This paper explores how organizations innovate collaboratively with multiple partners. While research about multipartner alliances often treats them as a collection of independent dyads, this view neglects the possibility of third party influence and interference in dyads that can inhibit innovation in organizational groups. How organizations innovate with multiple partners in light of these problems is not clear. Using a multiple case, inductive study of six triadic groups of organizations engaged in technology and product development in the computer industry, this paper examines the collaborative forms and processes that organizations use to innovate with multiple partners in groups. Groups using two collaborative forms – parallel dyads and unified triads – generated mistrust and conflict that stemmed from interactions with third parties. These groups had low innovation performance and weaker ties in this study. Yet other groups were able to avoid these problems using unique supradyadic mechanisms – isolating third parties and linking dyads between different pairs – to generate a sequence of innovative collaborations that cycle through combinations of partners in the group and strengthen ties. The main theoretical contribution is to research about the organization of innovation by re-framing multipartner collaboration as group dynamics that shape innovation.

Keywords: Group Dynamics; Collaborative Innovation; Alliance; Ecosystem; Interorganizational Relationship; Multiplexity; Networks.
JEL Classification: M13

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One of organizational theory's greatest achievements is a detailed understanding of why organizations form relationships with each other and to what ends. Among the most important types of relationships are technological collaborations that companies use to develop new innovations across organizational boundaries. In industry ecosystems like computing and communications, resources are widely distributed so that organizations are often compelled to form interorganizational relationships to access resource inputs necessary for innovation (Ahuja, 2000b; Powell, Koput, & Smith-Doerr, 1996; Sytch & Tatarynowicz, 2014a). Prominent examples include the alliances Intel and Microsoft used to develop the Wintel platform and gain control of the PC ecosystem (Bresnahan & Greenstein, 1999; Casadesus-Masanell & Yoffie, 2007). However, analysts are quick to note that despite this well publicized "collaborative innovation" activity, only a few of the collaborations attempted by companies successfully produce innovations (Ahuja, 2000a; Davis & Eisenhardt, 2011; Stuart, 2000). Why are some interorganizational collaborations more innovative than others?

Although collaborative arrangements can occur between any number of organizations, collaborative innovation has mostly been explored in dyadic alliances in which pairs collaborate. Many organizational analysts approach dyadic alliances from the perspective of social embeddedness (Granovetter, 1985), in which partners with interorganizational relationships characterized by a long history of working together are thought to account for their greater output than those without such a history (Gulati, 1995b; Uzzi, 1997). That is, the experience and trust gained in prior ties explains whether future ties are likely to be successful (Gulati, 1995a; Rowley, Behrens, & Krackhardt, 2000; Zaheer, McEvily, & Perrone, 1998). This structural explanation is complemented by rich, processual accounts of alliance governance processes that depend on social embeddedness but explain additional variation (Doz, 1996; Gulati, Khanna, & Nohria, 1994; Larson, 1992), such as a rotating leadership process in which organizations alternate control (Davis & Eisenhardt, 2011). Yet while the consensus around dyads has been solidifying, evidence is emerging that collaborating with *multiple* partners is the reason leading firms in the new millennium are able to access a broader array of resources and innovate more than their rivals (Lavie & Singh, 2012; Ozcan & Eisenhardt, 2008). 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). The period under study – roughly, the 2000s – is commonly understood to have enjoyed an explosion of collaborative activity and broader, multipartner "ecosystems," which scholarship is only beginning to explore (Adner & Kapoor, 2009; Bresnahan, Yin, & Davis, 2014; West & Wood, 2013).

There has been some attempt to extend embeddedness thinking to larger multipartner arrangements by treating these relationships as a portfolio of independent dyads (Khanna & Rivkin, 2006; Lavie & Singh, 2012; Ozcan & Eisenhardt, 2008). 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, research finds that dyadic relationships often precede triadic alliances (Nohria & Garcia-Pont, 1991; Rowley et al., 2004), and increase their likelihood of success (Browning, Beyer, & Shetler, 1995; Khanna & Rivkin, 2006). Building on closure theory, these studies suggest 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 (see Granovetter, 2005 for a discussion). That is, even closure models (and brokerage models to 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 (e.g., combinations of supradyadic and dyadic interactions) with which to search for innovations. However, the few empirical efforts examining multipartner alliances have mostly described their challenges: these include an increased likelihood of disagreement and conflict with a large number of partners (Beckman et al., 2014; Lavie, Lechner, & Singh, 2007; Rogan, 2013), as well as a surprising lack of trust (Browning, Beyer, & Shetler, 1995; Heidl, Steensma, & 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 Georg Simmel's (1950) analysis of triads, a set of insights that 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). For instance, Simmel (1950) noted how difficult it was for three or more people to speak frankly or become perfectly unified in their views when third parties were present 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 & Morris, 1978). Yet subgroups entail their own risks to the strength of the underlying relationships if conflict and mistrust are generated by the exclusion of members (Heider, 1958; Simmel, 1955). That is, members face a constant choice about who participates in each interaction that has important implications for group dynamics (Wageman, 1995).

While the dyadic mechanisms underlying social embeddedness do not address the group participation problem, it is possible that embedded relationships actually amplify this challenge (Azoulay, Repenning, & Zuckerman, 2010; Beckman et al., 2014), as the more extensive and idiosyncratic relational histories of embedded relationships may produce stronger expectations of future participation that make it difficult to decompose tasks into subsets of participants. In fact, conflict stemming from the multiplexity of longstanding roles and relationships seems to underlie many of the multipartner-alliance difficulties identified by strategy and organization scholars (Shipilov et al., 2014), including the inability to resolve product-market rivalries (Gimeno & Woo, 1996; Shipilov & Li, 2010), gain agreement about standards (Browning, Beyer, & Shetler, 1995; Ranganathan & Rosenkopf, 2014), and integrate knowledge across multiple boundaries (Rogan, 2014; Rosenkopf, Metiu, & George, 2001). 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 thereby extend our 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. The primary contribution is to conceive of multipartner alliances as organizational groups and to identify supradyadic network processes by which organizations mitigate problems arising from third party influence and interference in others' relationships. Given the 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 over time. The groups shared many similarities, including a "closed triad" structure in which all three member-organizations had prior embedded dyadic relationships, and new innovation objectives requiring contributions from multiple partners. Each of the organizations is a market leader in their sector of the industry (e.g., semiconductors, hardware, software, web services), with strong R&D capabilities in related areas (e.g., circuit design, systems integration, Internet software). Selecting cases that shared these structural characteristics enabled me to focus the analysis on less-explored group collaboration processes.

The findings focus on the collaborative forms and processes multiple organizations use to innovate in groups. Some groups examined in this study used a fixed collaborative form such as a set of independent parallel dyads or a single unified triad that was not extended beyond the initial efforts. Yet these fixed forms generated mistrust and conflict stemming from expectations about third party participation and overlapping roles. Mistrust and conflict diminished resource mobilization and decelerated technological development, leading to low innovation outcomes and, ultimately, weaker ties. By contrast, the innovative groups I studied were able to avoid these problems using a dynamic collaboration process that I call "group cycling" which extended innovative interactions across time. Managers in these cases viewed their triads as a small group in which collaborative dynamics and third party interests must be carefully managed across time. The group cycling process decomposes innovative

activities into a series of interlinked dyads between different pairs of partners – in this way, active collaboration can be said to "cycle" around the edges of a triad (or a larger group structure) and, ultimately, strengthen ties. By temporarily restricting participation to pairs, managers can choose which ideas, technologies, and resources to incorporate from third parties into single dyads, and then ensure that the outputs of multiple dyads are combined into a broader innovative whole.

The main theoretical contribution is to research about the organization of innovation. Prior literature generally views collaborative innovation as a joint recombinant search by two partners (Ahuja, 2000a; Davis & Eisenhardt, 2011; Powell, Koput, & Smith-Doerr, 1996; Stuart, 2000). Yet this approach neglects the many complex product platforms like smartphones, servers, and MRI machines that rely on technologies developed collaboratively by organizations in three or more sectors and the unique problems related to innovation with multiple partners (Gawer & Henderson, 2007; Lavie, Lechner, & Singh, 2007). By re-framing multipartner collaboration as group dynamics, this study identifies unique collaborative processes that extend interactions beyond what is possible by conceiving of collaborative innovation as synonymous with either independent subforms like parallel dyads or the maximal multipartner alliance form like a unified triad. The findings also contribute to network theory with insight into how actors manage supradyadic interactions in multiplex networks (Kuwabara, Luo, & Sheldon, 2010; Rogan, 2014; Shipilov, 2012). By selectively activating and interlinking their dyadic relationships in series, groups can mitigate third party interference and benefit from the greater combinatorial potential of multiple partners. The final contribution about how organizations innovate in the interdependent technology ecosystems where collaborative groups are often observed (Adner & Kapoor, 2009; Bresnahan & Greenstein, 1999). This study suggests that innovation in industry ecosystems, and the relative performance of product platforms, may be related to small group processes that enable partners to generate both independence from third parties within dyads and interdependence between dyads in 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, & Shetler, 1995; Dokko & Rosenkopf, 2010; Rosenkopf, Metiu, & George, 2001; Rysman & Simcoe, 2008). Retail and service organizations participate in peer groups to discover best practices and motivate managers (Whitford & Zeitlin, 2004; Zuckerman & Sgourev, 2006). Large business groups are formed to increase market power and consolidate ownership (Ghemawat & Khanna, 1998; Khanna & Rivkin, 2001; Perkins, Morck, & Yeung, 2006; Rowley et al., 2004). And firms increasingly use multipartner alliances – typically, triadic collaborations – for innovation, especially in industries where activities span more than two sectors (e.g., circuits, hardware, and software), as in information technology (Heidl, Steensma, & Phelps, 2014; Lavie, Lechner, & Singh, 2007).

