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DO TIES REALLY BIND? THE EFFECT OF KNOWLEDGE AND COMMERCIALIZATION NETWORKS ON OPPOSITION TO STANDARDS

RAM RANGANATHAN
Management Department, McCombs School of Business, University of Texas at Austin

LORI ROSENKOPF
Management Department, The Wharton School, University of Pennsylvania

We examine how the multiplicity of interorganizational relationships affects strategic behavior by studying the influence of two such relationships—knowledge linkages and commercialization ties—on the voting behavior of firms in a technological standards-setting committee. We find that, while centrally positioned firms in the *knowledge* network exhibit *lower* opposition to the standard, centrally positioned firms in the *commercialization* network exhibit *higher* opposition to the standard. Thus, the influence of network position on coordination is contingent upon the type of interorganizational tie. Furthermore, when we consider these relationships jointly, knowledge centrality moderates the opposing effect of commercialization centrality, such that the commercialization centrality effect increases with decreasing levels of knowledge centrality. In other words, firms most likely to delay the standard are peripheral in the knowledge network yet central in the commercialization network, which suggests that they have the most to lose from changes to current technology.

Over the past two decades, a key thesis that reverberates across strategy and organization theory research is that interorganizational relationships affect both firms' strategic actions and outcomes. Empirical support for this idea demonstrates that a firm's network position influences its investments (e.g., Stuart & Sorenson, 2007), its alliance formation patterns (e.g., Gulati, 1995a, 1999; Rosenkopf & Padula, 2008; Walker, Kogut, & Shan, 1997), and its choice of acquisition partners (e.g., Yang, Lin, & Peng, 2011). Similarly, strategy scholars interested in understanding heterogeneity in firm performance have found that a firm's network position influences several different outcomes, including innovation (e.g., Ahuja, 2000), survival (Baum, Calabrese, & Silverman, 2000), market share (Shipilov, 2006), and financial performance (e.g., Zaheer & Bell, 2005). The empirical evidence for the effect of strategic networks comes from a wide range of industries, including investment banking, computers, chemicals, mobile communications, and biotechnology.

While most prior organizational network studies either focus exclusively on a single interorganizational relationship or pool different types of ties together in an aggregated network, the more com-

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plex reality is that firms are simultaneously embedded in multiple types of interorganizational networks (Gulati, 1998; Shipilov & Li, 2012). One concern with suppressing multiplicity is whether results obtained are generalizable across the different network types in which a firm is embedded (Inkpen & Tsang, 2005). Additionally, however, it overlooks the interplay between a firm's positions in different interorganizational networks. In other words, a firm's positions in multiple networks may simultaneously influence its behavior (Gulati, 1999), and, depending upon the behavioral implications of specific types of ties, there may be both bright and dark sides to firms' embeddedness in interorganizational relationships (Gulati & Westphal, 1999). Therefore, teasing out such interplay may be particularly insightful if divergent behaviors or outcomes can be predicted when the effect of each relationship is considered independently.[1]

In this paper, we examine multiplicity in firms' strategic alliance ties—interorganizational relationships that encompass a variety of formal agreements between firms, including joint research and development (R&D), technology exchange, licensing, and marketing arrangements (Gulati, 1995a). Our specific focus in studying multiplicity is on the *different types* of alliance ties firms have across their sets of alliance relationships, and the divergent influences of these different types on firms' strategic choices.[2] Within the large body of alliance research, significant attention has been devoted to the potential of alliances to function as dual pathways that can enable both new knowledge creation and exploitation of existing complementary know-how (Koza & Lewin, 1998; Lavie & Rosenkopf, 2006; Rothaermel & Deeds, 2004). For instance, alliances are often conceptualized as boundary-spanning mechanisms that help organizations incorporate distant knowledge and, ultimately, shape technological evolution (e.g., Rosenkopf & Almeida, 2003; Rosenkopf & Nerkar, 2001). In contrast, alliances are also featured as mechanisms that help firms exploit existing complementary resources to successfully adapt to the challenges posed by new technologies (Rothaermel, 2001). While numerous network studies have examined networks comprising both types of alliances, few acknowledge the exploration–exploitation duality in the underlying ties in constructing these networks (see Gupta, Smith, & Shalley, 2006). As Table 1 shows, studies of alliance networks either combine both types into a single network or limit their scope to a single type, thus neglecting multiplicity within the alliance context.

