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Competition–cooperation interplay during multifirm technology coordination: The effect of firm heterogeneity on conflict and consensus in a technology standards organization

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Research Summary: We examine how competitive tensions and cooperative motivations together shape firms' interactions and group-level outcomes during technology coordination activities in multifirm settings. Analyzing the communication and voting behavior of 115 firms across three subcommittees of a computing industry technology standards-setting organization over 14 years, we find that existing product-market positions influence how firms with highly overlapped technological resources differ in their interactions: when their product-markets are more competitive, they exhibit greater support for the emerging standard, as evidenced by positivity and certainty of interaction tone; but when they possess a broader array of complementary products, support is tempered. At the subcommittee level, after accounting for aggregate competitive tensions in prior interactions, heterogeneity in both firms' relational influence as well as their prior multiparty experience improve consensus.

Managerial Summary: In innovation ecosystems, competing firms are often obligated to collaborate with each other in large multifirm forums to develop the technical standards that enable interoperability between their products. We show how the networks of technical and commercial relationships between firms shape such standards activities in two steps. First, firms who share many common technology interests with others communicate their support for new standards more vigorously when they participate in more competitive product-markets, but less vigorously when they possess more complementary products. Second, communities find broader support for standards when there is greater imbalance across both firms' prior collaborative experiences as well as their pattern of relationships. We demonstrate these results in a study of 115 firms participating in computer peripherals standards development over 14 years.

KEYWORDS

alliances, competition, cooperation, ecosystems, innovation, networks, standards, technological change

1 | INTRODUCTION

A central concern in strategic management has been to identify factors influencing technological change and evolution with critical consequences for firm strategy and survival (Adner & Levinthal, 2001; Eisenhardt & Martin, 2000; Henderson & Clark, 1990; Lavie, 2006; M. Tushman & Anderson, 1986; M. L. Tushman & Rosenkopf, 1992). Fundamental to this research direction are two distinct yet parallel notions—while research has found that competitive considerations affect firms' technological choices in dynamic environments (Katila & Chen, 2008; Peteraf, 1993; Polidoro & Toh, 2011; Young, Smith, & Grimm, 1996), others have shown that these environments also necessitate collaboration, coordination, and integration of these choices across firms (Lavie, Lechner, & Singh, 2007; Rosenkopf, Metiu, & George, 2001; Rothaermel, 2001).

In particular, in ecosystems characterized by technological interdependence between firms, the extent of value created by a particular firm's technological choices is crucially dependent on the choices made by other firms that possess complementary technologies (Adner & Kapoor, 2010). In the quest to unlock network effects and create "lock-in," firms need to coordinate these choices not only with upstream and downstream value chain participants but additionally with competitors and complementors (Dagnino & Padula, 2002; Gnyawali & Park, 2011). Such coordination activity frequently occurs within voluntary standard-setting committees (SSOs)—industry-wide multifirm collaborative arrangements that bring together representatives from several firms to derive the technical rules of compatibility between various system components (Leiponen, 2008; Ranganathan & Rosenkopf, 2014; Rosenkopf et al., 2001). In recent times, SSOs have flourished as preferred technology coordination forums in the information and communications technology sector (ICT),[1] with dominant standards such as WiFi, 3G, and HDMI emerging from such forums.

Despite SSOs being influential organizational settings that drive technological change and evolution, research is yet to investigate the extent to which firms are successful in coordinating technology within these bodies. As "competition to own the standard becomes, in some ways, competition for the market" (D. J. Teece, 2006), disagreements are likely to arise in SSOs as heterogeneously endowed firms each attempt to steer the collective toward choices that enhance private benefits (Farrell & Simcoe, 2012; Khanna, Gulati, & Nohria, 1998). Inducements to shift away from the status quo toward a new technological standard are also likely to be heterogeneous across participating

[1]For instance, in the information and communications technology sector (ICT), leading organizations such as Intel routinely participate in hundreds of different standards organizations alongside key competitors. Recent large-scale database initiatives focused on over 500 technology standards organizations further illustrate the pervasiveness of this organizational phenomenon (Baron & Spulber, 2015).

firms, some of which have ex-ante superior competitive positions or assets (E. L. Chen, Katila, McDonald, & Eisenhardt, 2010; Wu, Wan, & Levinthal, 2014). Competitive concerns may also arise when firms need to disclose technologies in the presence of rivals so as to incorporate those choices into the technological standard (Oxley & Sampson, 2004; Toh & Miller, 2017). These competitive tensions manifest in delays or even failures in the standard-setting process if firms are unable to agree on a compromise (Farrell & Simcoe, 2012).

However, despite these competitive concerns, a continued proliferation of standards bodies and their growing memberships suggests an organizational form that in a number of instances enables the participating firms to manage such competitive tensions to attain a cooperative technology agreement. From a strategy research perspective, this is particularly consequential because unlike dyadic alliances where appropriation hazards can be mitigated by contractual governance mechanisms (Gulati & Singh, 1998; Reuer & Arino, 2007), voluntary standards-setting is administered through committees (Reuer & Devarakonda, 2016) with success dependent on consensus formation between several equally empowered firms (Simcoe, 2012). This suggests a set of unexplored organizational factors affecting whether competing firms in SSOs can successfully engender collaborative outcomes.[2] Our objective in this article is to examine the micro dynamics that underlie this competition–cooperation interplay within the auspices of the SSO. We unpack the complex set of motivations firms experience as their representatives attempt to negotiate and shape a favorable standards outcome and balance private with collective benefits.

First, we theorize about the firm-level antecedents of competitive tensions within these voluntary organizations and how these tensions vary across member firms. We argue that competitive tension, manifest by expressed disagreement and indecision by a firm's representatives during standards creation activities, is curbed by the firm's exigency to achieve technical agreement with other member firms but aggravated by the technical complexity and the appropriation risk the process of obtaining such an agreement entails (Katila & Chen, 2008; Oxley & Sampson, 2004; Toh & Miller, 2017). Paradoxically, firms with the largest technical knowledge overlaps with other member firms experience the greatest need to attain agreement, but also face the highest contestation as they attempt to embed firm-specific knowledge. We resolve this dilemma by concurrently considering the potential erosion to the value of a firm's current downstream investments, due to the technological shift stemming from the standard (Wu et al., 2014): despite technology overlaps, firms with broader complementary product investments across the ecosystem or in favorable product-market positions will exhibit less support for the emerging standard.

Next, we examine community-level factors to determine whether these competitive tensions tend to persist at the aggregate, or whether firms resolve conflicts to achieve a collaborative solution. Our central argument is that in the presence of competitive tensions, consensus in the committee is more likely when the group is able to agree on a compromise solution, which we argue is shaped by the interfirm relational structure of the negotiating firms. A wider distribution of firms across this structure allows for collaborative pathways to form and central "hub" firms to emerge as solution orchestrators that identify and build coalitions (Ahuja, Soda, & Zaheer, 2012; Rosenkopf et al., 2001). We further submit that the extent of heterogeneity in firms' prior experience in similar multipartner settings serves to distribute negotiating power in the group, thus limiting delays and deadlocks and permitting compromise solutions to be realized.

[2]With the strategy field's typical focus on antecedents and consequences of firm conduct, quantitative studies of standards-setting activity have naturally focused on why and how firms participate and vote (Ranganathan & Rosenkopf, 2014) and also on how firms might benefit from participation (Rosenkopf et al., 2001; Rysman & Simcoe, 2008). In contrast, the actual process and factors underlying standards development at the committee level and their subsequent effects on performance have been typically relegated to qualitative studies and models (e.g., Garud, Jain, & Kumaraswamy, 2002; Fontana, 2008; Funk & Methe, 2001).

We find support for these arguments in the context of a leading computer industry SSO that coordinates peripheral interconnect standards. Our novel and rich data on member firms includes their email records communicating technology issues during standards development as well as their votes on standards ballots during the ratification process, integrated with alliance, patent, and product data. We contribute to research on the interplay of competition and cooperation among firms in the context of technological change and technology evolution. By assimilating prior research on competition in technological change settings and research on interfirm collaboration, networks, and ecosystems, we shed light on decision making within increasingly important multifirm organizational forms. Our results reveal the antecedents of competitive tensions within standards committees while also underscoring the complex tradeoff between cooperation and competition that firms experience heterogeneously. Empirically, we are able to connect the macro-level strategic considerations of firms to the micro-level actions of their representatives on committees. Our findings also demonstrate how competition and cooperation coevolve as a function of committee diversity, with firm heterogeneity in the technology and product spaces provoking competitive tensions, but heterogeneity in the relational space facilitating the resolution of these tensions.

2 | THEORY AND HYPOTHESES

"Standards" are the technical specifications that define the rules of interaction between the different complementary technologies that comprise a system. While de facto standards emerge from market-based competition as consumers gravitate toward one technical alternative (e.g., VHS vs. Betamax), de jure standards coordinated within SSOs (the target of this study), represent a multifirm collaborative organizational form where representatives of firms across the entire ecosystem, coordinate technical interoperability in order to reduce uncertainty and spur industry growth.

2.1 | The standards-setting context and the interplay of competition and cooperation

While participating firms share a common goal of reducing uncertainty and spurring industry growth, several characteristics of the standards-setting context suggest that translating this goal into specific technical choices creates a tension between competition and collaboration. While it is evident that any participating firm will attempt to steer the collective toward choices that enhance private benefits (Farrell & Simcoe, 2012; Khanna et al., 1998), it is less clear that the firm will be successful (e.g., Garud et al., 2002). Standards organizations, by encouraging divergent viewpoints,[3] bring together heterogeneous firms with unique and path-dependent prior investments (Nelson & Winter, 1982), often competing with one other in current technological and product-market spaces (Dokko et al., 2012; Ranganathan & Rosenkopf, 2014). For any single firm to influence the direction of the standard favorably, its representatives need to not only submit technical proposals within the working groups but also successfully contest competing proposals put forth by other firms. Standards committees also strive to prevent dominance by powerful firms[4]—debates are on technical

[3]According to American National Standards Institute (ANSI), "Participation shall be open to all…directly and materially affected by the activity in question. There shall be no undue financial barriers to participation. Voting membership …shall not be conditional upon…technical qualifications." Further, "Participants from diverse interest categories shall be sought with the objective of achieving balance. If a consensus body lacks balance…outreach to achieve balance shall be undertaken."