A unique rationale for forming and joining groups is to access the diverse resources of the multiple partner-organizations to achieve complex objectives like innovation (Baum, Calabrese, & Silverman, 2000; Guillen, 2000; Gulati & Westphal, 1999; Sakakibara, 1997). Yet although these motives are prominent, it appears that triadic (or larger) groups are relatively rare compared to the plethora of alliance dyads, suggesting some unique challenges of collaborating with multiple partners in a group. As noted above, groups are often characterized by conflict and mistrust that is related to disagreements or unmet expectations about who participates in collaborative interactions (Browning, Beyer, & Shetler, 1995; Casadesus-Masanell & Yoffie, 2007; Gimeno & Woo, 1996). From a network perspective, the major risk is that competing subgroups will emerge and isolate members (Heidl, Steensma, & Phelps, 2014; Lau & Murnighan, 1998; Sytch & Tatarynowicz, 2014b) who might be useful during innovative development. Yet because members can choose participation in groups (Simmel, 1950), there may be some capacity to select appropriate participants and mitigate conflict and mistrust. But to date there has not been extensive research about the processes used by groups of organizations to shape participation and collaborate over time.

Although not focused on multipartner collaboration, prior research about dyadic innovation is an important foundation for this study. The literature conceives of innovation as a recombination process that brings together existing elements in new and useful ways (Fleming, 2001; Schumpeter, 1934). Managers often look to collaborative arrangements to engage in a broader recombinant search that combines their

own organization's resources with those of a partner (Ahuja, 2000b; Rosenkopf & Almeida, 2003). One illustrative study is Rosenkopf and Nerkar's (2001) research about innovation in the optical disk sector. They found that the most innovative technologies like the compact disc (CD) came from a search process that combined different technologies of partners. The collaborative process is more likely to generate broad search than an in-house process because a more complementary and diverse set of combinations is possible in the resources of two organizations than one.

Yet achieving broad search collaboratively can be difficult, with only a small set of organizations actually developing innovations collaboratively. A major problem is that since 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 & Dahlander, 2014). When partners engage in recombination together, they may offer their own constraints on technological development not veto those of their partners. This can lead to partners choosing the lowest common denominator solution that will enable a sufficient – albeit less then innovative – outcome. Davis and Eisenhardt's (2011) study of technology collaborations describes 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 is explored.

Although these broad search processes are seemingly relevant, a number of issues arise in their application to groups. First, it is not entirely clear if rotating leadership or other dyadic processes would be effective since applying them to multiple partners (e.g., alternating control between three or more partners) might dramatically increase the likelihood of selecting an ineffective combination. Moreover, alternating control amongst multiple partners could take too much time, especially if the order of leadership is contested, a problem that is easier to resolve in dyads where non-leading partners are guaranteed to eventually assume control. Yet perhaps more important, 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. How multiple partners avoid the tendency towards local search is not clear.

The second major factor underlying successful collaborative innovation is the mobilization of resources for innovation (Allen, 1977; Katz & Tushman, 1981). Research about dyadic innovation suggests that accessing these resources depends on active involvement and influence by managers in the organization in which they are located (Maurer & Ebers, 2006; Obstfeld, 2005) because the necessary individuals may be deep inside organizational networks and distant from the locus of action (Obstfeld, Borgatti, & 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 first gather a variety of different resources from different individuals and organizations before integrating them into a broader whole. This suggests a focused, dynamic process in which different collaborative activities are separated in time (Lingo & O'Mahony, 2009).

This research about dyads has implications for collaborations in groups. In groups, mobilizing resources in smaller subforms like dyads is difficult because nonparticipatory third parties may be reluctant to share resources in a project where they have no influence. 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, etc.) to ensure that each organization actively participates and provides resources. However, if mobilizing distant resources requires clear, unilateral control rights, as it often does in dyads, then 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 resource combination of two organizations that is apparently complementary may be ruled out because of a negative (or positive but very costly) interdependency from a third party (Beckman et al., 2014; Rogan, 2014). How multiple partners avoid conflict and choose collaborative forms to manage resource interdependencies is not clear.

The third factor in effective collaborative innovation is the maintenance of interorganizational trust. Consistent with the literature, interorganizational trust is defined here as an organization-wide expectation that a partner will fulfill obligations, behave predictably, and act with goodwill when it is possible to be opportunistic (Das & Teng, 1998; Gulati, 1995a; Zaheer, McEvily, & 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 partner 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 & 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. However, trust may be lost if one party acts opportunistically (or is perceived to do so) (Zaheer, McEvily, & Perrone, 1998). Although interorganizational trust is at a higher level of analysis than interpersonal trust, it can also be gained or lost because of individual managers' beliefs if subordinates follow their lead (Das & Teng, 1998; Larson, 1992). Trust can be lost when individuals perceive their partners as a competitive threat, even if this is based on incorrect information or misperception that stems from gossip (Burt & Knez, 1995). For example, Graebner's (2009) research on interorganizational trust in acquisitions showed that partners can have asymmetric trust. Specifically, sellers tended to have more trust in buyers than buyers had in sellers because of disparities in their expectations of the future, with sellers expecting to lose power while buyers expected to gain it (Graebner, 2009). There is some evidence that trust asymmetries can exist in longstanding alliances as well (Doz, 1998).

As outlined in the introduction, strong dyadic relationships with interorganizational trust can be a foundation for group formation and an antecedent of multipartner alliances. However, the role of trust *inside* group collaborations that focus on innovation has not been substantially explored; while it is possible that trust is 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

The research design is an inductive, multiple-case study of six triadic groups of large, established organizations. Multiple cases permit a replication logic in which the cases are treated as a series of experiments that confirm or disconfirm emerging conceptual insights (Eisenhardt, 1989). The research uses an embedded design (i.e., multiple levels of analysis) that includes the triadic group, dyadic relationships, organizations, divisions/units/functions, labs, teams, and individuals.[i] Established organizations provide a useful context in which to explore interorganizational collaboration, because they are likely to have the basic structural characteristics associated with collaboration performance (e.g., extensive collaborative experience, strong relationships, 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 the acquisition of one by another, thus putting the prospect of mergers and acquisitions in the background and making collaboration crucial.

The research setting is the computing and communications industries. Organizations in these industries 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 where technology collaborations are often used to develop innovations across sector boundaries, such as collaborations between semiconductor, hardware, and software complementor firms (Bresnahan & Greenstein, 1999; Mowery & Rosenberg, 1998). Given the complex nature of information technologies, different resources from three or more firms may be needed to produce innovative products and services. As a result, multipartner interactions around innovation are salient in this context (Bresnahan & Greenstein, 1999; Ranganathan & Rosenkopf, 2014).

Data Collection and Sources

I used several data sources: qualitative and quantitative data from semi-structured interviews; publicly available data from Web sites, 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 that 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 within a large semiconductor company, Macbeth. Participant observation of boundary-spanning interactions strengthened my impression that triadic group-based collaborations were critical for these companies, as I detail below. Taken together, my triangulated, longitudinal data from primary sources in the field provide a rich view of technological collaboration within groups.

I mitigated informant bias in several ways (Golden, 1992; Miller, Cardinal, & 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 & Graebner, 2007).

Sample of Triadic Groups

For the initial study of dyadic collaborations, I had identified six pairs of organizations that were engaged in technological collaborations in which each firm also had a previous relationship with Lear. Lear is a prominent diversified computing firm with an extensive product line across the major areas of software (e.g., consumer, enterprise, server, Internet, mobility). In each case, a pair was considering whether to form a triadic multipartner collaboration with Lear, since inviting them to join in a multipartner collaboration 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. Consequently, focusing on triadic groups provided a tractable analytical window into organizational group dynamics.

The six triadic groups studied comprised twelve companies in the computing and communications industries, ranging from semiconductors (Macbeth) to operating systems (Lear,

Rosalind) to mobile devices (Rosalind, Portia). As described above, Lear was common in all groups – in addition, 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 competitors. Nine organizations were headquartered in the U.S. and three internationally, reflecting the global nature of these industries and enhancing generalizability. Details are in Table 1.

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. A quote by one Lear VP was indicative:

> "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 therefore saw themselves as having *both* strong interorganizational relationships, an important focus of prior alliance research, *and* membership in various organizational groups. Membership in groups with strong relationships can provide a strong foundation for productive collaboration (Granovetter, 2005; Khanna & Rivkin, 2001; Rowley et al., 2004). 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 MEASUREMENT APPENDIX, I found that participants had a high degree of consistency in perceptions of membership and little disagreement about group boundaries.[ii] Boundary disagreement never exceeded 17% in these cases, which increases confidence in the group unit of analysis studied here.

I analyzed all major technology collaborations produced by these groups from 2001 to 2012, naming each group for the primary technological areas where they focused. These areas span many of the relevant categories (e.g., Mobile Email and Operating Systems, Wireless Networks and Security, and

Spam and Instant Messaging) where innovations were emerging during this period. The six groups produced from one to eleven 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 triadic or set of dyads, and whether these sets were simultaneous or sequential. In each case, both formal (i.e., an alliance contract, financial arrangements) and informal (i.e., participation and communication) activity was indicated, suggesting that true collaboration was occurring.[iii] These collaborations are plotted in Figure 1.