Given this gap in interorganizational research, our goal is to highlight the tensions inherent in alliance network multiplicity by examining how a firm's positions in different types of alliance networks influence its strategic behavior differently. In investigating multiplicity, we dichotomize firms' participation in alliance networks based on the functional objective of their alliance ties—whether the goal of specific ties is to spur exploration of new knowledge or to enable exploitation via commercialization of existing capabilities and know-how. Our context is a voluntary technology standards-setting organization (SSO)—an industry-wide committee through which engineers from different firms attempt to forge a shared set of rules for future technological development (Dokko, Nigam, & Rosenkopf, 2012; Rosenkopf, Metiu, & George, 2001; Simcoe, 2012). SSOs have increasingly become a preferred arrangement for coordinating technological change and innovation across large numbers of firms (Chiao, Lerner, & Tirole, 2007; Farrell & Simcoe, 2012; Lavie, Lechner, & Singh, 2007). Within this context, we examine the influence of firms' network positions on their voting behavior to support or oppose the formation of standards. Intuitively, we expect the influence of multiple strategic networks on firms' conduct to be especially salient in the standards-setting context, as negotiations to arrive at a consensus standard are conducted multilaterally, where prior interorganizational linkages are likely to have an important bearing. Our specific choices of context (SSO in a technological change setting) and strategic behavior (voting for/against the standard) are particularly suitable for illuminating the contrasting influences of firms' positions in knowledge networks focused on longer-term exploration versus positions in commercialization networks focused on exploitation of current technologies.

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[1] One of the central tenets of the behavioral theory of the firm is that firms satisfice across multiple goals and across different organizational coalitions (Cyert & March, 1963). Since a firm's position in each network signifies a strategic resource that has emerged from a path-dependent pattern of investments and commitments (Gulati, 1999), it may make decisions that involve trade-offs across these different network resources.

[2] Note that the potential overlap of the different types of ties a firm has with the *same* partner firm also constitutes a kind of multiplicity or multiplexity. Although these types of ties are included in our analyses, we do not focus on them either conceptually or empirically.

TABLE 1
Alliance Literature and Functional Multiplicity

Research Article	Setting	Alliance Functions Sampled	Conceptual Handling of Functional Multiplicity	Empirical Handling of Functional Multiplicity
Ahuja (2000)	Chemicals	All alliances	None	None
Bae & Gargiulo (2004)	Telecommunications	All horizontal alliances	None	None
Baum et al. (2000)	Biotechnology (Canadian)	All alliances	None	Splitting counts by function
Gulati (1995b)	Biopharmaceuticals, new materials, automobiles	All alliances	None	Control for R&D alliances
Gulati (1995a, 1999), Gulati & Gargiulo (1999)	New materials, industrial automation, automotive products	All alliances	None	None
Gulati & Higgins (2003)	Biotechnology	Downstream alliances with prominent pharmaceutical firms	None	None
Gulati & Singh (1998)	Biopharmaceuticals, new materials, automobiles	All alliances	None	Control for R&D alliances
Koka & Prescott (2002, 2008)	Steel	All alliances	None	Control for ratio of multiplex partners to total partners
Lee (2007)	Computer and networking	All horizontal alliances	None	None
Lee, Lee, & Pennings (2001)	Korean technology start-ups	Technology and marketing alliances	None	None
Lin, Yang, & Arya (2009)	Computer, steel, pharmaceuticals, petroleum, and natural gas	All alliances	None	None
Yang, Lin, & Lin (2010)	Computer	All alliances (within industry)	None	None
Madhavan, Koka, & Prescott (1998, 2004)	Steel	All horizontal alliances	None	None
Owen-Smith & Powell (2004)	Biotechnology	All alliances	None	Control for R&D ties
Phelps (2010)	Telecommunications (equipment manufacturing)	Technology dev. & exchange	None	None
Polidoro, Ahuja & Mitchell (2011)	Chemicals	Technology joint ventures	None	None
Powell, Koput, & Smith-Doerr (1996)	Biotechnology	All alliances	R&D/Others	R&D/Non-R&D measures
Rosenkopf & Almeida (2003)	Semiconductors	All alliances	None	None
Rosenkopf et al. (2001)	Telecommunications (wireless)	R&D alliances	None	None
Rosenkopf & Padula (2008)	Telecommunications (wireless)	All alliances	None	None
Rowley, Behrens, & Krackhardt (2000)	Semiconductors and steel	All alliances	None	Strong (R&D) vs. weak (licensing)
Singh (1997)	Hospital software systems	All alliances	Technology/Others	Technology/Other measures
Stuart (2000)	Semiconductors	All horizontal alliances	None	Control for technology alliance
Stuart, Hoang, & Hybels (1999)	Biotechnology	All alliances	None	None
Walker et al. (1997)	Biotechnology	All alliances by start-ups	None	None
Whittington, Owen-Smith, & Powell (2009)	Biotechnology	All alliances	None	None
Yang, Lin, & Peng (2011)	Computer industry	All alliances	Exploration/Others	Exploration index