[4]According to ANSI, "The standards development process shall not be dominated by any single interest category, individual or organization. Dominance means a position or exercise of dominant authority, leadership, or influence by reason of superior leverage, strength, or representation to the exclusion of fair and equitable consideration of other viewpoints."

merit and even firms with market or technical clout need to divulge details of their firm-specific technical choices should they contend to incorporate them into the standard (Toh & Miller, 2017).

Further, the committee-based governance of standards organizations[5] differs substantially from traditional alliances where contractual incentives or hierarchical structures bound divergence and opportunistic behavior (Reuer & Devarakonda, 2016). As the onus is on obtaining consensus via ballots on the technical standard after deliberations have concluded,[6] firms must negotiate with one other and collaborate to reconcile divergences (DeLacey, Herman, Kiron, & Lerner, 2006; Rosenkopf et al., 2001).

Should a consensus emerge, it has substantial implications for the nature of downstream product-markets with network externalities fueling growth in standard-certified products while simultaneously substituting away from proprietary technologies or legacy systems that do not incorporate the standard (Bayus & Agarwal, 2007). However, this transformation is crucially dependent on the extent and promptness of consensus—a speedy resolution of divergence shifts the technological landscape expeditiously and spurs downstream growth based on the standard's technologies (e.g., Augereau, Greenstein, & Rysman, 2006), but a sustained lack of consensus causes delays (e.g., Simcoe, 2012) and even failures (Saloner, 1990), with status quo persisting in product-markets.

The above contextual characteristics allow us to obtain a set of theoretical antecedents for firms' strategic behavior within these committees. First, although the idea of a standard is to reduce uncertainty and spur growth, the future value capture from the standard for any specific firm is less predictable. As value capture depends upon the technological direction taken by the standard, which itself is an outcome of the competitive standards development process and constrained within the rules of SSOs, we can expect heterogeneity in the extent to which firms experience competition–cooperation tensions and exhibit disagreements during the standards creation process.[7] In order to imprint their technological choices into the standard, firms will need to evaluate both the benefits and the risks of the detailed disclosure of their technologies, and also compete successfully against alternative proposals. In other words, the potential advantages of shared value creation by collaboration in the standard's technological areas have to be weighed against the erosion of technological capabilities either through spillover to competitors or by the selection of alternative and even conflicting technological choices by the SSO. Accordingly, firms' motivations to support the standard will derive from these *technological considerations* that are heterogeneous across firms.

Second, in conjunction with technological motivations that drive participation on standards committees, firms will also contrast the uncertain future value capture from the standard with the relatively assured value appropriation (or loss of appropriation due to the standard). In other words, when debating technological choices, each firm has to assess whether shifts in the status quo, should

[5]To facilitate collaborative knowledge-exchange and problem solving (Garud & Karnoe, 2003), the procedures of most SSOs require that the concerns and objections of every firm, no matter how small the concern or the firm, be deliberated and addressed. For instance, according to ANSI rules, criteria for consensus may include that at least two-thirds of those voting approve and further that the comments and issues accompanying the No-votes be considered and deliberated.

[6]To support this process, standard-setting organizations ensure that every member firm gets an equal vote (Ranganathan & Rosenkopf, 2014). Voting takes place at specific milestones in the process to assess whether agreement is achieved on the proposed specification and if the standard can progress to the next level of review.

[7]An interesting counter-argument is why firms would participate at all in SSOs if they perceived a loss of value. However, any ex-ante assessment of relative value accruing to a firm vis- à -vis its competitors within the standards committee presuppose highly rational firms endowed with near-perfect information across hundreds of firms. Not only is such a scenario unlikely in an uncertain technological environment with a distributed locus of knowledge, but it also implies the preclusion of firms that are value "losers," which would (by construction) lead to the collapse of such organizations —this runs counter to the anecdotal evidence of the proliferation of SSOs.

the emerging standard be agreed upon and adopted, is likely to enhance or weaken its existing competitive product-market position. Thus, firms' motivations to support the standard will also be associated with their *product-market considerations*.

Finally, stimulated by a consensus-based governance process, perceived value for a firm from the standard may shift as divergences are debated and resolved with other member firms. Although firms may have heterogeneous notions of value, interactions at the group level may alter these notions as the iterative resolution norms are geared toward achieving widespread agreement. Thus, the extent to which the community can achieve consensus will depend upon the *relational considerations* of the group that underlie the negotiation and collaboration activities prior to standards ratification (Ahuja et al., 2012; Rosenkopf et al., 2001).

Next, we develop hypotheses that connect these theoretical drivers—*technological*, *product-market*, and *relational considerations*—to the competition–cooperation interplay within the SSO.

2.2 | Technological considerations and competition-cooperation interplay

We conceptualize each firm as occupying a position in the technological space, as identified by the path-dependent nature of its upstream R&D investments across different technological knowledge areas. This position constitutes the technological resource of the firm that is germane to its interactions and deliberations within standards committees. We posit that the technological consideration of a firm depends upon the extent of overlap of its technological resource with that of other member firms (Stuart, 1998). This has a duality of driving both the urgency for the firm to coordinate through standards-setting and the competitive tensions experienced within.

Without standard-setting coordination, a firm occupying a technological position that has a high degree of overlap is confronted with the challenge of driving downstream adoption and unlocking network effects when comparable technological alternatives exist. When several technological alternatives exist, uncertainty around future viability of the firm's technology as well as concerns of compatibility with complementary technologies and lock-in are likely to stymie such a firm's growth efforts. By ensuring a unified technological trajectory, a common standard overcomes these issues and, thus, for such a firm, appears promising from a value-creation standpoint. In contrast, a firm that has a low degree of overlap with others occupies a technological niche and is more likely to gain market acceptance for its technologies independent of coordination—the benefits of collaborative standards-setting are thus less apparent. Such a firm has to also carefully consider the appropriation risk involved in standards-setting. To successfully imprint elements of its technology into the standard, the firm must reveal details about it, and such exposure may provide important clues to competitors on where hitherto unknown and profitable opportunities might lie in the technology space (W. Cohen, Nelson, & Walsh, 2000; Katila & Chen, 2008; Toh & Miller, 2017). The attendant competitive tensions of imitation and appropriation (Oxley & Sampson, 2004) are greater for firms that occupy technology niches that are valuable sources of licensing and royalty revenue, than for firms in comparatively congested and undifferentiated technological areas. Thus:

> **Hypothesis 1a (H1a)** *The greater a firm's overlap in technological resources with other member firms, the higher the collaborative support it exhibits during standards creation.*

On the other hand, although the outcome of the coordination process creates shared value, to appropriate this value, a firm must contest choices so that its proprietary interests are reflected in the chosen technology platform (e.g., Saloner, 1990). A firm whose technological resource position is highly overlapped with other participating firms is likely to exhibit greater contestation as it attempts to influence the standard. Compared to firms in specialized technology niches, firms in crowded technology spaces must closely challenge technical aspects of the standard's specification as several peers in the same technology area attempt to steer these decisions toward alternatives that are proximate to their own prior idiosyncratic choices. Empirical evidence suggests that the stakes for such contests are substantial—firms whose technologies are ultimately included in the standards specifications gain disproportionate benefits compared to otherwise technologically similar firms, as these become foundational to future technological evolution (Rysman & Simcoe, 2008). As Ahuja, Lampert, and Novelli (2013) suggest, a firm's "generative appropriability"—its effectiveness in appropriating value from future innovations spawned from existing technologies—may be as crucial to its competitive advantage as its ability to exploit current technology. In contrast, a firm that is in a technological niche has relatively unique and isolated technologies, and its idiosyncratic choices in bridging those technologies with other parts of the ecosystem are less likely to be contested. It is thus easier for a niche firm to support the standard without conceding generative appropriability. Thus:

> **Hypothesis 1b (H1b)** *The greater a firm's overlap in technological resources with other member firms, the lower the collaborative support it exhibits during standards creation.*

In sum, value appropriation concerns of *technological considerations* work against the value creation benefits, rendering the overall effect indeterminate. Therefore, we turn our attention on clarifying when technological considerations will have a predictable effect on a firm's support for the standard.

2.3 | Technological and product-market considerations

Elements of the firm's existing product-market position in the ecosystem have an important bearing on its decisions around technological change (Kapoor & Furr, 2015; Wu et al., 2014). Specifically, the technological change deliberated within standards committees has implications for the firm's product-market competitiveness (Bayus & Agarwal, 2007; Schilling, 1998) and we focus on how two such attributes—*product complements* and *product competition*—in conjunction with a firm's technological considerations, drive its support for the standard.

2.3.1 | Technological consideration and product complements

An important facet of innovation ecosystems is the technological interdependence between a focal product or component and its complements, because products "need to be combined with…complements if they are to present a value-creating solution to customers" (Adner & Kapoor, 2010). This poses challenges for firms as the rate of technical change in product complements may differ from that of the focal product and consequently the availability of complements can constrain the performance of the entire system (S. K. Ethiraj, 2007). Some firms deal with this technological uncertainty by integrating technologies and providing a breadth of complementary products to offer a "one-stop shop" system model. For instance, in the computer industry, Digital Equipment Corporation (DEC) and IBM routinely integrated into complements such as software, peripherals, and accessories when innovating on computer hardware systems, thus providing an entire proprietary platform of products to consumers (Grove, 1996). Others specialize in a narrow range of products, typically relying on other partners such as value-added-resellers (VARs) or systems integrators to provide compatibility solutions.