An advantage of the research design is its focus on groups where partners had the key antecedents of superior collaboration performance, including extensive collaborating experience and dedicated alliance functions (Gulati, 1995b; Kale, Dyer, & 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 (Fleming & Waguespack, 2006; Tushman, 1977; Uzzi, 1997). All participants dedicated significant resources to joint development and governed their collaborations with loose "memorandums of understanding" (MoUs), incomplete relational contracts specifying "broad areas of technology exploration" (Baker, Gibbons, & Murphy, 2002; Mayer & Argyres, 2004). Finally, these firms were technical and market leaders (i.e., 1st or 2nd in market share) in their domains, and thus desirable partners who shared the common language of the IT industry (Ahuja, 2000a; Dougherty, 1992; Leonardi, 2011). Overall, 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-on from this. In the MEASUREMENT APPENDIX, I describe a multi-factor measure of the innovation performance of the initial collaborations which is consistent with

prior innovation literature (Ahuja, 2000a; Cohen & Levinthal, 1990; Fleming, 2001; Henderson & Clark, 1990; Katila & Ahuja, 2002). It includes five measures: (1) the new technologies generated by the collaboration; (2) codified intellectual property; (3) immediate product line impact (e.g., changes to an existing product platform or new releases); (4) market acceptance of the new technologies, including qualitative evaluations by analysts and immediate financial product performance; 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 the initial trust and initial conflict at the beginning of the case, as well as the final trust and final conflict at the end. This is detailed in the MEASUREMENT APPENDIX. Consistent with prior literature, I measure interorganizational trust is dyadically (i.e., A may trust B but not C) (Gulati, 1995a; Larson, 1992), and with three main components – fulfilling obligations or commitments, behaving according to expectations, and acting fairly (Graebner, 2009; Zaheer, McEvily, & Perrone, 1998). Collaborative conflict indicates the disagreements or tension of employees in two partner-organizations (Doz, 1996; Jehn, 1997; Pondy, 1967; Ring & Van de Ven, 1994). 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 of the partners can contribute useful resources to a broad recombinant search process, and when they are densely interconnected with dyadic relationships that could support trusting collaboration among multiple partners. 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

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 initiated simultaneously, they overlapped in time for most of their duration, as illustrated in Figure 1. Why do partners choose to conduct parallel dyads?

Why Multiple Partners Collaborate in Parallel Dyads. Group participants form parallel dyads for a variety of reasons. Often, partners are motivated to 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 1). 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. They believed that if resources from third parties became relevant, they could be incorporated at the end of the dyad. Second, there was some concern that three partners might have difficulty agreeing on strategic objectives in a triadic collaboration, especially related to whether they should emphasize the 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, partners using parallel dyads had low innovation performance in this study. Parallel dyads generated a surprising trust problem amongst 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 maintain some expectation that critical resources can be mobilized, should they become necessary, or that third parties will have some capacity to 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 lead 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 in this study began with high *initial trust* at the beginning of their collaborations, as detailed in Table 1. The groups using parallel dyads were unique in this study in the dramatic deterioration of trust during the collaboration, compared to groups using other collaborative forms and processes. The evolution of trust in all cases is detailed in Table 2. Why did trust decline in parallel dyads, and what impact did it have on innovation?

During parallel dyads, trust was diminished when third parties rebuffed their partners' requests for resource access. Although parallel dyads are ostensibly separate, partners often maintained a private expectation that critical resources from third parties could be accessed if necessary. Since 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 resource access. These demands defied the expectation of predictability and good will that underlie the trusting relationships.

Diminishing trust is illustrated by case 1, in which Falstaff, Macbeth and Lear initially agreed to parallelize their Wireless Networks and Security collaborations: as large semiconductor and networking equipment companies, Falstaff and Macbeth preferred to develop security technologies independently from Lear, in order to build platform-independent products that would work with operating systems from

both Lear and their competitors. The group began with a high initial trust of 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 Macbeth's managers decided that as changes to semiconductor product development would take a long time, they should begin collaborating with Lear quickly on how to include their security requirements in the circuit firmware. In a third parallel project, Falstaff collaborated with Lear to update their 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.

Soon, Falstaff and Macbeth's managers realized that they needed a more detailed understanding of Lear's security protocols and access to their 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, they 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, since 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 has publically 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 their 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."

On reflection, 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 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 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. Above, the problem of diminishing trust is seen from the perspective of the two partners involved in a dyad, yet diminishing trust arises from the unmet expectations of third parties as well. Although each partner agreed to forgo participation in their partners' 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 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 payments 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 email 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 worry about modifying the software to satisfy Horatio later, if it proved 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. However, limited time made it difficult to get the right executives together, and after seven months of back-and-forth over email and phone, only one face-to-face meeting was eventually 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 email—but not between 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 they 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 their 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 in order to focus on their 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, time and budget pressures forced them to focus on a rudimentary website that did not use XML richly and only sold Horatio's hardware system. This system fulfilled 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 of them 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. In fact, 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. On the one hand, third parties appear responsible for mistrust, as simple misunderstandings or disagreements can lead them to distrust their two partners. If they refuse resource access, this can lead the two partners to mistrust the third. From the third party's perspective, it is the two collaborators that are responsible for mistrust since

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 triadic basis for resolution, leading to delays that diminish innovation performance and subsequent dyads.

Unified Triads

As the parallel dyad cases illustrate, group members have expectations of participation in collaborations with other partners, despite having agreed otherwise when deciding on that collaborative form. Thus, one might assume that collaborating in a true multiparty arrangement could enable organizations to mobilize resources and avoid the participation disagreement that emerge in parallel dyads. Two groups 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. The process involves sending representatives from all three companies to 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, the data indicates that partners form unified triads as a vehicle for innovation because they believe it maximizes the chances that potentially innovative combinations of knowledge, technologies, and resources will 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. Finally − and consistent with the evidence about parallel dyads − group members using unified triads expressed a belief that strong relationships entail some rights to participate in any collaboration organized in the group context: organizations may be eager to maintain the sense of group solidarity and include partners that express 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 efforts. One vice-president at Falstaff summarized their motivations as follows:

> "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."

Additionally, these partners enjoyed strong prior relationships and recent innovative dyads – the combination of these structural factors and the eagerness of third parties to participate is a common antecedent of unified triads. Participants in each organization believed that these conditions were ideal for collective innovation. However, I found that groups working in a unified triad actually had low innovation performance because of conflict about roles and relationships, as I detail below.

Collaborative Conflict and Overlapping Roles. A critical problem in multipartner collaborations is that multiple partners may prefer to perform the same roles, or different roles that conflict. By roles, I mean 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 (Bechky, 2006; Doz, 1996) – 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. In unified triads, different members expected a single partner to assume two distinct roles, or else two partners encountered unexpected conflict as they enacted roles

that were unsuitable to a third party. Conflict challenged partners' expectations and increased the costs of coordinating activities, ultimately impacting innovation.

Usually conflict emerged over which group member would apply capabilities to a given problem. Nearly all of the complex organizations in these groups have some partially overlapping capabilities, so it is not surprising that disagreements arise. 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 a high initial trust of 8 out of 10 and low initial conflict of 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 firm had cutting-edge Internet software capabilities and argued that it should develop the platform. This conflict consumed several months and delayed development in which a different competitor released their own new anti-spam and instant messaging products. The group's final conflict rating was 7 out of 10.

Partners also had 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 upon 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 sets of demands from different sales managers would micromanage innovation efforts.

To resolve this disagreement, partners agreed to change the process by which the alliance would be evaluated so that sales managers would only participate in the final progress reviews. But this compromise proved unsatisfactory. Although Falstaff's managers could seemingly work without sales involvement, alliance managers at Claudius and Lear had difficulty making joint decisions without advice from their sales colleagues. Ultimately, 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 high 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 that make it difficult to reach agreement on joint innovation objectives or methods. By content, I mean 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, because the content of relationships is strongly related to the roles that two partners divide amongst themselves. It is useful to continue with case 3 to illustrate. 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 provided very little ability for customers 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." By contrast, Lear and Falstaff had less competitive interactions with Viola: 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 their new virtualization

technologies, while Lear's desire to offer a richly featured product stemmed from a wish to demonstrate how each of their different applications could take advantage of virtualization technologies.

To mollify Claudius, the group removed features to accelerate development. Yet this compromise about objectives proved unsatisfactory: although agreeing in principle to defeature the product, they found it difficult to do so in practice. Virtualization technologies proved to be an area where many ideas for new features were continually emerging during engineering. Lear's executives abided by the letter if not the spirit of the agreement by instructing their engineers to "codify" and "document" these new ideas so they could return to them in the future. However, their engineers' excitement about these new features proved infectious, and soon Falstaff and even Claudius's engineers were working on new feature "side projects" that were not sanctioned by the collaboration's managers.

By contrast, problems with incommensurable content in the Spam and Instant Messaging collaboration (case 4) were less technical than social. Lear and Antonio's managers had established a pattern of engaging participants around elaborate sporting events and dinners where the informal work relationships were solidified and family members could attend. 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." However, 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's has 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. This is illustrated in the Server Integration and Virtualization collaboration detailed above (case 3).

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.

What is particularly interesting about this example is that it appears that Falstaff and Claudius 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. That is, there is some evidence that tie strength weakened after the unified triad. An executive vice-president at Falstaff summarized:

> "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. While it may be possible to resolve these conflicts, attempting to do so requires either 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 (Jehn, 1995; Sherif et al., 1961). As the informant indicated, there may be some effect of unified triads on diminishing trust too, but the trust measures indicated that this may only be minimal: case 3 has an average reduction (i.e., final minus initial) in trust 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 more severely diminished, since there was no strong perception of unfairness, hidden opportunism, or shirking obligations in unified triads since 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: parallel dyads diminish trust in a manner that reduces resource availability and leads to disagreement about participation, while unified triads reveal conflicting roles and incommensurable collaborative objectives that decelerate development. In contrast, 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 were able to generate 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 Email 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 email 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 dependent on two key mechanisms – third party isolation and dyadic linking – that are illustrated below.