We posit that, while centrality in a knowledge network represents a firm's control and likely acceptance of future technological change in the form of proposed standards, centrality in a commercialization network represents a firm's ability to appropriate value from using alliance resources in the current state of technology. Accordingly, in our novel dataset of firms' voting records over a 14-year standard-setting period in the computer industry, we find that firms peripheral in the knowledge network yet central in current commercialization networks have the most to lose from technological changes, which leads them to strategically delay the standard. By demonstrating that different types of alliance network ties have opposing effects on firms' strategic choices within these collaborative innovation communities, our study provides important and novel insights to the relationship between alliance networks and innovation. Departing from the majority of alliance studies that focus on the positive effects of interorganizational relations on technological innovation and the benefits of complementary assets, our findings show that specific types of interorganizational ties that are aimed at exploiting current technology can also be a powerful force in impeding community-driven technological change. Furthermore, the joint effects of these different types of network positions on firms' voting behavior suggest that firms are considering their strategic options, at least in part, based on their whole multiplex portfolio of interorganizational ties. This underscores the importance of explicitly considering tie multiplexity when studying firm behavior and outcomes.

ORGANIZATIONAL CONTEXT—STANDARDS-SETTING COMMITTEES

Shaped by heterogeneous, path-dependent capabilities and beliefs, firms make different strategic bets on technologies (Denrell, Fang, & Winter, 2003; Nelson & Winter, 1982). The presence of positive network externalities and switching costs in technology-driven industries such as personal computers (PCs) (Katz & Shapiro, 1986) provides a selection mechanism for a "winning" or dominant design amongst these technologies (Schilling, 2002; Tushman & Anderson, 1986). Although the emergence of a dominant design selects between different technological platforms (Baldwin & Woodard, 2009), it leaves considerable scope for future technical elaboration of standards, at both the component and the intercomponent level.[3] A firm's ability to control this subsequent technological evolution such that its capabilities are sustained or even enhanced may become a crucial determinant of its advantage (Teece, 2007). Technology standards-setting committees (i.e., SSOs) are contexts in which firms have opportunities to shape such change (Dokko et al., 2012). These industry-wide organizations are venues where firms debate and coordinate the technological rules that define a common path for future technological development (e.g., Doz, Olk, & Ring, 2000). By shaping choices within these organizations, firms thus have opportunities to build attributes of their specific technologies into the evolving industry-wide standard (Garud, Jain, & Kumaraswamy, 2002; Gomes-Casseres, 1994).

Why Might Firms Contest the Standard?

Although the overall objective of standards committees is to reduce technological uncertainty and avoid costly standards wars (Farrell & Simcoe, 2012), these cooperative arrangements are also characterized by conflicts (e.g., Browning, Beyer, & Shelter, 1995). Firms are likely to have divergent opinions on which particular technological alternative to pursue in the standard, or even whether there should be a standard at all (Garud et al., 2002). This is because decisions made within these committees have significant and divergent consequences for the value of firms' technological capabilities (see Gomes-Casseres, 1994; Dokko & Rosenkopf, 2010; Rysman & Simcoe, 2008). In particular, as these committees propose standardized rules of interaction between different system components (e.g., Henderson & Clark, 1990), they have the potential to cause adverse technological, economic, and organizational consequences for participating firms. Technologically, by selecting between different alternatives, standards have the potential to differentially reward some firms while disadvantaging oth-