A firm's breadth of prior investments in product complements has decisive implications on how technological considerations affect its support for the creation of a common standard. By forging a unified platform among different firms about the role and the interaction between different components, standards increase the modularity of the entire ecosystem and allow previously interdependent components to be uncoupled, thus allowing different parts of the system to be designed and produced separately (Baldwin & Clark, 1997; S Ethiraj & Levinthal, 2004). Such an increase in modularity opens up the competitive landscape, enabling both existing and new firms to specialize at component levels without having to invest in idiosyncratic solutions to obtain compatibility with each other's products. On the consumer side, it provides flexibility to mix and match variants of complements from different firms that all build to the same common standard.

Consider a firm that already provides a broad array of complementary products that also has a high degree of technological overlap with other member firms. In H1a, we posited that the high-overlap firms would have a greater need to coordinate through standards. However, for a high-overlap firm that also offers a broad range of complements, the increased modularity from a proposed industry-wide standard threatens to substitute its existing proprietary investments that integrate across the different product components, with a common set of technology rules. These common technology rules would eventually allow all firms to achieve compatibility with each other's technologies by simply "building to the standard," thus threatening an important source of differentiation the focal firm has of being an integrated solution provider in the product-market.[8] Thus, the pressure a high-technology-overlap firm experiences to coordinate on standards is counterbalanced when it has broader complementary investments (H1a effect is diminished).[9] In H1b, we posited that the greater a firm's technology overlap with others, the greater the competitive tension it experiences as it must closely contest technical decisions of the standard to ensure that these are aligned with its own prior choices. These tensions will be even higher for a high-technology-overlap firm that has also invested in a wide array of complements—such a firm must forcefully contest not only the component-level choices but also architectural ones that affect intercomponent interactions, in order to preserve its generative appropriability (H1b effect is magnified).

In contrast, for a high-technology-overlap firm that is specialized (e.g., a firm focused on a single product or component), the standard promises to reduce the downstream costs of building compatibility with different types of complementary products (e.g., it no longer needs to partner with integrators and resellers) thereby allowing it to redirect resources toward improving the technological performance of its focal product. On committee interactions, contestation can be limited to issues pertaining to this specialized component, while the firm could take a more supportive and "satisficing" approach to resolve other points of overlap with peer firms. Thus:

> **Hypothesis 2 (H2)** *The broader the firm's investments in product complements, the more the firm's technological overlap with other firms will decrease its collaborative support during standards creation.*

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[8]It is important to underscore that we do not suggest that the substitute technologies are readily available in other firms but that the standard itself will eventually substitute for all existing ways that firms have attempted to achieve compatibility.

[9]A valid question may be why firms join standards organizations if they are disadvantaged. Within the standard, firms may participate and disagree with the specifications being discussed (as our results suggest), and even vote against the consensus. Typical norms require that the opinions of the dissenting minority also be considered before the standard can be promoted to the next stage of deliberations. Even if such firms are not able to stop the eventual acceptance of the standard, they may be able to delay and thereby buy additional time to adjust their technologies and their strategy to embrace the emergent changes in the industry. Firms may also need to participate to understand the technical specifications of the proposed standard that is emergent even if the standard is not favorable—once the standard is adopted and network effects are dominant, firms have little choice but to incorporate these specifications in their technologies and products.

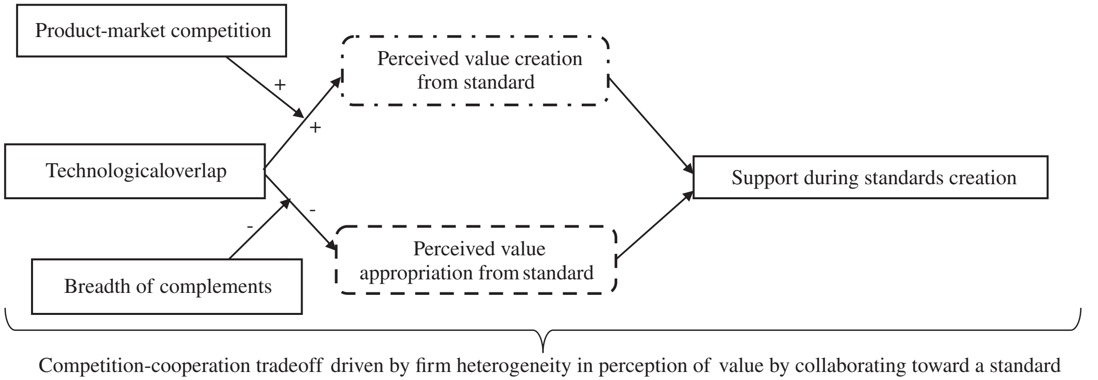

FIGURE 1 Conceptual framework: Firm-level characteristics driving tradeoff between competition and cooperation

2.3.2 | Technological consideration and product competition

Next we examine a contingency that increases the urgency to coordinate on standards and decreases contestation and appropriability concerns—*product competition*, namely, the extent of competition a firm experiences in the product-market space that it is incumbent in. In a technological change context, a firm's product-market position engenders two additional dimensions to its decision-making prism (Wu et al., 2014). First, it reveals the extent to which a firm is currently able to appropriate rents exclusively in the downstream market—a firm that is in a crowded product space (fragmented market) faces greater rivalry than a firm that is in a niche space (M. Porter, 1980), which negatively impacts performance (Young et al., 1996). This has direct implications on how a firm views the balance between shared value creation (urgency to coordinate a standard and grow the market) vs. individual value appropriation (maintaining a competitive advantage) as outlined in our initial competing hypotheses. Relatedly, it also implies the presence or absence of ex-post barriers to entry in the product space (Peteraf, 1993). A niche product space suggests that the incumbent firm likely possesses some unique advantage—for example, in downstream activities such as manufacturing, marketing, or distribution—that is unavailable to potential entrants or is simply too costly to acquire (Dierickx & Cool, 1989). The downstream rent protection has a bearing on how a firm might evaluate the appropriation risk associated with its sharing details of its technologies or how it might contest technical proposals.

Consider the inducements of two firms, both in completely overlapped technological spaces but with one firm in a niche product space and the other in a crowded product space. While both firms operate in a technological space with numerous competing alternatives and would benefit from coordination through standards, the intense rivalry experienced by the firm in the crowded product space magnifies the urgency to increase the current market size (the H1a effect is amplified). Similarly, competitive tensions to incorporate firm-specific choices is muted for the firm in the crowded product space—such a firm is likely to satisfice to accelerate coordination rather than optimize and risk persistence of the fragmented market (the H1b effect is diminished). In contrast, despite competition in the technological space, the greater rent protection accruing to the niche product firm tempers the urgency to coordinate and increases the tendency to maintain status quo in the established product-market (E. L. Chen et al., 2010) (the H1a effect is diminished). Compared to a firm in a competitive product space, a firm in a niche product space may also exhibit greater contestation in standards discussions to persuade others to accept its proposed technology into the standard. Despite lacking differentiation in the technological space, the firm could continue to capture rents if its technology is embedded in the industry standard and niche downstream assets are co-specialized (H1b effect is amplified) (D. Teece, 1986; Wu et al., 2014). We can analogously compare two firms in technological niches but at opposite ends of the product space.[10] Thus:

> **Hypothesis 3 (H3)** *The more competitive a firm's product-market space, the more the firm's technological overlap with other firms will increase its collaborative support during standards creation.*

Figure 1 illustrates how firm-level characteristics drive the competition-cooperation tradeoff.

2.4 | Community-level factors affecting competition–cooperation interplay

Following our illumination of the source of competitive tensions in SSOs in the preceding hypotheses, our subsequent focus is in determining whether the participating firms are ultimately successful in engendering a collaborative outcome and the conditions under which this occurs. An accepted measure of success in the standard-setting context is whether a technology solution reflecting consensus[11] of opinion among all member firms ensues (Ranganathan & Rosenkopf, 2014; Simcoe, 2012). Consensus is revealed in the extent to which the group achieves agreement when voting to endorse proposed technological specifications.[12] Between firms submitting technical proposals and voting on the standard, SSO rules allow for firms to negotiate on divergent issues and resolve conflicts (Farrell & Simcoe, 2012). Thus, the level of consensus reflects the extent to which the group has been successful in working out differences prior to formal ratification.

We examine factors that facilitate such issue resolution among participating firms, building on recent advances in interorganizational collaboration and negotiation studies, while illustrating their application to the focal context using examples from prior SSO studies. We argue that consensus is contingent on whether group characteristics support the formation of a collaborative coalition of firms, and enable subsequent negotiations. We focus on two *relational considerations*: the distribution of relational influence across firms that drives coalition formation and problem resolution, and the distribution of multiparty experience across firms that facilitates negotiations.

2.4.1 | Distribution of relational influence and committee consensus

We suggest that consensus on a particular committee ballot depends on the extent to which community characteristics can induce a unified coalition despite preliminary differences (Funk & Methe, 2001). The formation of such coalitions requires firms to actively seek out partners to collaborate on problem-solving and issue resolution where divergence exists. Prior research suggests that the *distribution of relational influence* can affect the identification and realization of such collaboration opportunities (Ahuja, Polidoro, & Mitchell, 2009; Davis, 2016; Heidl, Steensma, & Phelps, 2014; Zhang, Gupta, & Hallen, 2017). "Relational influence" represents the extent of power or control that

[10]While all firms with niche technological resources experience lower urgency to coordinate on technical compatibility and higher appropriation risk (H1a effect), those in a more rivalrous product space may be more willing to reveal proprietary technology within standards discussions as a way to eventually increase market size (H1a effect is diminished). Further, if a firm in a competitive product space is able to incorporate its niche technology into the standard, it stands to garner benefits beyond simply participating in a larger market. As the niche provider of some portion of the standardized technology, the firm could gain royalty revenues as others develop it further (e.g., Rysman & Simcoe, 2008) or be a highly sought after alliance partner by the numerous potential entrants in a growing market (Stuart, 1998).

[11]Where consensus "requires that all views and objections be considered and that an effort be made toward their resolution" (Source: ANSI).

[12]To facilitate such consensus-building, these organizations emphasize due process, which calls for a clear demarcation between the technical work of soliciting inputs from firms' engineers who propose technical aspects of the standard from the more formal task of ratifying sections of the standard, which occurs via voting on ballots.