Third-Party Isolation and Dyadic Independence. Third party isolation occurs when two parties collaborate without the participation of third parties. In this study I record instances of isolation conservatively as occurring only when a third party is left inactive relative to two parties who are actively engaged in a technological collaboration. Of course, the third party continues their own activities and may communicate with the other two parties, but during isolation they do 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. As I describe below, the potential outcomes of future collaborations can be used as an inducement to sit out current collaborations. Isolation enables partners to alleviate the constraints and conflicts that emanate from third-party members, and 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, possessed an open architecture and 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 software 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. This middleware could then be used to create virtual machines that would run independently of a user's current desktop or the Internet systems they would access. The collaboration was in Ariel's interests because it would promote their Internet software tools and their server products that leveraged these tools. It was in Cleopatra's interests because it would enable their enterprise software to access the Internet in a rich fashion.

Ariel and Cleopatra considered inviting Lear into this initial collaboration. Although Ariel and Cleopatra could pursue some aspects of middleware and virtualization as a pair, Lear 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 different dyadic collaborations between the three partners gave them some confidence that a three-way collaboration could be successful; for example, the three had pursued multiple different procurement contracts, technology standards, joint sales and marketing, and technology collaborations together in the past. Like other groups in this sample, this group began with a high initial trust of 8 out of 10 and low initial conflict of 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 them later. An Ariel executive described their rationale:

> "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. In order to effectively isolate Lear from the initial collaboration whilst preserving the opportunity to collaborate with them 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 their vision of a general-purpose middleware that Lear and other firms could use to access the Internet. Lear had heard rumors about Ariel and Cleopatra's collaboration, so they were satisfied to be thought of as a future partner.

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 surface 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 their products. Had Lear been involved, they would have probably demanded interfacing with their applications as well, which most likely would have duplicated any general problems discovered in this phase, but also would have doubled the work because of the tailoring of the middleware to their product.

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 email technologies, while later collaborations about internet browsing and search were negotiated. By contrast, 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. How? 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 where they 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 for the third party to make the effective use of prior outputs. The key point, however, is that it is the two parties decide whether and how to reflect third-party technologies and interests in the present collaboration. As implied above, isolation and sequential linking are related, since future collaborations may induce third parties to be isolated in the present.

Consider the Middleware and Virtualization collaboration (case 6) discussed above. In negotiating the collaborations, 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, where Lear focused) would actually benefit Lear. Ariel and Cleopatra suggested that Lear could begin collaborating by modifying their 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 went on to complete extensive development of their middleware in an initial collaboration over the next two and a half years. Lear was updated on Ariel and Cleopatra's progress twice in this period, which allowed Lear to prepare for their own collaborations with the two firms and adjust their product roadmap accordingly. Of their own accord, Ariel and Cleopatra made technical modifications to the middleware to make it easier to interface with Lear's products. They saved these changes as a surprise for Lear and even joked 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, they wanted immediate and tangible value from these subsequent collaborations. They proposed a second collaboration that would integrate Cleopatra's enterprise applications with Lear's calendar software using the new middleware. This would cut 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 their applications to the Internet, but since that would be similar to the virtualization efforts that Ariel and Cleopatra envisioned they would leave that project open for a collaboration in the distant future.

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). These projects 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. That is, in contrast to unified triads, partners were able to maintain relatively low conflict by avoiding disagreement about participation. The group's final conflict rating remained low at 4 out of 10.

Linking can either be explicitly negotiated − so that outputs of prior collaborations become inputs to future collaborations − or reliant on tacit knowledge of partners 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 email and productivity applications, but actually ended up collaborating on two additional collaborations related to mobile internet and search that only emerged when the original two were completed. These emergent collaborations seemed to strengthen the already strong relationships

between 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 only plan one or two collaborations ahead in the cycle because they would like benefit from whatever serendipitous collaborative innovation ideas emerge. For example, the output of Ariel's and Lear's fifth collaboration about programming languages formed a surprisingly useful framework for using the middleware with Lear's software in the sixth collaboration with Cleopatra. With their help, Lear used the middleware to encode the application's data to their own format, in effect "fooling" a computer into accessing an "Internet database that was actually just application data on the same computer." 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 eleven collaborations enabled each company to change their 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 ten 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. However, 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. Yet productive

sequential linkages were never made because conflicting roles and relational content discouraged the emergence of few or no new collaborations. It was only in the cases with group cycling that true isolation of third parties was achieved, because partners could provide a credible story about how successive linkages would emerge between current collaborations and future collaborations; this motivated these third parties to remain isolated during others' dyadic collaborations.

DISCUSSION

I began by noting that although most of the prior literature about collaborative innovation focuses on dyads there is some evidence that leading firms use collaborations with *multiple* partners to create broader and more impactful innovations (Powell et al., 2005; Ranganathan & Rosenkopf, 2014; Sytch & Tatarynowicz, 2014a). Existing literature tends to view multiparty relationships as decomposable to a set of independent dyads. Dyadic network theory emphasizes the positive aspects of collaborating with multiple partners. For instance, social embeddedness theory suggests that both dyads were a useful foundation for triadic and larger arrangements (Granovetter, 1973). And closure theory suggests that third-party ties should enhance trust and diminish conflict in these relationships (Coleman, 1988, 1990). Yet these views neglect 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 where multiple partners collaborate in a single alliance with common objectives. What was unclear was how some organizations were able to overcome these problems and choose appropriate collaborative forms to achieve innovation with multiple partners. Using an inductive multiple case study of triadic groups in the computer industry, I sought to fill this gap and develop a better understanding of the collaborative forms and processes used to develop innovations with multiple partners.

Multiparty Collaboration as Group Dynamics

The findings suggest that a better understanding of collaborative innovation is possible by reframing multiparty collaboration as group dynamics. Echoing research about groups of individuals, underlying this perspective is a view of interconnected organizations as members of distinct groups with their own unique processes that are not reducible to prior dyadic network structure (Heider, 1958;

Simmel, 1950). 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).[iv] I found that collaboration in larger multipartner forms like unified triads are 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. This is summarized in Table 3. These conflict and trust problems suggest that interorganizational collaboration can suffer from distinct coordination and cooperation challenges (Gulati, Wohlgezogen, & 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 intra-group 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 & Eisenhardt, 2011). The second 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 that are associated with inactive third parties that maintain indirect relationships with both partners (Burt & Knez, 1995). Isolation and linking are complementary because their combined use ensures that partners can generate a lengthy cycle of dyads that make 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 (Ahuja, 2000a; Gulati & Gargiulo, 1999; Powell, Koput, & Smith-Doerr, 1996). Using the provocative imagery of EA Abbott (1884), it can be said that organizational theorists have so far restricted themselves to the "flatland" of two-member interorganizational relationships. Yet it is

conceivable that relationships with three, four or arbitrarily many members defined by common objectives and interactions are projecting "out of the page". These supradyadic ties could have an outsized influence on the performance outcomes of collaborations. Indeed, as Simmel (1950) originally 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, leading network scholars to ignore 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 than the isolated dyads that are the unit of analysis in most alliance research, because of the influence of supradyadic conflict and trust on 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 be dependent 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, & Rowley, 2003; Khanna & Rivkin, 2006; Rowley et al., 2004). Rather than supplant dyads, 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 of relational content. My study adds some unique implications for understanding the strength of long-run dyadic relationships in groups. The data indicate that group dynamics may be an antecedent to 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 have diminished both cooperation and coordination (Gulati, Wohlgezogen, & Zhelyazkov, 2012), suggesting that the underlying interorganizational relationships may have been weakened 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 mistrust 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 where collaborative groups are most often observed (Adner & Kapoor, 2009; Bresnahan & Greenstein, 1999). 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. I have no doubt that the modularity of modern information technologies aids in decomposition and cumulative innovation on platforms (Baldwin & Clark, 2000). But I find that modularity alone is not enough to ensure that groups successfully innovate in these interdependent environments, particularly if innovation requires collaboration amongst multiple partners. My study suggests that group innovation processes are necessary antecedents of complex innovation in interdependent industry ecosystems (Adner & 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

As in all research, it is important to examine alternative explanations, particularly in inductive research to check the face validity of the theory induced. One alternative explanation is that differences in the innovative objectives may account for differences in performance if they shape the aspirations of collaborators (Greve, 1998).[v] Yet this explanation seems unlikely, 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.

This is related to another alternative suggesting that differences in technology types are responsible for differences in innovation.[vi] For instance, there may be differences in interdependence across technologies (Thompson, 1967) and certain pairs of capabilities are inherently more

complementary than others (Milgrom & Roberts, 1995). To some extent, the existence of strong dyadic relationships and the common inclusion of Lear controls for these factors. Yet 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, where parallel dyads and unified triads might be more appropriate, respectively. Also, software is sometimes thought to be more flexible than semiconductor projects (Cusumano, 1995). But these explanations are unlikely in my data, because similar capabilities and technologies were involved in both more and less innovative collaborations, as shown in Table 1. All collaborations brought together well-known bases of complementarity in this industry (e.g., circuits/systems, middleware/applications) (Mitsuhashi & Greve, 2009). It is true that IT sectors are characterized by moderate-to-high interdependence. But the modular interfaces and specialized layers of the computer industry gives participants the capacity to choose whether complex innovation is managed in a sequential, pooled, reciprocal manner (Baldwin & Clark, 2000; Bresnahan & Greenstein, 1999). Other inducements for dyadic collaboration – firm size, uncertainty, and rivalry – are likely to be inducements for group collaboration as well (Ahuja, 2000b; Hoang & Rothaermel, 2005; Schilling, 2015; Schilling & Phelps, 2007). Finally, elements of software, systems and circuits appeared in all cases, and representative collaborations where the dominant focus was one of these had both high and low innovation performance, suggesting a technologically-determined explanation is not consistent with this data.