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[3] For example, even after the emergence of "Wintel"—the dominant design in the PC industry—there has been continuous change and refinement of the system, with major component-level innovations (e.g., solid state, optical, and flash memory following tape and disk technologies) as well as architectural innovations (e.g., emergence of USB, Firewire, and SCSI (small computer system interface) as alternative peripheral interface standards to serial and parallel ports).

ers (e.g., Rysman & Simcoe, 2008).[4] Economically, a firm's technologies may need to be reconfigured to follow new standardized rules—this may require additional investments without assured returns. Organizationally, the changes that a firm needs to make in processes, structure, and resource allocations to conform to the new standard may face opposition within the organization (e.g., Christensen & Bower, 1996; Henderson & Clark, 1990; Tripsas & Gavetti, 2000).

As a result, as discussions in a committee progress, some firms are likely to view the emerging standard as beneficial while others consider it detrimental. This, in turn, will influence their respective strategic behavior—specifically, firms that are more likely to be disadvantaged by the standard will contest its passage, while firms that are more likely to benefit from it will exhibit support for its expeditious acceptance. As decision making in voluntary standards committees is consensus based, even contestation by a small number of firms is likely to delay the standard-setting process, if not derail it completely. For instance, Simcoe (2012) finds that conflicts from divergent firm interests led to an eight-month delay for the Internet Engineering Task Force (IETF). Even if a standard does eventually emerge, delays may allow inertial firms to adapt to the new technological rules. In dynamic settings marked by frequent technological change, a firm's ability to negotiate and extend the life cycle of technologies, even by a few months, may be critical to its competitiveness and survival. In our arguments, our focus is therefore on understanding the drivers behind firms' actions to contest the passage of the standard.

Empirical Setting—INCITS

We focus our empirical inquiry on the International Committee for Information Technology Standards (INCITS), a leading voluntary standards committee in the computer industry. Sustained technological change, divided technical leadership, and an extensive use of strategic alliances by firms in this industry make it an ideal setting to study the effect of interorganizational ties on opposition to standards (Bresnahan & Greenstein, 1999; Rosenkopf & Schilling, 2007). Member firms in INCITS included both complementers (Adner & Kapoor, 2010) and competitors (see Hagedoorn, Carayannis, & Alexander, 2001), with major semiconductor firms, hard disk manufacturers, cable and controller firms, and systems software firms involved in the process.[5] Financially backed by the Information Technology Industry Council (ITI)—a large trade association representing the majority of firms in the information technology sector[6]—INCITS supported an open governance structure and allowed for equal contribution and representation of all organizations, large and small.[7,8] Irrespective of size, a member firm could appoint only one principal voting representative—thus, no individual member firm controlled the standard-setting process. Further, membership was open to all (including the general public) and the low membership fee spurred the involvement of several

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[4] By narrowing the feasible options for future technological development, standards also reduce uncertainty, thereby promoting increased modularity (Sanchez & Mahoney, 1996). As products become more modular, component tasks get decoupled, resulting in further specialization and architectural change that may be competence destroying for some firms (Baldwin & Clark, 2000; Henderson & Clark, 1990). Standards also allow different components to be produced separately and different variants of the same component to be used interchangeably (Garud & Kumaraswamy, 1995)—again, entailing architectural shifts that may be challenging for firms.

[5] The membership was representative of the population of firms in these sectors. In 2008, INCITS firms in our sample classified under the Standard Industrial Classification (SIC) code 3570 (Computers and office equipment) had a combined market share of 95%, those classified under 3571 (Electronic computers) had a combined market share of 98%, and those classified under 3678 (Electronic connectors) had a combined market share of 70%.

[6] ITI members employ more than one million people in the United States, and, in 2000, their revenues exceeded $668 billion worldwide (Source: www.incits.org).

[7] Between 1961 and 1997, INCITS was known as the Accredited Standards Committee X3, Information Technology (Source: www.incits.org).