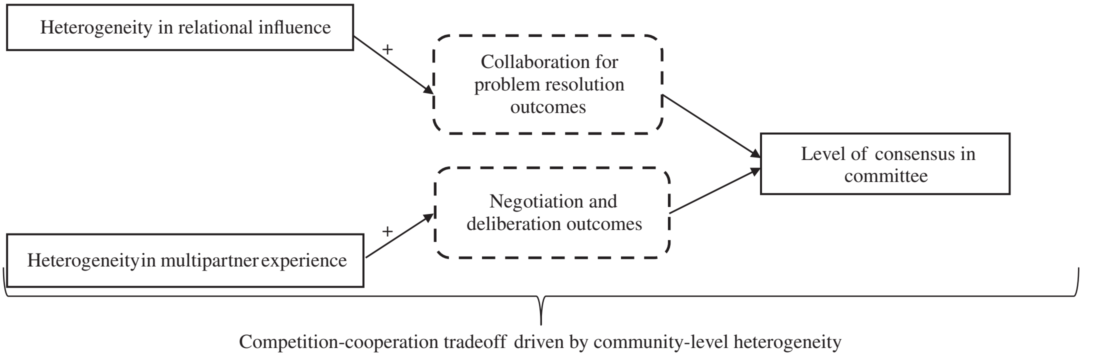

FIGURE 2 Conceptual framework: Community-level characteristics driving tradeoff between competition and cooperation

a particular firm has over other firms and is revealed by "its location in the network of interorganizational relations" (Cook, 1977, p. 71), where the relations comprising this network reflect prior collaborative links between firms (Gulati, 1995).

A high differentiation of influence across firms enables the group to clearly identify a "hub" firm that can fill the leadership void in the absence of hierarchical authority, and orchestrate knowledge exchange and socialization processes across divergent firms (Dhanaraj & Parkhe, 2006). For instance, a study of the Semiconductor Manufacturing Technology (SEMATECH) standards body in semiconductors suggests that having one principal firm to kick-start the collaborations avoids concerns of knowledge sharing (Browning, Beyer, & Shetler, 1995). Greater influence differentiation also clarifies the limits of any firm's clout and underscores the need for "satisficing" from available choices (Besen & Johnson, 1986; Jain, 2012; Winter, 2000) without being overcautious about proprietary interests or mired in impractical efforts to obtain a technically optimal solution (Jain, 2012). Heidl et al. (2014) demonstrate support for this idea in their finding that multipartner alliances comprising a mix of both influential and peripheral firms are less prone to conflict. They argue that influential firms lead by example to act as peacekeepers and coordinators of more peripheral partners. In a standards context, the more powerful firms can demonstrate the importance of compromise by forgoing their own idiosyncratic value appropriation advantages, thereby enhancing the legitimacy of the coalition (e.g., Garud et al., 2002). For example, in the case of the Ethernet standard, Jain (2012) illustrates how a dominant firm Digital Equipment Corporation (DEC) withdrew its proposal, which paved the way for standards discussions to proceed.

The distribution of relational influence also affects the collaborative problem solving that is necessary for technical overlaps and divergences to be resolved. In SSOs, attempting problem solving at the multilateral level is a complex endeavor—balancing several divergent interests and tradeoffs simultaneously can cause delays when hierarchical governance is absent (Reuer & Devarakonda, 2016). In an analogous multipartner technology setting, Davis (2016) finds that conflict and divergence can be mitigated through a dynamic collaboration process where multilateral activities are decomposed into a series of dyadic collaborations. Prior research suggests that the structure of relational influence is critical to the formation of these dyads, with collaborations spurred between firms in more disparate positions (Ahuja et al., 2009). While central firms have greater inducements to see that a consensus emerges (to transform their current influence into industry-wide technology adoption), peripheral firms may also be more open to satisficing as these associations confer them with other benefits (e.g., Ahuja et al., 2009; Zhang et al., 2017). Thus, influence distribution may translate into coalition-building between influential and peripheral firms.

In contrast, influential firms may view the presence of other influential firms as a competitive threat. As value appropriation in a post-standards world becomes less certain with more influential firms competing, the prospect of risky compatible competition becomes less promising than the assured status quo (Farrell & Klemperer, 2007). Thus, with several influential firms present, the group may opt for a more deliberate, bureaucratic approach to issue resolution as the slowdown offers protection for their current positions (E. L. Chen et al., 2010; Lehr, 1996). Ozcan and Santos (2015) offer some evidence for this in the mobile payments industry, finding that powerful players have difficulty in coordinating decisions with any resultant compromise being ineffective. Thus:

Hypothesis 4 (H4) *The level of consensus achieved will be higher when standards committees have greater heterogeneity of relational influence across member firms.*

2.4.2 | Distribution of prior multiparty experience and consensus

Consensus formation may also be hindered if firms remain deadlocked and are unable to arrive at a compromise (Farrell & Simcoe, 2012). We posit that the distribution of firms' negotiation experience—as obtained through prior exposure to the multiparty setting—constitutes an additional facet of interfirm influence that positively affects the ability of the group to arrive at a compromise. From the research on negotiations that has directly examined the nature and effect of prior experience, two important (and contrasting) findings are relevant in the standard-setting context. On the one hand, negotiation experience allows a negotiating entity to better prioritize and sort through issues, more accurately gauge the preferences of the other party and make mutually beneficial trade-offs (Loewenstein & Thompson, 2006; Thompson, 1990).[13] On the other hand, when negotiators with experience are involved, they also tend to be less likely to acquiesce during negotiations, recognizing that in some situations an impasse may be more desirable than agreeing to a compromise (T. R. Cohen, Leonardelli, & Thompson, 2014). In contrast, relatively naïve negotiators with little experience tend to fall into suboptimal "agreement traps" (Thompson, 1990; Thompson & Leonardelli, 2004). Cuypers, Cuypers, and Martin (2017) demonstrate how asymmetry in such negotiation experience affects value appropriation in merger agreements.

Taken together, these studies suggest that the *heterogeneity* of prior experiences of firms may be an antecedent to preventing deadlocks and ultimately achieving consensus. In committees where there is an experience distribution such that some firms are more experienced in prior multiparty settings while others lack such experience, then firms with prior experience can prioritize issues, identify areas of compromise, and present candidate solutions for negotiation while using their competence to guide the relatively inexperienced firms toward an agreement. In contrast, if most firms have little or no experience in prior multiparty settings, they are less likely to discriminate correctly on small private losses that may be traded off without major impacts, thus failing to realize the value of a compromise. Such committees are likely to be mired in delays over minor technical details. At the other extreme, when committees are comprised chiefly of firms possessing high levels of prior experience, they will likely remain resolute on the *same* set of issues that are likely to be critical determinants of future competitive advantage. In other words, while experienced firms are likely to be able and willing to negotiate on several areas of the proposed standard, they are also likely to overlap in those areas where compromise and debate is not an option. Thus:

[13] In a case study of the third-generation Code-division multiple access (CDMA) wireless standards committee, Funk and Methe (2001) find that experiential learning is instrumental to such negotiation outcomes—as firms gain exposure over time to different standards-setting contexts, they are able to compare the effectiveness of committees with market-based mechanisms, and as a result are more motivated to facilitate collaborative solutions and less prone to deadlocks.

Hypothesis 5 (H5) *The level of consensus achieved will be higher when committees have greater heterogeneity of prior multiparty experience across member firms.*

Figure 2 illustrates how community-level characteristics drive the competition–cooperation tradeoff.

3 | METHODOLOGY

Our empirical setting is the International Committee for Information Technology Standards (INCITS), a large voluntary standards-setting organization in the computer industry.[14] Within INCITS we study three subcommittee groups that devise standards for computer peripheral interfaces—the T10, T11 and T13 subcommittees.[15] Several characteristics of the computer ecosystem make it an appropriate context to study the interplay of competition and cooperation during technology coordination. The industry is systemic in nature with technical interdependencies among the various components and complements (e.g., hardware and software) with strong network externalities necessitating large-scale de-jure coordination. It has undergone continuous technological change with several successive generations of component-level innovations (e.g., optical drives and flash memory succeeding magnetic tape and disk technologies) as well as architectural innovations (e.g., USB, Firewire, and SCSI standards displacing older interfaces such as serial and parallel ports). Further, high levels of modularity architected by leading firms such as IBM have led to gradual de-verticalization with a corresponding dispersal in the locus of technical knowledge, further underscoring the importance of coordination. The ecosystem has also witnessed the widespread use of strategic technology collaborations and multipartner alliances by firms (Bresnahan & Greenstein, 1999; Rosenkopf & Schilling, 2007). Our focal subcommittees comprise a wide representation of competitor and complementor firms across the ecosystem, including in sectors such as semiconductors, hard disks, printers, cable and controllers, and operating system software that collaborate to create interoperability standards around peripheral connectivity.[16] Finally, INCITS employs numerous rules and regulations to ensure balance and consensus.[17]

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[14]INCITS is backed by the Information Technology Industry Council (ITI)—a trade association that represents a large number of firms in information technology sectors. It allows for contribution and representation from diverse organizations, large and small. Membership is not restricted and "open to all organizations that consider themselves to be directly or materially affected by the development or use of standards-based information technology products and services" (www.incits.org). Each firm, independent of market power or size, is allowed only one voting representative, thus preempting potential mandates of large "sponsor" firms

[15]The T10 subcommittee is responsible for developing standards for connecting peripheral devices for personal computers, particularly the series of SCSI (Small Computer System Interface) standards including parallel-SCSI and serial-SCSI (Firewire/1394). Standards developed within the T11 subcommittee are oriented toward higher-performance computing applications such as interoperability of different peripheral devices on a high-speed storage-area network (e.g. Intelligent Peripheral Interface [IPI], High-Performance Parallel Interface [HIPPI], and Fibre Channel [FC]). The T13 subcommittee develops a family of standards called ATA/-Serial ATA (AT-Attachment), which is used in connecting a majority of hard-disks today. While all three subcommittees run in parallel, they develop closely related interface standards (the T11 and T13 were created out of the T10 committee).