Another alternative explanation suggests 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.[vii] Moreover, if different pairs of partners have differential needs for Lear's contributions, this could mediate innovative success[viii] (Katila, Rosenberger, & Eisenhardt, 2008; Rogan & Greve, 2014). 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 on each other (Casciaro & Piskorski, 2005; Gulati & Sytch, 2007). Lear was prominent in multiple markets at the turn of millennium, and each partner could see the utility of

collaborating with them. Yet this does suggest that mutual dependence may be a boundary condition for this theory, and an antecedent of the cycling 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. Yet, by relaxing the selection criteria of this study (strong relationships, high trust, low conflict, symmetric power relations, complementary capabilities) researchers could explore the viable configurations of structure and processes in a larger sample.

This study takes some first steps towards exploring how groups of organizations innovate collaboratively. In going beyond the dyadic assumptions of prior research, it conceives of multipartner innovation efforts as involving group dynamics in which a variety of collaborative forms and processes can be utilized to complement structure (a network of socially embedded relationships). Innovative collaboration seems to depend on managing third party influence and interference with supradyadic mechanisms that enable partners to achieve independence within single dyads and interdependence across multiple dyads in groups. Future studies could explore other collaboration mechanisms at the group level of analysis, as interdependent ecosystems become 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.

Figure 1: Group Technological Collaborations from 2001 to 2012

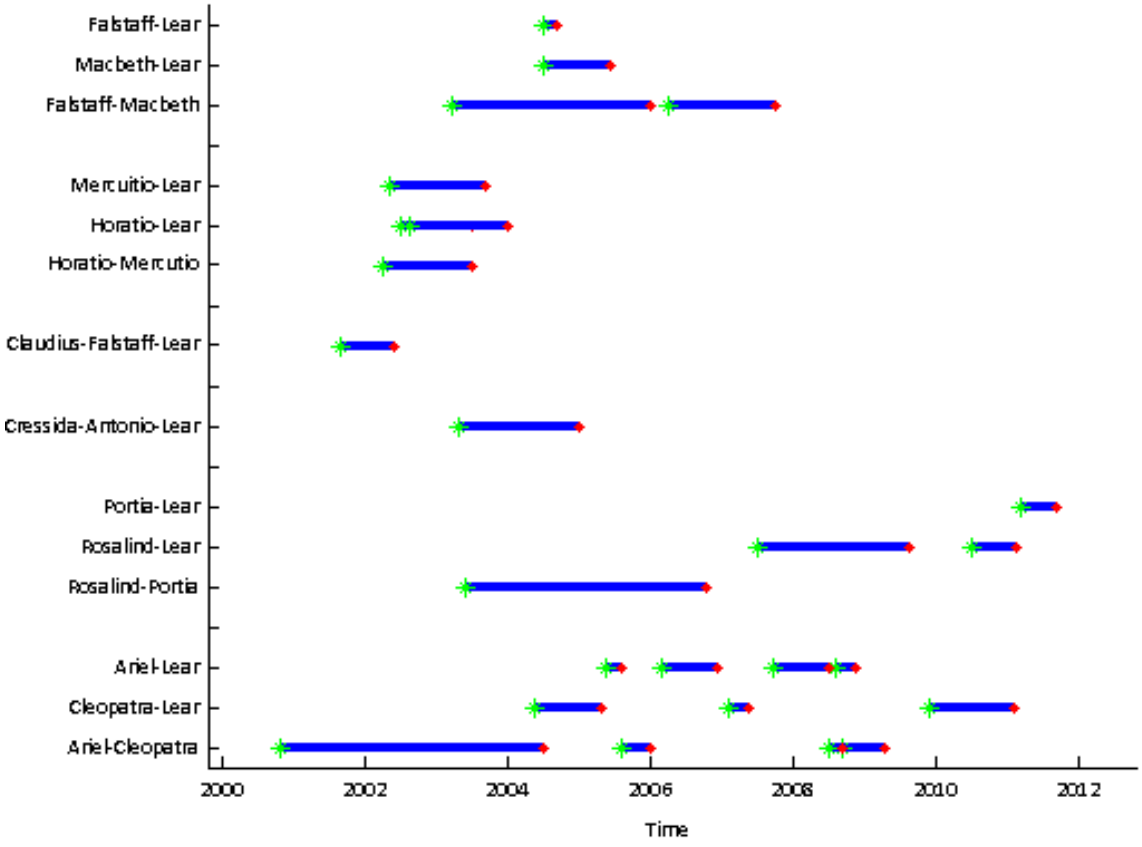

Figure 2: Collaborative Forms and Process in Organizational Groups

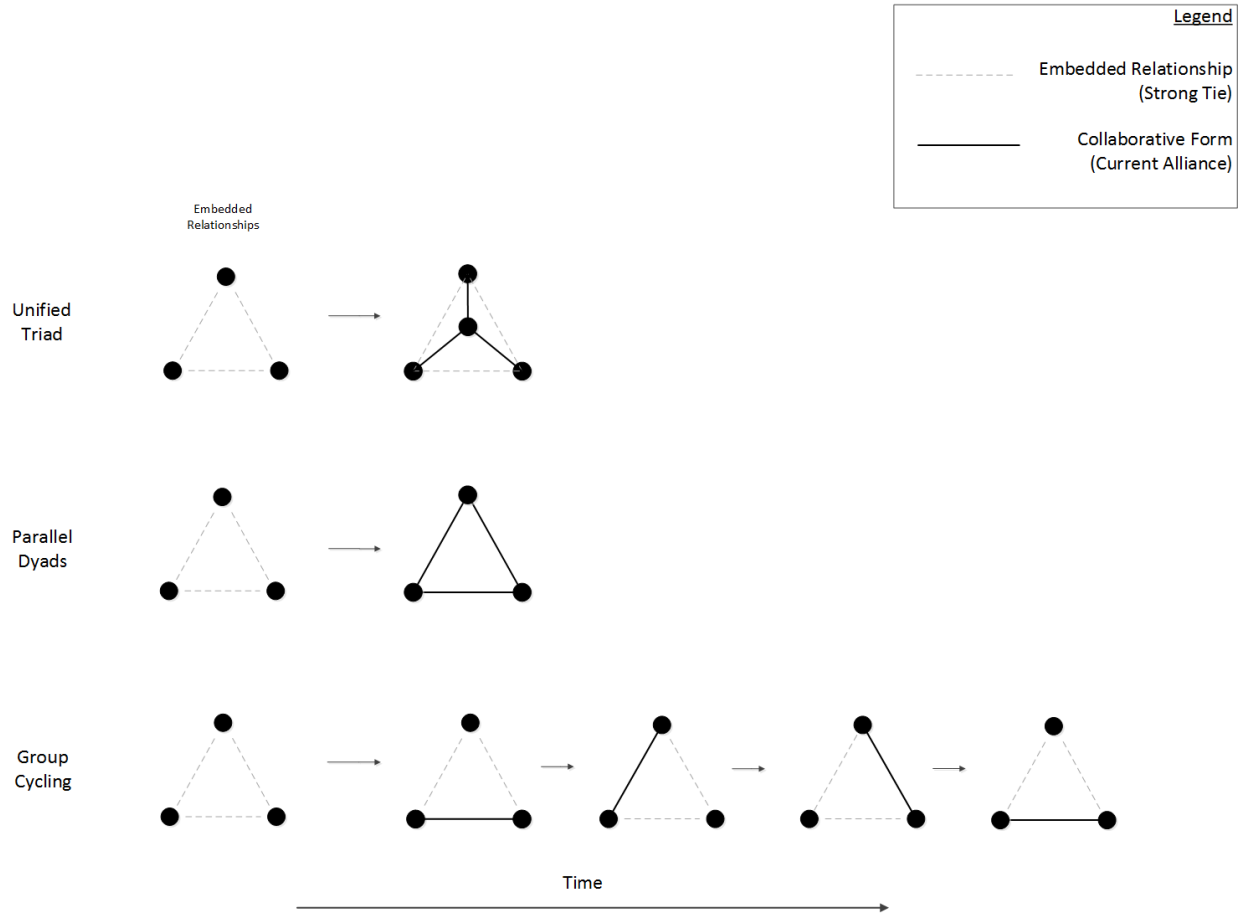

Figure 3: Supradyadic Mechanisms and Structural Outcomes in Organizational Groups