[8] Accredited by the American National Standards Institute (ANSI), INCITS brings together more than 1,700 firms for the creation and maintenance of formal de jure IT standards. It operates more than 50 different technical committees under ANSI rules, which are designed to ensure that voluntary standards are developed by the "consensus of directly and materially affected interests" (Source: www.incits.org). The influence of INCITS in the information technology sector is evident from 750+ standards its subcommittees have published, encompassing a range of technology domains including programming languages, computer graphics, cyber security, distributed processing, and computer peripheral interfaces.

small start-up firms as well as independent technology consultants.

INCITS committees also followed several checks and balances to ensure that the standards reflected a true consensus. During the standards development process, firms voted on ballot measures to ratify important milestones, which encompassed the entire range of standards-setting activities, from the initiation of a new project to the approval of the final specification document.[9] Firms were also free to propose ballot measures for any issues that warranted a vote from all participants. INCITS further required that member firms addressed the contesting votes and associated comments on a ballot, even if the required majority to pass the ballot had been achieved.[10] In other words, specific objections of firms needed to be addressed before the standard could progress, even though these firms may represent a small minority. Although such mechanisms prevented standards from progressing if outstanding concerns existed,[11] they also implied that firms could delay the standard by voting anything other than a "yes" on ballots.[12,13]

Within INCITS, we focus on decision making within three interrelated subcommittees that devise standards for computer peripheral interfaces—the T10, T11, and T13 subcommittees.[14] While all three subcommittees run in parallel, they develop closely related interface standards (the T11 and T13 were created out of the T10 committee). We track activity in these committees from 1994 (the year T10 was formed) up until 2008.

HYPOTHESES

In the hypotheses that follow, we contend that firms' decisions to contest or support the standard are shaped independently and jointly by their positions in the "knowledge network" and the "commercialization network" of member firms in the committee. Our choice of networks follows the work of several scholars studying technological change and innovation who have identified these two types of relationships as being instrumental influences on technological evolution (e.g., Adner & Kapoor, 2010; Afuah & Bahram, 1995; Henderson & Clark, 1990; Rosenkopf & Almeida, 2003; Rosenkopf & Nerkar, 2001; Stuart & Podolny, 1996).

Effect of Knowledge Network Position

The main principle behind how a firm's knowledge network position affects its opposition to the standard is that any firm's influence on standards discussions depends on the relational context that the firm's knowledge is positioned within (Podolny & Stuart, 1995). Conceptually, each node in a knowledge network of member firms in the standards committee represents a particular firm's technological knowledge base, and the ties between firms represent some convergence of their knowledge bases (e.g., Stuart, 2000).[15] A firm that is relationally embedded in such a knowledge network is therefore one with knowledge that has been instru-

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[9] INCITS identifies a total of eight milestones: (1) approval of the standards project, (2) notification to the public, (3) technical development, (4) initial public review, (5) management review, (6) executive board approval, (7) ANSI approval, and (8) publication.

[10] "[T]he purpose of . . . letter ballot resolution is to resolve any comments submitted with 'No' votes in response to . . . letter ballots, such that those 'No' votes become 'Yes' votes and indicate greater consensus" (Source: www.incits.org).

[11] As prior research has pointed out, such standards may ultimately face legitimacy issues and run the risk that they don't attract a crucial mass of committed firms to develop products (Garud et al., 2002).

[12] We provide greater detail on the different voting options in the Methods section of this paper.

[13] Firms are also not permitted from discussing future votes. Ballots are generally submitted electronically and the results of the ballots are available only after the voting process is complete.

[14] T10 is responsible for developing standards for connecting peripheral devices to personal computers, particularly the series of SCSI standards. T11 develops peripheral standards targeted at higher-performance computing applications, including the high-performance parallel interface and fibre channel sets of standards. Finally, T13 develops a family of standards relating to the ATA/Serial ATA (AT Attachment) storage interface used to interface the majority of hard disks in PCs. These are interface standards committees in the "architectural innovation" sense (Henderson & Clark, 1990), as the specifications they draft affect different components of a computer system, including the microprocessor circuitry and digital logic to support different peripheral devices, the algorithms and protocols to transfer data between these devices and the computer, the connectors (e.g., USB cables, converter plugs, ports, and sockets) that physically transmit this data, and the peripherals that store or generate this data (e.g., disks, cameras, portable drives).