[16]For example, in the year 2008 (the last year of the data), INCITS member firms in our sample that were classified under the SIC code 3570 (computers and office equipment) had a combined market share of 95%, those that were classified under the SIC code 3571 (electronic computers) had a combined market share of 98%, and those classified under the SIC code 3678 (electronic connectors) had a combined market share of 70%. Overall, member firms had a combined market share of more than 70% in these sectors. Most large established public firms in these industries participated in INCITS standards creation.

[17]The operating structure of these committees meant that engineers had to collaborate within smaller working groups in order to propose additions or changes to the emerging standards specification. Any firm could choose to be part of any working group. Further, firms voted to ratify important milestones during the standards development process. These milestones covered the entire spectrum of standards-setting activities, from the initiation of a new project to the approval of the final specification document. Members were also free to propose ballot measures for any issues that merited a vote from all participants. It was obligatory that the member firms addressed the contesting votes and associated comments on a ballot even if the required majority to pass the ballot had been achieved. Said differently, detailed objections of firms needed to be resolved before the standard could move to the next stage, even if the firms objecting were a small minority.

3.1 | Data sources

We tracked member firms' activities in the three INCITS subcommittees over a 15-year period beginning in 1994 with the formation of the first subcommittee (t10).[18] The INCITS data included firms' memberships, emails communicated by firm representatives (which we use to build our first dependent variable), technical documents submitted, working-group meeting minutes, and votes on ballots (which we use to build our second dependent variable).[19,20] We obtained patent data from the National Bureau of Economic Research (NBER) project (Hall, Jaffe, & Trajtenberg, 2001) to construct independent variables and controls relating to technological resources[21] and supplemented this with Derwent patent data to get information on firms' patent claims that were specific to the emerging standard.[22] We collected data on firms' products and complements using the Corptech Directory of Technology Companies.[23] For each firm in our sample we collected all Corptech product codes assigned to them at the most granular level. We used Factiva, an aggregator of news sources, to gather information on firms' prior strategic alliances.[24,25] Our search on Factiva yielded 3,365 alliance ties between pairs of member firms and 311 multipartner alliances that involved at least one member firm.[26,27] Finally, we obtained data on firm financials, industry participation, and mergers and acquisitions using a combination of Compustat, *Hoover*'s, *BusinessWeek* online, Corptech, and other specialized trade journals such as Storagesearch.com that covered the peripherals sector of the computer industry.[28]

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[18]We obtained this information from the electronic databases available at www.t10.org, www.t11.org and www.t13.org.

[19]We mapped every vote on a ballot to corresponding firms in the committee and we downloaded each email document from the standards committee records and developed automated scripts to identify the sending firm's representative, the date, and the specific subcommittee. Our final sample yielded 31,406 emails sent by member-firm representatives and 254 different ballots that were put forth to vote in order for member firms to ratify the standard at various milestones.

[20]We developed a variety of automated techniques to filter out email data that was either spam, from non-member organizations and individuals, or simply not relevant from a technical discussion standpoint. These included: notification of meeting locations, meeting agenda, meeting minutes, and reminders to vote on ballots, among other administrative and housekeeping items.

[21]From the full patent dataset of more than 3 million patents, we extracted the subset of patents that were assigned to member firms of the technical subcommittees. We then narrowed this subset using the technical categories and subcategories that were germane to the t10, t11, and t13 standards discussions. As these standards were far-reaching in their scope and integrated across a whole variety of computer technologies, we correspondingly adopted a broad definition of the technology space· For instance, the member firms participating in these committees were from industries such as computers, computer storage devices, computer communication equipment, semiconductors, electronic and other electrical equipment, electronic connectors, computer programming, audio and video equipment, computer-integrated systems design, telephone and telegraph apparatus, and prepackaged software. Therefore, we included patents from the Hall Jaffe Trajtenberg (HJT) technology category 2 (Computers and Communications) with subcategories 21 (Communications), Computer Hardware and Software (22), Computer Peripherals (23), Information Storage (24), Electronic business methods and software (25), and those from HJT technology category 4 (Electrical and Electronic) with subcategories 41 (Electrical Devices), Measuring and Testing (43), Power Systems (45), Semiconductor Devices (46), Miscellaneous Electrical/Electronic (49).

[22]We used keyword searches pertaining to the standard's technologies in order to filter out these patents. For instance, we included keywords such as SCSI, Firewire ATA, ATAPI, Fibre channel.

[23]Published by Corporate Technology Information Services, Corptech provides this information longitudinally on both private and public companies. The data base is longitudinal and organized using a hierarchical, fine-grained taxonomy of products. For example, in Corptech's taxonomy, Adaptec, Inc.'s (one of the firms in our sample) product categories are SCSI test systems: AUT-AT-H; Smart cards: COM-AX–MS; SCSI host adapters: SUB-CL-A; and Ethernet cards: TEL-TD-S. Each of the categories has descriptors at three nested levels. In this example "SUB" refers to the category subassemblies and components, "CL" refers to a nested subcategory of cables and connectors, and "A" to a third-level nested subcategory of adapters.

[24]As Lavie (2007) notes, Securities Data Company (SDC) Platinum coverage of alliances can be quite sparse in some sectors.

[25]As Factiva often reports rumored ties duplicate listings of the same alliance announcement, we used a combination of manual and automated techniques to filter these out.

[26]More than two firms in the alliance.

[27]We used Lavie and Rosenkopf's (2006) procedure used to identify technology development alliances using the text from the announcement of the alliance.

[28]We integrated different subsidiaries of the same firm and also integrated patent data across subsidiary firms as well as firms that were acquired or merged.

3.2 | Measures[29]

3.2.1 | Dependent variables

Positivity index as a measure of firm support

Unlike typical organizations, the standards body consists of physically dispersed representatives of several different firms with limited ability to interact in real time (Martins, Gilson, & Maynard, 2004). The working groups within these committees therefore rely on electronic communications to discuss issues. To measure firms' support during standards creation, we therefore used the text of the electronic mails sent by firm representatives where they propose and debate technical issues relevant to the standard. We employed the Linguistic Inquiry Word Count (LIWC) software's *positivity index* that measures conversational tone in order to gauge the extent to which firm's outlook is supportive toward the emerging standard, as captured in the e-mail communications of its representatives.[30,31] LIWC checks each word against an internal dictionary of more than 6,400 words and word stems and assigns it to specific linguistic categories, reporting the percentage of total words in each category (Pennebaker, Francis, & Booth, 2001).[32] The categories of interest for our measure are the two groups of words indicating positive tone and negative tone in conversation. The positivity index is constructed by LIWC as the difference between the scores for positive category words (e.g., fantastic, happy, excellent, promising) and negative category words (e.g., disagree, dislike, uncertain, unsure)[33] (Cohn, Mehl, & Pennebaker, 2004). Higher scores indicate greater positivity, which suggests a more collaborative than competitive outlook, while lower scores indicate lower positivity, which suggests greater competitive tensions. We aggregated scores at the firm-month level (using the monthly average score) to organize the data into longitudinal panels.

Certainty index as an alternate measure of firm support

In addition to the positivity index, we also measure a firm's interaction tone during standards creation activities using a measure called the certainty index. Like the positivity measure, the certainty index is also based on a reliable linguistic measure of the extent of confidence that is expressed in the discourse being analyzed.[34] What sets the certainty measure apart is that it captures the level of assurance or optimism independent of emotional content (evidenced by a low correlation of 0.13 with the positivity index).

Committee consensus on a ballot

To model our construct of consensus, we used ballot-voting data to ascertain the resolution of differences that arose during the creation of the standard. Ballots are voted on by firms at specific

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[29]Summary of measures and data sources are available in Appendix Tables A3 and A4 in File S1.

[30]These emails are not sent to a specific firm-representative but are addressed to the committee's mailing list. Thus they are indicative of the firm's communication toward the entire standards committee.

[31]LIWC is a reliable method to measure underlying motivations of organizational actors as manifested in their communications (Helms et al., 2012), with a number of prior studies in strategic management utilizing the LIWC positivity index (e.g., Pfarrer, Pollock, & Rindova, 2010).

[32]The default word categories that are available in LIWC were created and validated through an extensive dictionary development and psychometric testing process that drew upon ~181,000 text files and 231 million words.

[33]The current version of LIWC is even able to identify contemporary "netspeak" language. For instance "☺" is coded as a positive tone category word.

[34]For instance, in recent research, G. Chen, Crossland, and Luo (2015) used the LIWC certainty variable to measure the extent to which CEOs may be overconfident.

milestones during the standard-setting process.[35] The inputs to these ballots are specifications that have been created by firm collaboration, after they have already debated the direction of specific technical choices for the standard in working groups. Firms' votes fall in one of four categories: "Yes," "Abstain," "Yes with comments," and "No." We computed a Herfindahl–Hirschman index of these vote choices, with higher values indicating stronger agreement between firms and lower ones indicating the persistence of divergent opinions.[36]

3.2.2 | Independent variables

To test hypotheses 1–3, we constructed the following firm-level variables:

Technological overlap

We followed Podolny, Stuart, and Hannan (1996) to measure technological overlap using patent data. We first defined the niche overlap between each pair of firms i & j as the intersection set of the number of patents the two firms cite in a given year. In other words, we count common back cited patents for each pair of firms to get $nicheOverlap_{ij}$. We aggregate this across all pairs formed by a firm with every other member firm. Thus, technological overlap of firm i is:

$$\sum_j nicheOverlap_{ij}$$

Product-market competition

We computed an analogous product-market competitive position measure using the Corptech product data. We first used the product codes at the most granular (third) level[37] to calculate the number of product overlaps between the focal firm and each member firm, $productOverlap_{ij}$. We then defined the downstream competition for firm i as the aggregate number over all dyadic i,j product overlaps:

$$\sum_j productOverlap_{ij}$$

Breadth of firm's complementary products

To measure the breadth of a firm's complementary products, we used a 5-year window of the count of the number of distinct product categories that the firm was classified into in Corptech. Thus, the higher the number of product categories a firm spans, the broader is the firm's array of complementary products.