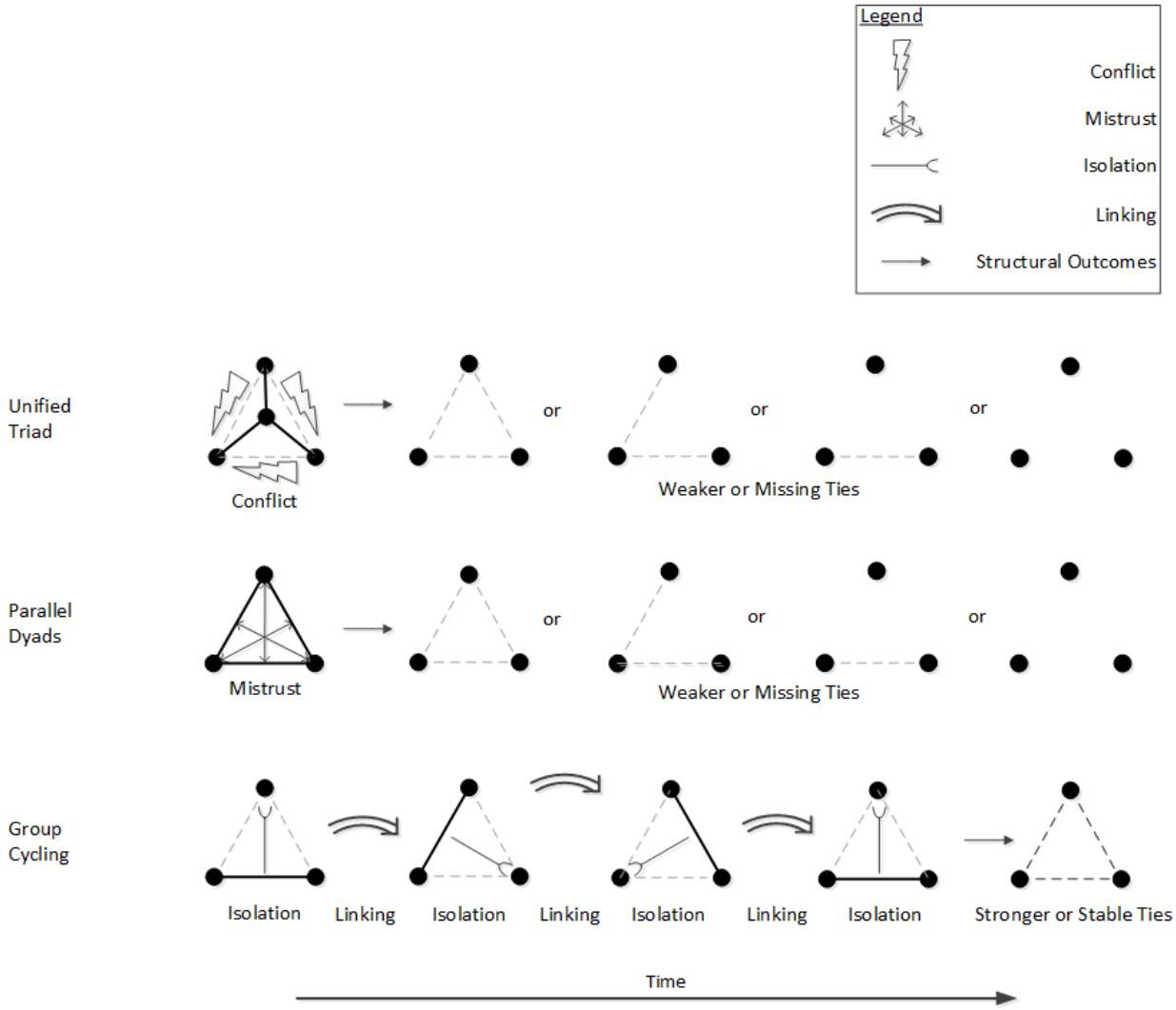

Table 1. Description of Collaborative Groups

Case #: Technology Focus	Partners	Partner's Relevant Capabilities	Focus of Previous Interorganizational Relationships (Partners Involved in Each Type)	Boundary Disagree-ment Initial Trust Initial Conflict	Initial Collaboration Innovation Objective Initial Collaboration Duration	Size in Employees per Firm	Informant Positions and Titles	Interviews per Firm Total Interviews Total Pages
#1: Wireless Networks and Security	**Falstaff** **Macbeth** **Lear**	Semiconductors / Circuits Network Equipment Mobile OS / Server Software	Joint sales & 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% 9 3	Network circuits and software 34 Months	34000 79000 55000	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 17 Total 1200 / 1700
#2: E-Commerce Tools and Online Marketplace	**Horatio** **Mercutio** **Lear**	OS / Software Applications Online Marketplaces Server Software / OS	R&D consortia (HM,ML,LH), buyer/supplier (HM,LH), joint sales & marketing (HM,ML,LH), technology collaboration (HM,ML,LH)	17% 8 4	E-Commerce software tools 18 Months	86000 3000 51000	SVP Engineering, Director Technical Marketing, Head Technical Evangelist, BD Manager, Program Manager, Alliance Manager, Product Director, Technical Lead	3 3 5 11 Total 700 / 1100
#3: Server Integration and Virtualization	**Falstaff** **Claudius** **Lear**	Semiconductors / Circuits Servers / Network Systems Server Software / OS	Joint sales & marketing (FC,CL,LF), buyer/supplier (FC,CL,LF), technology standards (FC,CL,LF), R&D consortia (FC,CL,LF), technology	0% 9 3	Server software and hardware 10 Months	38000 316000 48000	CTO, VP Wireless Division, Lab Head, BD Manager, Engineering Partnerships Manager, Program Manager, Alliance Manager, Product Director	3 3 4 10 Total 900 / 1100

			collaboration (FC,CL,LF)					
#4: Spam and Instant Messaging	**Cressida** **Antonio** **Lear**	Internet Software Internet Services OS / Applications	Joint sales & marketing (CA,AL,LC), buyer/supplier (AL,LC), technology standards (CA,AL,LC), technology collaboration (AL,LC)	0% 8 4	Security Software 21 Months	4000 60000 55000	SVP Business Unit, VP Internet Division, Director Software Development, Program Manager, Alliance Manager, Product Director	3 2 4 9 Total 300 / 500
#5: Mobile Email and Operating System	**Rosalind** **Portia** **Lear**	Mobile Devices / OS Mobile Devices / Mobile Software Mobile OS / Applications	Technology standards (RP,PL,LR), R&D consortia (RP,PL,LR), direct competition (RP,PL,LR), technology collaboration (RP,PL,LR)	0% 7 4	Mobile email devices and software 42 Months	27000 17000 55000	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 11 Total 1400 / 1100
#6: Middleware and Virtualization	**Ariel** **Cleopatra** **Lear**	Network Systems Software Applications OS / Applications	Joint sales & marketing (CL,LA), buyer/supplier (AC,CL,LA), technology standards (AC,CL,LA), technology collaboration (AC,CL,LA)	17% 8 4	Internet-enabled enterprise middleware 45 Months	38000 29000 48000	VP Business Unit, Director of Software Architecture, Director Technology Standards, Program Manager, Alliance Manager, Product Director, Technical Lead	4 3 5 12 Total 1100 / 1500

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

Case Number: Technology Focus	Partners	Evolution of Trust	Initial Trust / Final Trust	Collaborative Conflict	Initial Conflict / Final Conflict	Isolating Third Parties	Linking Collaborations
#1: Wireless Networks and Security	Falstaff-Macbeth-Lear	Lear lost trust in Falstaff and Macbeth when they came to believe that their project would help their competitors. Falstaff and Macbeth lost trust in Lear when they would not give access to their 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	Number of Isolations = 0 Although Falstaff, Macbeth, and Lear agreed not to participate in each other's trio of parallel dyadic collaborations, they each eventually demanded some involvement and influence in these dyads that leads 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	Horatio-Mercutio-Lear	Horatio lost trust in Mercutio and Lear when they disregarded their request to keep the payment technologies open. Lear lost trust in Mercutio and Horatio because they did not honor the 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 their payment systems collaboration.	4 / 6	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	Falstaff-Claudius-Lear	Some trust was lost in Lear and Claudius when conflict emerged about whether to defeature the product and reduce salespeople	9 / 6	Falstaff, Claudius and Lear were conflicted over how partners would mobilize specialists, including the role of salespeople in the process.	3 / 8	Number of Isolations = 0 Falstaff and Claudius invited Lear to join their collaboration in order to broaden their efforts and leverage their expertise in	N/A

		involvement.		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 where they had strong interests.		operating systems, application, and server software. Lear agreed, so there was no isolation.	
#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 their senior executives declined to attend the social events.	4 7	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 Email 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 where former rivals, no significant	4 4	Number of Isolations = 4 Unilateral Isolation: Rosalind and Portia began mobile email collaboration without Lear's knowledge to reap benefits before engaging with Lear. Unilateral Isolation: Lear	Number of Dyad-Dyad Linkages = 3 Explicit Output-to-Input Linkage: Lear's subsequent collaboration with Rosalind used a modified version of the mobile email to enrich Rosalind's smartphones. Explicit Output-to-Input Linkage:

				examples of conflict were noted.		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 Portia and Lear collaboration about search functionalities, the fourth and final dyad.	Lear's other collaboration with Rosalind used a modified version of the mobile email 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 email product on various handsets that was acquired in the previous collaborations with Rosalind.
#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	Number of Isolations = 11 Unilateral / Negotiated Isolation: Ariel and Cleopatra isolated Lear from an initial collaboration focused on Middleware in order to free themselves from Lear's constraints. Unilateral Isolation: Lear conducted second and third dyadic collaborations with Cleopatra and Ariel where Ariel and Cleopatra are isolated, respectively. Negotiated Isolation: Lear offered to allow Ariel and Cleopatra to collaborate alone in order to develop their own quick win about adaptive computing in a	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 signon technologies.

	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.	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.
	Negotiated Isolation: Ariel, Cleopatra and Lear orchestrated five collaborations in sequence – the seventh to eleventh dyads – where respective third parties were isolated to quickly develop integrated virtualization technologies based on prior middleware technologies.	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.

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

				Innovation Performance		
Number	**Technology Focus**	**Partners**	**Collaborative Form or Process**	**Initial Collaboration's Innovation Performance**	**Other Collaborations: Concurrent / Subsequent**	**Other Collaborations' Innovation 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 Email 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

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[i] 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).

[ii] The boundary agreement found here may not be representative of the industry. While convenient for this analysis, it is possible that groups of less established firms or firms entering new industries (e.g., nanotechnology) may have more disagreement about the membership of their groups.

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

[iv] It is useful to consider what micro-foundational assumptions are necessary to extend group dynamics theory to the organizational level, including the boundary-spanning interactions that may required to achieve unitary action across multiple alliances. This question is left for future research.