Finally, we created interaction variables *Technological overlap* × *Breadth of complements* and *Technological overlap* × *Product-market competition* as the product of the above independent variables.

To test hypotheses 4 and 5, we created the following ballot-level variables:

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[35] According to INCITS rules and regulations, these milestones correspond to (in chronological order): Approval of the Standards Project, Notification to the Public, Technical Development, Initial Public Review, Management Review, Executive Board Approval, ANSI Approval, and Final Publication.

[36] For e.g. a value of 1 at the extreme indicates that all votes were in the same category.

[37] We also computed this measure using coarser second- and first-level product codes to assess robustness.

Heterogeneity in relational influence

To measure the dispersion in firms' relational influence (Hypothesis 4), we first constructed the member firms' multipartner alliance network. We coded ties between firms if we observed at least one common multipartner alliance in a 5-year window preceding a focal ballot. This set of ties formed the adjacency matrix that defined our member firms' network. Using this matrix, we calculated an eigenvector centrality measure for each firm and then constructed the heterogeneity in relational influence measure for a ballot as the standard deviation of the centrality scores for all firms voting in that ballot (Gulati and Gargiulo (1999)'s structural differentiation measure). Higher values indicate greater heterogeneity in relational influence.

Heterogeneity in multiparty experience

Our intent in Hypothesis 5 is to understand how differentiation in prior multipartner alliance experience across firms affected the adjudication process at the committee level. To derive this measure, we first counted the number of multipartner alliances (MPA) that each firm on a focal ballot had been involved with in five preceding years and also the number of partners the firm had in each of those alliances. We then constructed the measure as the standard deviation of the average of number of partners of the firms' prior MPAs. Thus, our measure weights the experience of firms based on multipartner alliance size.[38]

3.2.3 | Control variables for firm-level analyses

We control for a number of variables at the firm level that could drive a focal firm's interaction tone during the standards-creation process. First, we include *Patents on standard's technologies* to control for intellectual property claims specific to the standard. We include *Participation in committee working group*—a measure of firms' involvement in meetings. We also include measures for *Size* (log of Assets), *Financial slack* (debt ratio), *Financial performance* (log of revenues), *Sector size* (log of sector assets), and *Time*.

3.2.4 | Control variables for ballot-level analyses

Since our hypothesized predictors for multipartner experience and relational influence are both effects of diversity or deviation, we control for potential effects arising from the central tendency of these variables with *Median MPA experience of firms* (median MPA experience across all firms in a ballot using the average number of partners measure), and *MPA network centralization* (median eigenvector centrality across firms in the ballot). Our remaining controls at the ballot level include two types of variables—stock and deviation. While stock variables are calculated by summing up a firm-level measure across all firms voting on the ballot, deviation variables are measured using the standard deviation of the firm-level measure. We include *Stock of firms' involvement (technical proposals)* to account for differences in involvement across different ballots that may affect consensus formation. We include *Deviation in firms' tenure on the standard* and *Deviation in firms' industry opportunities* to control for differences in value creation and appropriation tendencies owing to idiosyncratic membership timing or sector differences that may affect consensus formation. Similarly, we also control for *Stock of firms' patent claims*, *Sum of Firms' assets* and *Sum of Firms' revenues.* We control for the *Number of firms voting* (ballots with fewer firms may have different dynamics with respect to consensus formation compared to ballots with many firms). We account for the

[38]For instance, firms that have on an average been part of 20+ member multipartner alliances bring a potentially superior ability to deliberate within the standards-setting context than firms that have on an average been part of only three firm multipartner alliances. Our measure reflects this notion.

TABLE 1 Descriptive statistics and correlations – firm-level (All variables centered and standardized: Mean = 0, *SD* = 1)

	Measure	1	2	3	4	5	6	7	8	9	10
1	Positivity in communications	1									
2	Technological overlap	−0.06	1								
3	Breadth of firm's complements	−0.07	0.73	1							
4	Product-market competition	−0.07	0.79	0.84	1						
5	Participation in working group associated with ballot	−0.04	0.02	0.04	0.07	1					
6	Patents on standard's technologies	−0.04	0.43	0.37	0.42	0.18	1				
7	Size (assets)	−0.02	0.68	0.67	0.7	−0.03	0.42	1			
8	Performance (revenues)	−0.05	0.66	0.67	0.67	0.05	0.38	0.96	1		
9	Sector size (assets)	−0.09	0.42	0.43	0.47	0.07	0.3	0.49	0.44	1	
10	Financial slack (Debt)	−0.03	0.72	0.64	0.58	0.02	0.53	0.72	0.68	0.43	1

difference in complexity of achieving a consensus across time by using *Sequence of ballot* and indicator variables for *Milestone category,* each of which control for inter-temporal considerations such as increasing maturity of the technologies under discussion and progression or advancement of the standard. Additionally, we include values of our dependent and independent variables from our firm-level analyses aggregated to the ballot's particular time period.[39]

3.2.5 | Estimation

We estimate the two conceptual levels of our framework in separate firm- and ballot-level regressions. Independent variables are lagged to alleviate simultaneity concerns. For the firm level (Hypotheses 1–3), we predict positivity and certainty using the variables calculated from email data, and for the ballot level (Hypotheses 4–5), we predict consensus after controlling for the predicted tones from the firm-level analyses.

Unobserved heterogeneity and endogeneity of firm interaction tone

In the firm-level analyses, we use panel-mixed models to account for unobserved subcommittee, firm, and month effects. Our models incorporate a conservative unstructured covariance structure that does not assume independence across these multiple levels. In the committee analyses, to model firms' interaction tones (which are endogenous), we use the median and standard deviation of the predicted positivity from the firm-level analyses, aggregated to the ballot level, to control for both the average positivity as well as its distribution across firms. Our ballot estimation uses panel data quasi-least squares models (each subcommittee forms one panel with each ballot as a specific longitudinal observation of the panel), with first order autoregressive (AR(1)) correlation error structures to account for serial correlation across ballots.

4 | RESULTS

Tables 1 and 2 show descriptive statistics and correlations for our firm-level and community-level analyses. All measures are centered and standardized to facilitate interpretation of coefficients.

[39]We link the tone during standards creation present in the community to a ballot by first calculating the predicted values of positivity and certainty from our firm-level models and then deriving aggregate (median) and deviation measures from these predictions, specifically the period between the dates of the previous ballot and the focal ballot. Similarly, we also include the collective versions of the firm-level competition and scope explanatory variables as controls.

TABLE 2 Descriptive statistics and correlations—community level (All variables centered and standardized: Mean = 0, SD = 1)

	Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Consensus on ballot	1														
2	Heterogeneity in firms' multipartner alliance (MPA) experience	0.41	1													
3	Median MPA experience of firms	−0.25	−0.42	1												
4	Heterogeneity in firms' relational influence	0.1	0.02	−0.69	1											
5	MPA network centralization	0.31	0.52	−0.77	0.57	1										
6	Technological overlap (median)	0.12	0.29	−0.04	−0.2	0.08	1									
7	Breadth of firm's complements (median)	0	0.11	−0.3	0.26	0.13	0.44	1								
8	Product-market competition (median)	−0.23	−0.51	0.04	0.03	−0.24	0.2	0.48	1							
9	Stock of firms' involvement (technical proposals)	0.13	−0.12	−0.06	0.28	0.24	0.09	0.19	0.14	1						
10	Deviation in firms' tenure on standards committee	−0.4	−0.69	0.7	−0.3	−0.72	−0.51	−0.27	0.15	0.00	1					
11	Deviation in firms' industry opportunity	−0.09	−0.23	0.2	−0.1	−0.13	−0.11	−0.01	0.09	0.59	0.44	1				
12	Stock of firms' patent claims	−0.17	−0.6	0.53	−0.35	−0.47	0.35	0.02	0.33	0.28	0.24	0.22	1			
13	Firms' assets (sum)	−0.18	−0.23	0.52	−0.4	−0.55	−0.34	−0.22	−0.13	−0.39	0.52	−0.12	0.08	1		
14	Firms' revenues (sum)	0.08	0.12	0.26	−0.33	−0.16	−0.32	−0.24	−0.27	−0.41	0.17	−0.38	−0.26	0.77	1	
15	Number of firms voting	−0.08	−0.34	0.04	0.23	−0.06	−0.09	0.06	0.17	0.69	0.34	0.74	0.37	−0.28	−0.55	1

TABLE 3 Firm-level analyses. Panel data mixed models controlling for time, firm, and subcommittee effects

Models / Variables	(1) Positivity	(2) Positivity	(3) Positivity	(4) Positivity Level 2 Product	(5) Positivity Level 1 Product	(6) Certainty
H1: Technological overlap	−0.0179	0.1455	0.0276	0.1702	0.1404	−0.1559
	(.7510)	(.1281)	(.7978)	(.0654)	(.1256)	(.0943)
H2: Technological overlap × Breadth of firm's complements		−0.1114	−0.2778	−0.2905	−0.2428	−0.1760
		(.0358)	(.0015)	(.0010)	(.0015)	(.0227)
H3: Technological overlap × Product-market competition			0.2366	0.0080	0.0056	0.4097
			(.0166)	(.0125)	(.0113)	(.0000)
Breadth of firm's complements	−0.0266	0.0069	0.0249	0.0309	0.0107	0.1038
	(.5658)	(.8888)	(.6170)	(.5488)	(.8021)	(.0066)
Product-market competition	0.0133	0.0022	−0.0304	0.0010	0.0040	−0.0590
	(.7804)	(.9627)	(.5394)	(.7185)	(.0285)	(.2023)
Participation level in committee working group	0.0044	0.0034	0.0033	0.0025	0.0041	0.0195
	(.7902)	(.8375)	(.8419)	(.8809)	(.8070)	(.2129)
Patents on standard's technologies	−0.0109	−0.0193	−0.0047	−0.0058	−0.0099	0.0093
	(.6646)	(.4478)	(.8581)	(.8230)	(.7013)	(.6999)
Size (assets)	0.4785	0.4495	0.4678	0.4597	0.4429	0.2247
	(.0000)	(.0000)	(.0000)	(.0000)	(.0000)	(.0036)
Performance (revenues)	−0.2224	−0.2281	−0.2274	−0.2246	−0.2229	−0.1245
	(.0000)	(.0000)	(.0000)	(.0000)	(.0000)	(.0002)
Sector size (assets)	−0.1340	−0.1459	−0.1420	−0.1420	−0.1358	0.0181
	(.0000)	(.0000)	(.0000)	(.0000)	(.0001)	(.6068)
Financial slack (debt)	0.0130	0.0210	0.0123	0.0061	0.0018	−0.1697
	(.7452)	(.5996)	(.7583)	(.8746)	(.9633)	(.0000)
Time (months)	−0.0007	−0.0006	−0.0008	−0.0008	−0.0005	−0.0043
	(.8472)	(.8692)	(.8327)	(.8346)	(.8910)	(.0000)
Constant	0.4356	0.4635	0.4184	0.3922	0.4662	0.4569
	(.0021)	(.0012)	(.0037)	(.0070)	(.0018)	(.0000)
Observations	5,344	5,344	5,344	5,352	5,344	5,344
Number of firms	115	115	115	115	115	115
Number of subcommittees	3	3	3	3	3	3
Log likelihood	−7,342	−7,342	−7,340	−7,346	−7,347	−7,203

Note. p-values indicated in parentheses. Dependent variable is positivity index (Models 1–5) and certainty index (Model 6).

Table 3 displays the results of our regressions testing Hypotheses 1–3. Model 1 shows the results of the test for the competing hypothesis H1, and Models 2 and 3 add the variables to test H2 and H3.

Since the dependent variable is the positivity index, a negative coefficient for an independent variable indicates an effect of increasing concern regarding the standard, while a positive coefficient indicates higher levels of optimism and confidence regarding the proposed standard. In H1, we argued that *Technological overlap* by itself has an ambiguous effect on the tradeoff a firm experiences during standards creation. Indeed, there is not clear and consistent effect for this coefficient (*p*-values ranging from .12 to .179), which supports our reasoning. In H2, we argued that firms in more overlapped technology spaces and with a broader array of product complements will exhibit lower support during the standards creation process. In Models 2 and 3, the negative coefficient of *Technological overlap* × *Breadth of firm's complements* (p-value = .0015 in Model 3) supports H2; a one standard-deviation increase in this variable decreases the dependent variable positivity by 0.2778 standard deviations. In H3, we argued that firms in more overlapped technology spaces and simultaneously in more competitive product markets will exhibit higher support during the standards creation process. In Model 3, the positive coefficient of *Technological overlap* × *Product-market competition* (Beta = 0.2366, p-value = .0166) supports H3. In Models 4 and 5, we used the second- and first-level product codes to create firms' product-market competition measures[40] and the results are consistent. The coefficient sizes in these models are very close to zero (0.0080 at p-value = .012 in Model 4; 0.0056 at p-value = .0113 in Model 5) when compared to Model 3 (0.2366 at p-value = .001) indicating that in our context where there is a rich heterogeneity of firms even within the same sector, competitive motivations are more accurately identified by using granular product-level data versus coarser industry groupings. Finally, Model 6 shows that results using our second measure of support—certainty index—are consistent with those obtained when using the positivity index.

Moving to our committee-level ballot analyses, Table 4 displays the results of our regressions to test Hypotheses 4 and 5. Model 1 is controls-only; in Models 2–3 we add the variables of interest.

Since our dependent variable is the level of consensus in a subcommittee-ballot, a positive coefficient for a predictor variable indicates an effect of increasing consensus and a negative coefficient an effect of decreasing consensus. In H4, we argued that the level of consensus achieved will be higher for ballots when there is greater heterogeneity in firms' relational influence in the interorganizational network of member firms, and this is supported by the positive coefficient of *Heterogeneity in relational influence* in Models 2 and 3 (p-value = .0021 in Model 3): A one-standard-deviation increase in this variable increases the level of consensus by 0.32 standard deviations. Relatedly, the coefficient for *MPA network centralization* is negative (Beta = −0.2388 at a p-value = .004 in Model 2), indicating that the presence of several relationally influential firms reduces consensus achieved. In H5, we argued that the level of consensus achieved will be higher for ballots with greater heterogeneity of multiparty experience across voting firms, and this is supported by the positive coefficient of *Heterogeneity in MPA experience* in Model 3 (Beta = 0.4652, p-value = .0057): A one-standard-deviation increase in this variable increases the level of consensus by 0.47 standard deviations. Relatedly, the coefficient for *Median MPA experience of firms* is negative (p-value = .0004), indicating that when several firms are highly experienced, negotiations may be less constructive.

We also analyzed the influence of our predictors on subcommittee ballots that had higher levels of discord among member firms by splitting the sample of ballots at the median of the ballot-level positivity. Effects consistent with our hypotheses are obtained only in one half of the sample (Model 4), where the ballots are characterized by firms expressing greater levels of discord (*Heterogeneity of firms' multipartner experience* has a coefficient of 0.3700 at a p-value = .09, and *Heterogeneity of firms' relational influence* has a coefficient of 0.6684 at a p-value = .02).

4.1 | Robustness checks

We carried out a series of robustness checks in order to assess the sensitivity of our assumptions around choice of measures and models. To begin with, our two independent variables—*breadth of*

[40]The first-level product code is essentially analogous to an industry-level overlap measure.

TABLE 4 Community-level analyses. Panel data quasi least squares models with AR1 correlation error structure

Models	(1)	(2)	(3)	(4) Low positivity	(5) High positivity
H4: Heterogeneity in relational influence		0.2136	0.3189	0.3684	0.6374
		(.000)	(.0021)	(.0244)	(.5452)
H5: Heterogeneity in multipartner alliance (MPA) experience			0.4652	0.3700	−1.1205
			(.0057)	(.0989)	(.0000)
MPA network centralization		−0.2388	−0.2301	−0.2539	−0.1572
		(.004)	(.0156)	(.3793)	(.9289)
Median MPA experience of firms			−0.3763	−0.7235	−0.2377
			(.0004)	(.0000)	(.9225)
Median positivity in firms' interaction prior to ballot (predicted)	0.1832	0.2419	0.3522	0.0065	0.2340
	(.1096)	(.150)	(.0044)	(.9838)	(.3928)
Deviation in positivity (predicted)	−0.2331	−0.2237	−0.2756	−0.1879	−0.0100
	(.0253)	(.074)	(.0149)	(.3231)	(.9135)
Median certainty in firms' interaction prior to ballot (predicted)	0.2907	0.3281	0.3022	1.5705	0.1650
	(.3044)	(.493)	(.4837)	(.0000)	(.8914)
Deviation in certainty (predicted)	−0.2201	−0.2171	−0.2019	−0.1935	0.0762
	(.0001)	(.006)	(.0323)	(.1448)	(.6985)
Technological overlap (median)	−0.1819	−0.1619	−0.1637	−0.1298	−0.0637
	(.0594)	(.135)	(.0347)	(.0941)	(.6230)
Breadth of firms' complements (median)	0.1059	0.0749	−0.0006	0.1860	−0.1583
	(.0921)	(.403)	(.9949)	(.0411)	(.1792)
Product-market competition (median)	−0.0453	−0.0639	0.0103	−0.0846	0.0917
	(.7046)	(.625)	(.9455)	(.6178)	(.4900)
Stock of firms' involvement (technical proposals)	0.1023	0.0516	0.1510	0.2658	−0.0845
	(.5574)	(.763)	(.3261)	(.0000)	(.8363)
Deviation in firms' tenure on standards committee	−0.6517	−0.7619	−0.6409	−1.0999	−0.0963
	(.0193)	(.002)	(.0008)	(.0236)	(.8368)
Deviation in firms' industry opportunity	0.1968	0.3245	0.3325	0.5261	−0.0592
	(.2444)	(.014)	(.0000)	(.0026)	(.6082)
Stock of firms' patent claims	0.1086	0.1348	0.5129	0.2888	0.8508
	(.0001)	(.000)	(.0000)	(.2549)	(.0152)
Firms' assets (sum)	0.0433	−0.0866	−0.1298	0.0388	−0.2505
	(.7619)	(.612)	(.4735)	(.8199)	(.4912)
Firms' revenues (sum)	0.3123	0.4879	0.4384	0.3375	0.1967
	(.0000)	(.000)	(.0000)	(.2512)	(.4941)
Number of firms voting	0.3258	0.3026	0.1580	0.1950	−0.2923
	(.1335)	(.165)	(.4776)	(.1806)	(.1070)
Sequence of ballot	0.2115	0.1853	0.5758	2.5957	0.8234
	(.3160)	(.621)	(.3481)	(.0000)	(.6061)
Milestone category dummies	Yes	Yes	Yes	Yes	Yes
Constant	0.5104	0.5395	0.5080	1.2187	−0.2789
	(.0102)	(.007)	(.0080)	(.0000)	(.5761)
Number of ballots (subcommittees)	260 (3)	254(3)	254(3)	126(3)	123(3)

Note. p-values indicated in parentheses. Dependent variable is Consensus formation on a subcommmittee ballot *product complements* and *product-market competition*—are highly correlated (~0.84). While this is natural,[41] it does open up concerns of multicollinearity. However, as one effect of multicollinearity is to increase the size of standard errors, making it more difficult to obtain smaller *p*-values, we are less likely to find supporting results for our hypotheses. Our robust results across various specifications (discussed subsequently) therefore alleviate this concern to some extent. Additionally, we also verified in three separate robustness checks that collinearity is not likely affecting our results.[42] We ran additional tests to verify that the variation in the technological content being discussed in ballots is not confounding our results (the concern being that content may vary across ballots to which the communications pertain, with some content being more pertinent or relevant for a firm to contest).[43] We then examined two alternate dependent variables that captured support for standards creation from a source other than email communications.[44] Finally, we verified that our results remained robust across different model specifications.[45]

5 | DISCUSSION

As research focused on innovation and survival in settings marked by technological change has traditionally been carried out in separate streams of either competition (e.g., Katila & Chen, 2008; Polidoro & Toh, 2011) or collaboration (Afuah, 2000; Ahuja et al., 2009; Gulati et al., 2009; Rosenkopf et al., 2001; Rothaermel, 2001), these disjointed perspectives can only offer us a limited understanding of decision making in organizations such as standards bodies that bring competitors together to coordinate technological choices. In systemic industries, such organizations have become a dominant mode of harmonizing across the technological resources of firms with the attendant benefits of "growing the pie" for the entire ecosystem of players while avoiding the potentially ruinous consequences of market-based competition and standards wars. Our examination of the micro dynamics behind the interplay of competition and cooperation in this context exposed factors affecting whether competing firms successfully arrive at collaborative outcomes.