[v] The concern is that some objectives may be less ambitious to start and easier to achieve. Or perhaps some partners only desire upstream benefits of innovation like patents while others desire only downstream benefits like revenue. These differences could account for differential motivation 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.

[vi] 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.

[vii] I appreciate the suggestion of an anonymous reviewer about antecedent conditions like trust and symmetric power. While 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.

[viii] 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.

MEASUREMENT APPENDIX

Data Analytics and New Measures

This study used a standard set of analytical steps for multiple case research that includes both within-case and cross-case techniques (Eisenhardt, 1989). I began by writing detailed chronological case histories of the initial collaborations (ranging from approximately 40 to 90 single-spaced pages and took over eight months). Later, I added material on subsequent collaborations and their outcomes as information emerged. I iterated between the cases and emergent theory and then contrasted the results to relevant literature, making extensive use of tabular displays and figures (Miles & Huberman, 1994). Repeated iterations, reflections, and discussions with colleagues led me to identify problems and mechanisms that were common to organizational groups and a broad view of innovation performance. After a causal logic emerged, I returned to the informants for an additional round of data collection about new theoretical constructs related to trust and conflict. These multiple iterations between data and theory led to a more robust theoretical understanding than could be produced with a single iteration alone (Eisenhardt & Graebner, 2007).

Measuring the Innovation Performance of Groups

During data analysis, it became clear that informants assessed their group's collaborative innovation performance in two ways: first, by the innovation outcomes of any given collaboration, and second, by the capacity of the group to generate multiple new collaborations that follow-on from initial collaborations, so that extended innovation might be possible.

I began by first assessing the innovation outcomes of each initial collaboration. Consistent with both this study's informants and the prior literature, I defined a collaboration's innovation performance as the degree to which it generated new technologies and intellectual property that had a positive impact on product lines and company performance. This definition integrates various aspects of innovation in the literature, including new technologies and codified intellectual property such as patents created in the process (Ahuja, 2000; Comanor & Scherer, 1969; Griliches, 1990; Nelson, 2009); the impact these technologies have on organizations' product lines, including new product releases and improved product platforms (Henderson & Clark, 1990; Katila & Ahuja, 2002); and the consequences of innovation such as product performance (Cohen & Levinthal, 1989; Grant, 1996; Kogut & Zander, 1992).

I assessed these factors for each group's initial collaboration by operationalizing their innovation performance with five distinct measures: (1) the number of new technologies generated by the collaboration; (2) codified intellectual property; (3) immediate product line impact (e.g., changes to an existing product platform or new product releases); (4) market acceptance of the new technologies, including qualitative evaluations by analysts and immediate financial performance of the products; and (5) participants' perceptions of the overall innovation performance. The result is a particularly robust multifactor measure of innovation performance.

As a measure of intellectual property, I used the number of U.S. patent applications filed. The organizations in the sample use experienced patent lawyers and tend to have high patent acceptance rates, making patent applications a useful proxy measure of innovation (Comanor & Scherer, 1969; Trajtenberg, 1990). I also noted the number of white papers produced. I then assessed each collaboration's impact on its partners for at least one year post-collaboration with data on technology exploitation and product-line impact, defined as product or platform enhancements and new products released as a result of these new technologies (Katila & Ahuja, 2002). I conservatively recorded only a few clear instances of performance changes that were a direct result of new technologies generated by the collaborations (Levin et al., 1987; Narin, Norma, & Perry, 1988). Finally, I supplemented these data with informants' subjective assessments of their group's innovation performance as measured on a 10-point scale. Averaged across all informants and rounded to the nearest integer, these ratings were highly similar across levels of hierarchy (i.e., executives, managers, and engineers) and between partners (Krippendorff's alpha = .7905), suggesting high inter-rater reliability. Taken together, these measures overcome several shortcomings of prior measures of collaborative innovation performance, such as their limited relevance for innovation (e.g., alliance duration) and narrow focus (e.g., patents only), and is a major advantage of the research design.

I also addressed the second component of each group's innovation performance, their capacity to generate related concurrent or subsequent collaborations. This measure is analogous to that found in prior research on dyadic alliances, which often uses repeat alliance formation as a measure of previous alliance success (e.g., Gulati, 1995). It is particularly important as it sheds light on changes in tie strength, as a long period of alliance activity can often indicate that tie diminishment or dissolution has occurred (Dahlander & McFarland, 2013). Although detailed data on additional collaborations was less extensive than those on initial collaborations, I was able to assess the new technologies they generated, and measure a subjective rating of innovation performance of the set for each case. Taken together, these measures provide a robust understanding of the innovation performance of these groups, as is detailed in Appendix Table 1.

Measuring Trust and Conflict in Groups

The analysis revealed that interorganizational trust and collaborative conflict are two important constructs that vary across groups. During the early data collection efforts, I found that trust was high and conflict was low in all of the groups as they began collaborating (see Appendix Table 1), which is consistent with their strong interorganizational relationships. Yet over time, trust and conflict diverged dramatically across groups, as I detail in Appendix Tables 2 and 3.

According to prior literature, interorganizational trust is a dyadic construct (i.e., A can trust B but not C) (Gulati, 1995; Larson, 1992), and has three main components – fulfilling obligations or commitments, behaving according to expectations, and acting fairly (Zaheer, McEvily, & Perrone, 1998). In early discussions, I found no large divergences in these dimensions (e.g., mistrust over fairness was associated with mistrust about obligations and expectations), so I asked a compound question using a 10-point Likert scale to assess trust:

> "Next, I would like to assess the amount of trust you have in your partners. When an organization's trust in their partner is high, the organization's employees believe that the partner will fulfill their obligations, that they will behave predictably, and that they will act fairly. On a 10 point scale where 10 is the highest trust and 1 is the lowest trust, please tell me how much your organizations trusts _____."

I asked this question of members in each organization about both their partners, separately. There were no large divergences across partners – that is, groups with (low) high trust had mutual (mis)trust, perhaps because the long timeframe of these collaborations enabled well-known positive (and negative) feedback cycles of trust (and mistrust) to create symmetric (mis)trust across partners (see Graebner 2009 for a discussion). Consequently, I present group-level averages of the initial trust and final trust rounded to the nearest integer in Appendix Tables 1 and 2.

Prior literature also defines collaborative conflict dyadically, as the degree to which an organization's employees have disagreements or tension with employees in a partner-organization (Doz, 1996; Pondy, 1967; Ring & Van de Ven, 1994). These disagreements or tension can vary along three dimensions, including affective, task, and process conflict (Jehn, 1997). In early discussions, I found no large divergences in these types of conflict (e.g., task conflict was associated with affective and process conflict, etc.), so I asked a compound question using a 10-point Likert scale:

> "Next, I would like to assess the amount of conflict you have with your partners. When conflict with an organization's partner is high, the organization's employees have differing opinions, disagreements, arguments, and emotional tension about communication, task responsibilities, and the process for managing projects. On a 10 point scale where 10 is the highest amount of conflict and 1 is the lowest, please tell me how much conflict your organization has with _____."

I asked this question of members in each organization about both of their partners. Since there were no large divergences across partners (i.e., conflict seemed to be mutual when it emerged, as I detail in the results), I present group-level averages of the initial conflict and final conflict of groups rounded to the nearest integer in Appendix Tables 1 and 3.

Measuring Group Boundary Disagreement

To assess group boundaries, I adapted Mortensen's (2014) measure of boundary disagreement, which compares partners' perception of group membership. For this study, I asked participants to name groups in which their company was a member and rich collaboration was occurring. Typically, participants only mentioned two of three groups in response to this open-ended question. Although the question was not limited to groups of three, triadic groups were most often mentioned. When compared to the triadic groups on which the cases focus, I found that partners had a low amount of disagreement about these triadic group boundaries – boundary disagreement never exceeded 17% in this sample, as shown in Table 1. In contrast to research on groups of individuals where groups are often very large and members have substantial disagreement about who belongs (Hinds & Mortensen, 2005; Mortensen, 2014), these partners had a high degree of consistency in perceptions of membership and little disagreement about group boundaries.

I also inquired about larger collaborative groups (i.e., four or more firms), but was told by multiple informants that although they participated in larger technology standards bodies where contact was minimal (cf. Browning, Beyer, & Shetler, 1995), rich collaboration about joint technology development rarely occurred in groups larger than three organizations. My own analysis turned up no more than two press releases with four or more players planning joint development in the broader computer industry. Taken together, these data increase the confidence in the unit of analysis in this study.

Appendix Table 1. Innovation Performance of Collaborative Groups

Innovation Performance of the Initial Collaboration				Innovation Performance of Other Collaborations		
New technologies and intellectual property	**New and improved products and platforms**	**Market acceptance and product performance**	**Average subjective evaluation of innovation performance**	**Number of Concurrent / Subsequent Collaborations**	**Average Subjective Evaluation of Other Collaboration's Innovation Performance**	**Summary of Technological Outputs and Impact of Other Collaborations**
#1: Wireless Networks and Security (Falstaff-Macbeth-Lear)						
Mobile router and transceiver technologies with increased bandwidth, range, and memory. 9 patent applications, 5 white papers.	Mobile router device delivered to the military; no impact on Macbeth or Falstaff's main product lines. Next generation transceiver technology appears in the new wireless router product line.	Mobile router product is not launched. Transceiver viewed as incremental "next step" building block technology and does not result in significant revenue growth. Bundled features get good ratings from analysts, but generate little excitement with customers.	5 out of 10	2 / 1	3 out of 10	Two concurrent collaborations made minor improvements to wireless security, including a software update to Lear's products that protected against threats due to hardware integration. A subsequent collaboration produced some anti-spam software, but it did not tackle the most pervasive form of spam.
#2: E-Commerce Tools and Online Marketplace (Horatio-Mercutio-Lear)						
New software tools that link Internet content to client software applications like spreadsheets, email and web design tools.	XML based add-ons available by download from Lear.com, but not as stand-alone client applications.	Prominent joint-marketing and demo events impress industry analysts.	4 out of 10	2 / 0	6 out of 10	Two concurrent collaborations produce new network-attached-storage devices that become popular, as

7 patent applications, a few white papers.	Mercutio sees steady growth of automated transactions through Lear's applications, yet these offer little value for both customer bases.	Mercutio's power user community adopts some features, demonstrating their desire for transaction-automation tools.				well as integrated web services-enabled internet tools that address some minor problems in running e-commerce businesses.
#3: Server Integration and Virtualization (Falstaff-Claudius-Lear)						
Minor server integration between Claudius and Lear 2 patent applications, 1 white paper.	Minor updates to Claudius and Lear's products	Updates not recognized by analysts.	3 out of 10	0 / 0	N/A	N/A
#4: Spam and Instant Messaging (Cressida-Antonio-Lear)						
No new technologies 0 patent applications, 1 white paper.	Push email and mobile data services available on Rosalind's next generation smartphones.		2 out of 10	0 / 0	N/A	N/A
#5: Mobile Email and Operating System (Rosalind-Portia-Lear)						
Push email software ported to Rosalind's OS.	Portia's basic push email product available on Rosalind's current generation handsets.	Develops small “beta test” user base for current generation phone market before larger subscriber growth of next generation smartphones.	7 out of 10	0 / 3	8 out of 10	Three subsequent collaborations build on the initial mobile email collaboration to expand the functionalities on Rosalind's phone with

Technologies for 3rd party smartphone vendors including client-email integration, conference calling, speakerphone inter-operability, and security locking. 13 patent applications, multiple white papers.	Push email and mobile data services available on Rosalind's next generation smartphones.	Portia improves its voice quality of service, and Rosalind improves its Rosalind-branded email program offerings.				push email, build mobile productivity solutions for professionals using Lear's application suite for both Rosalind and Portia's phones, put internet search on Portia's mobile phones, and ultimately to rework Lear's mobile operating system and port it to Rosalind's devices.
#6: Middleware and Virtualization (Ariel-Cleopatra-Lear)						
New robust programming environment for enterprises. New Internet-based middleware that supports virtualization, portals, and authentication. Directory and application server technologies. 18 patent applications, multiple white papers.	Ariel's robust middleware engine used in large-scale enterprise applications. Cleopatra's shifts to new programming language and Internet-based middleware that is robust and easier to support. Mercutio sees steady growth of automated transactions through Lear's applications, yet these offer little value for both customer bases.	Ariel's tool sets become dominant in Internet development market. Cleopatra's new Internet-based middleware and applications are rated as excellent by industry analysts and gain market leadership in every important segment in the next 3 years.	9 out of 10	0 / 10	8 out of 10	Ten subsequent collaborations used the middleware to produce calendar technologies, sign-on interfaces, adaptive computing products, new programming software, enterprise-robust consumer applications, fully virtualized middleware, a virtualized internet toolbar, virtualized server applications, cross-vendor integrated applications.

Appendix Table 2. Interorganizational Trust, Resource Availability, and Participation Agreement

Case Number: Technology Focus	Partners	Resource Availability	Participation Agreement	Evolution of Trust	Initial Trust Rating	Final Trust Rating
#1: Wireless Networks and Security	Falstaff-Macbeth-Lear	Lear would not grant access to their security professionals or development tools.	Falstaff-Macbeth-Lear	Lear lost trust in Falstaff and Macbeth when they came to believe that their project would help their competitors. Falstaff and Macbeth lost trust in Lear when they would not give access to their security professionals or development tools.	9	4
#2: E-Commerce Tools and Online Marketplace	Horatio-Mercutio-Lear	Horatio, Mercutio and Lear were not allowed to access engineering know-how, prototype products, schematics, and marketing plans of third parties in their dyads.	Horatio wished to join Mercutio and Lear's payments collaboration, but they resisted. Lear wished to join Horatio and Mercutio's online store collaboration and share the profits, but were rebuffed as well.	Horatio lost trust in Mercutio and Lear when they disregarded their request to keep the payment technologies open. Lear lost trust in Mercutio and Horatio because they did not honor the request to pause payment and storage system collaborations.	8	5

#3: Server Integration and Virtualization	Falstaff-Claudius-Lear	Falstaff, Claudius and Lear provided extensive access to technological and material resources. Some conflict led to slower access to salesperson expertise.	Falstaff, Claudius and Lear agreed to all participate in a triadic collaboration.	Some trust was lost in Lear and Claudius when conflict emerged about whether to defeature the product and reduce salespeople involvement.	9	6
#4: Spam and Instant Messaging	Cressida-Antonio-Lear	Cressida, Antonio and Lear gave open access to technological and other resources.	Cressida, Antonio and Lear initially agreed to participate in a triadic collaboration, although some discussion emerged about whether Cressida should be forced to exit.	Cressida lost some trust in Antonio and Lear when disagreement about collaborative activities emerged.	8	6
#5: Mobile Email and Operating System	Rosalind-Portia-Lear	Rosalind, Portia and Lear accessed in-house resources from their partners during dyadic collaborations, and resource outputs of prior collaborations with different partners.	Rosalind and Portia began collaboration without Lear's knowledge, but later spent considerable effort convincing Lear that it was better to remain outside and collaborate later in subsequent dyadic alliances.	Rosalind, Portia and Lear maintained high trust during this collaboration.	7	8
#6: Middleware and Virtualization	Ariel-Cleopatra-Lear	Ariel, Cleopatra and Lear accessed in-house resources from their partners during dyadic collaborations, and resource outputs of prior collaborations with different partners.	Although Lear requested to be involved with Ariel and Cleopatra in a triadic alliance, they were ultimately convinced to collaborate in sequential dyadic alliances.	Ariel, Cleopatra and Lear maintained high trust during this collaboration.	8	7

Appendix Table 3. Collaborative Conflict, Multiple Roles, and Relational Patterns

Case Number: Technology Focus	Partners	Multiple Roles	Relational Patterns	Collaborative Conflict	Initial Conflict Rating	Final Conflict Rating
#1: Wireless Networks and Security	Falstaff-Macbeth-Lear	Falstaff, Macbeth and Lear had similar project and alliance management competencies. Lear and Falstaff had overlapping technological capabilities in servers.	Falstaff had experience adjusting to Macbeth's slower pace of semiconductor design because their prior technology collaborations involved changed to circuits. Lear and Macbeth's prior technology collaborations were software-based, so Lear had not worked in this slower pace. However, these different paces did not conflict since dyads were separate.	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, Mercutio and Lear had similar project and alliance management competencies. Horatio and Lear had overlapping technological capabilities around OS software, Mercutio and Lear had overlapping middleware capabilities, and Horatio and Mercutio had overlapping internet software capabilities.	Lear and Mercutio had focused on PR focused collaborations around internet technologies, whereas Mercutio and Horatio had focused on internet infrastructure collaborations whose PR value was farther in the future. Mercutio and Lear acknowledged that storage systems were the most urgent collaborative objectives, whereas Horatio and Mercutio didn't think storage was a critical collaborative objective. However, these differences in collaborative focus and urgency did not create much conflict because their dyads were separate.	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 their payment systems collaboration.	4	6

#3: Server Integration and Virtualization	Falstaff-Claudius-Lear	Falstaff, Claudius and Lear had similar project and alliance management competencies and overlapping technological capabilities in hardware systems.	Claudius and Lear had previously conducted technology collaborations with strong involvement from salespeople. By contrast, Claudius and Falstaff collaborated on technology in a variety of ways with a various business units and functions involved. Conflict about these which approach to use emerged in their unified triad.	Falstaff, Claudius and Lear 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. To satisfy Claudius, Falstaff and Lear removed some features but continued to work on them on the side. Conflict emerged over whether Claudius was trying to form a separate alliance with Lear to avoid including Falstaff in difficult decisions where they had strong interests.	3	8
#4: Spam and Instant Messaging	Cressida-Antonio-Lear	Although Cressida, Antonio and Lear's alliance and project management competencies were only somewhat similar, they had strongly overlapping internet software capabilities.	Cressida preferred to collaborate in a different manner than Antonio and Lear. Cressida preferred to bond over working late-nights in a "startup style" whereas Antonio and Lear took a corporate approach and organized outside social events where family members should attend. In prior dyads, Cressida pushed Antonio and Lear to accept their style, but conflict about styles emerged in their unified triad.	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 their senior executives declined to attend the social events.	4	7

#5: Mobile Email and Operating System	Rosalind-Portia-Lear	Rosalind, Portia and Lear had similar project and alliance management competencies and strongly overlapping technological capabilities in mobile systems.	Although they were formerly director competitors, Rosalind and Portia came together as collaborators when Portia shifted strategies. As a result they tended to focus on projects where hardware and software components were clearly delineated. By contrast, Rosalind and Lear tended to collaborate on integrated phone/software systems. Portia and Lear tended to focus on both application and systems software projects. However, these differences did not create conflict because their dyads were separated across time.	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 where 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.	Ariel and Cleopatra had collaborated in a stereotypical pattern where Ariel would provide technology infrastructure that enabled Cleopatra to build more robust enterprise applications. Ariel's collaborations with Lear were more varied, though, involving some consumer-focused in some way where both partners were involved in application development. However, these differences did not create conflict because their dyads were separated across time.	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