[41]Firms that are incumbents in more product categories likely experience more competitors.

[42]First, we examined variance inflation factors (VIFs) (after running an OLS [ordinary least squares] with the base model) and found that the highest VIF was well below the accepted threshold of 10. We then followed prior research to orthogonalize the two independent variables of interest using the Gram-Schmidt procedure (Sine, Mitsuhashi, & Kirsch, 2006)—this removes any correlation between the variables. We entered these orthogonalized versions along with their interaction terms into the regression. Our results (Appendix A1.1 in File S1) remained robust. Finally, we examined two alternative formulations of the variables using different product code levels (these had reduced correlations of ~0.6). Our results (Appendix A1.2 and A1.3 in File S1) remained robust.

[43]As it is extraordinarily challenging (even with relevant expertise) to parse more than 60,000 emails and thousands of additional technical-standards documents to reasonably assess content, we instead grouped together emails that pertained to particular ballots with the variation in ballots across time, proxying for the variation in content being debated. Additionally we included ballot milestone information to account for the effect of specific project phases that may relate to content as well. These results are robust and are reported in A1.4 and A1.5 in File S1.

[44]These alternate formulations were the number of technical documents submitted by the firm within the standard's archival records (a measure of support by technical involvement) and participation in working-group meetings measured by a count of the firm's name in meeting minutes (a measure of support by engagement). We report robust results for these measures in A1.6–A1.7 in File S1.

[45]For our firm-level hypotheses tests, we illustrate robustness with an exchangeable correlation structure for the covariance matrix (A2.1 in File S1), a panel independent error structure (A2.2 in File S1), a panel data fixed-effects model (A2.3 in File S1), a panel data generalized least squares model (A2.4 in File S1), a panel data generalized estimating equation (GEE) model (A2.5 in File S1), as well as OLS regression models (A2.6 and A2.7 in File S1). For our community-level hypotheses tests, we demonstrate robustness with OLS models (A3.1 –A3.4 in File S1), panel data random (A3.5 in File S1) and fixed effects models (A3.6 in File S1), panel data generalized least squares models with heteroskedasticity and panel-specific autocorrelation error structure (A3.7 in File S1), a panel GEE model with an exchangeable correlation structure (A3.8 in File S1), and using a count of prior multipartner alliances instead of number of partners in order construct heterogeneity in multiparty experience to test Hypothesis 5 (A3.9 in File S1).

To unpack the competition–cooperation interplay, we began by illustrating why competitive tensions arise within standards bodies, noting that while every firm that participates in standard-setting would want favorable standards and would push for such choices in committee interactions, the natural heterogeneity across firms and the consensus governance characteristics of the standards context suggests any unified choice is unlikely to favor all firms equally. This creates one aspect of competitive tension during standards discussions as firms jostle with one other to push choices through that are in line with their idiosyncratic investments. We followed this line of inquiry to then describe additional drivers and moderators of competitive tensions, why such tensions may be experienced differently across participating firms, and under what conditions they may get resolved.

Our theorizing, which integrates concepts from the competition and cooperation research domains, suggests that the motivations for both standards development and their ultimate support are richly nuanced because numerous firms are embedded in an interdependent ecosystem of technologies, product-markets, and complements. Our results demonstrate the importance of considering the complete ecosystem (Adner & Kapoor, 2010), as interactions provided far greater explanatory power than isolated main effects. Said differently, a firm's competitive position in downstream product-markets and its investments in complementary products clearly moderate how technological resource overlaps shape communication during standards development by resolving tradeoffs between value-creation and value-appropriation motivations. Specifically, product-market competition positively moderated the effect of technological resources on collaborative support, which is likely attributable to the increase in the urgency to create value from cooperation. In contrast, greater investments in product complements negatively moderated the effect of technological resource overlaps on collaborative support. This is likely attributable to firms' concerns over loss of value appropriation from sunk investments in product complements as well as concerns of a broader future threat to generative appropriability (Ahuja et al., 2013) and systemic innovation potential rooted in integrated product platforms (Helfat & Campo-Rembado, 2016).

We then expand the ecosystem of technology, product-markets, and complements to include interorganizational relationships (Dyer & Singh, 1998), and find that on committee-level ballots that represent a resolution of heterogeneous firm motivations, heterogeneity in these relational considerations actually *facilitates* consensus. With regard to the structure of this alliance network, when committees have greater heterogeneity in relational influence they reach higher levels of consensus. Similarly, with regard to participation in multiparty alliances, greater heterogeneity in prior experience promotes consensus. Importantly, these results are driven by ballots with higher friction during prior deliberation, where putative divergence is therefore highest. We attribute these findings to a clear "pecking" order of hub vs. peripheral firms that allows the formation of coalitions to support a particular technological direction when divergences exist, and ultimately enables the group to negotiate on compromises. In other words, more differentiated committees prescribe natural patterns of interaction and circumscribe direct competition, easing both consensus-building and value-distribution concerns, and implying that SSOs should ensure opportunities for peripheral firms to participate as representatives in working groups.

By demonstrating how the interplay of competition and cooperation might shape the direction of technological change, our study also informs research on technological evolution. While researchers have predominantly examined radical technological change and discontinuities that lead to the emergence of dominant designs in industries (M. Tushman & Anderson, 1986), we focus on coordination activities in existing ecosystems that are aimed at refining and extending established designs. As dominant designs tend to persist, much of the technological change actually takes place in standards forums and yet researchers have paid little attention to how firms competing with each other to appropriate value in a postdominant design marketplace might also simultaneously collaborate through technology coordination. Importantly, entrenching the dominant design and spawning additional growth through network externalities requires technical interoperability among firms. However, from an individual firm's perspective, it is not clear that the (uncertain) value appropriation from these future growth opportunities or the attendant intellectual property risks necessarily overshadow the short-run, less uncertain benefits from lower competition or a proprietary product system. This uncertainty may engender competitive tensions in standards interactions that impede consensus and lead to the spawning of alternate, sponsor-backed forums (DeLacey et al., 2006) that alter both the direction and the pace of technological investments.

5.1 | Limitations and future directions

We address several aspects of our focal context to suggest both boundary conditions as well as future research directions on the interplay of competition and cooperation.

5.1.1 | Industry characteristics

The computer industry is characterized by modularity, knowledge fragmentation, and a distributed locus of innovative capabilities, spurring high levels of participation and membership in its SSOs. In contexts with a greater centralization of knowledge, firms may organize along more traditional collaborative lines that are governed through conventional contracts or equity arrangements.[46] Additionally, the engineers in our context who collaborate to develop the standards are representatives of their firms, and we make the reasonable assumption that the tone of their interactions during standards development is reflective of their firms' interests. Efforts to replicate our research in other settings can identify limits to such generalizability.

5.1.2 | Voluntary standards context

In our setting, the subcommittees pursued a goal of developing technical functionality within a common technology standard. Further research is needed to assess whether we would observe similar effects in multiparty settings whose goals are more commercial.[47] In such contexts, activities such as technology certification and promotion are likely focused around immediate value capture and the identification of downstream complementary approaches to grow markets. Similarly, in multiparty arrangements tightly controlled by sponsor firms, hierarchical governance to curtail technology competition or appropriation hazards may reduce divergence.

5.1.3 | Multiparty alliance typology

In our effort to operationalize firm-level experience in collaboration settings that would be relevant to the standards process, we amassed substantial alliance contract data from well-established alliance databases, and ultimately focused our accounting on alliance agreements between three or more firms. Besides being fundamentally different from standards bodies on dimensions of governance and goals, these alliances are much smaller than a typical SSO. Future research must develop more fine-grained taxonomies that can help researchers establish clear distinctions between alliance contracts with varied functional purposes, multiparty contractual alliances, consortia, proprietary standards, and open standards organizations.

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[46]Indeed the need for and the participation in collaborative standards in such contexts may be more tempered. Relatedly, technology selection may be the outcome of more traditional "standards wars" rather than collaboration amongst competitors.

[47]E.g., the WiFi alliance that was based on the IEEE 802.11 technology standard as illustrated in Lavie et al. (2007).

5.1.4 | Firm strategy across competing standards

While our framework laid out the basis for how firm and community-level factors influence value creation and appropriation within a single multiparty standards forum, future research could examine how firms navigate competing standards forums and how the effectiveness of these forums may be influenced by divergent motivations and structures across these settings.

5.2 | Conclusion

Examining communication and consensus in a standards-setting organization illustrates both the complexity and the power of studying the interplay of cooperation and competition. Much work remains in understanding firm perceptions of value creation and value appropriation in multifirm settings, in analyzing when such organizations achieve their desired outcomes, and in categorizing and discriminating between the diverse multiparty forms themselves. As endeavors like these become all the more important due to the continued rise and growth of ecosystems, networked technologies, and the firms and institutions that support them, the strategic management field will be uniquely well-positioned to deliver on their promise by integrating behavioral and economic perspectives in their pursuit.

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