[15] We measure this network in two distinct ways—with alliance ties and also with cross citations of patents.

mental in driving the innovation efforts of the other firms in the network. As discussions within the committee progress and different technological alternatives are evaluated by member firms, the group as a whole is less likely to find a consensus solution in a knowledge area that is distant from the core of the knowledge network (Fleming & Sorenson, 2004; Levinthal, 1997). It follows, then, that firms that are the most centrally positioned in this knowledge network are likely to be the closest in terms of "knowledge distance" from the emerging standard. In other words, because a central firm's position represents the extent to which a firm's knowledge *has been* foundational amongst peer firms in the committee (Stuart & Podolny, 1996), there is a greater likelihood that the technological rules that the committee identifies as part of the standard *will continue* to build on this foundational knowledge.

The idea that the relational structure of knowledge exhibits inertial pressures has important implications for the ability of firms to derive economic rents based on their technological capabilities. On the one extreme, the most central firms will be able to expeditiously develop innovative products based on the standard compared to the other firms (the advantage of possessing foundational knowledge). They also benefit from reinforcing effects of increased royalties as other firms continue to build on this knowledge (Stuart, 1998). At the other extreme, firms on the periphery of the knowledge network face the challenging prospect that their knowledge, which, thus far, has been a tangential influence on other firms' innovation efforts, will be further marginalized by its exclusion from the emerging standard. During deliberations, these firms will not only be more likely to propose divergent ideas and viewpoints, but also be more likely to have these proposals excluded from the standard. This idea is also consistent with prior research on institutional change that suggests that challenges to a prevailing order are more likely to originate from the periphery of a field than the core (e.g., Kraatz & Moore, 2002; Leblibici, Salancik, Gopay, & King, 1991). For such firms, the economic and organizational costs of acceding to an unfavorable standard will outweigh any shared industry-wide benefits that the standard is likely to usher in. We contend that these considerations will influence firms' strategic behavior in the committee such that:

> *Hypothesis 1. The more central a focal firm is within the knowledge network of member firms, the lower its opposition to the standard.*

Effect of Commercialization Network Position

While the knowledge network position reflects a firm's control and acceptance of *future* technological change in the form of the proposed standard, its commercialization network position captures the pattern of its formal agreements to commercialize *current* technologies. Firms most central in these commercialization networks have maximized the utilization of complementary resources through extensive partnering with upstream and/or downstream firms (Hamel, Doz, & Prahalad, 1989; Koza & Lewin, 1998).[16] In the existing state of technology, such firms are positioned advantageously to appropriate rents using existing network resources.[17]

To analyze the influence of firms' positions in such a commercialization network on their strategic behavior in the standards committee, we first note that, in an industry characterized by systemic innovation and separability of innovation activities, the critical complementary assets that a firm needs to access in order to successfully commercialize its innovation are the other interconnected technologies or components needed to complete the system (Rosenkopf & Schilling, 2007; Teece, 1986). For example, in the computer industry, operating system software is a complementary asset for hardware, application software is a complementary asset to the operating system, and peripheral ports are complementary to cables and connectors.

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[16] It is important to note that, although there is likely to be some degree of overlap between these two kinds of ties—knowledge and commercialization—they are not conceptually the same. In other words, a firm's search for partners that is driven by commercialization needs (i.e., product market penetration) is distinct from the same firm's pattern of knowledge flows underlying its own and others' innovations.

[17] Although prior research has highlighted the "pipes" aspect (Podolny, 2001) of complementary asset networks (i.e., networks as resource access relationships that help firms adapt to technological change), emerging work suggests that such capabilities may also act as "prisms" through which firms evaluate new technological options (e.g., Wu, Wan, & Levinthal, 2013; Taylor & Helfat, 2009). Clearly, supporting an emerging industry-wide standard is one such strategic choice for firms that their positions in complementary asset networks might influence.

The function of a firm's commercialization relationships in such settings is primarily to ensure *compatibility* of its innovation with the larger system.[18] Second, beyond actually ensuring technical integration across the system, these agreements serve as important signals to consumers that certain technologies offer them greater flexibility to mix and match components from different vendors. This becomes particularly decisive in industries in which concerns of interoperability and lock-in may hinder adoption of new technologies (Katz & Shapiro, 1986). Thus, a firm that is in a central position in such a network of complementers also commands a certain competitive advantage by being able to, ultimately, offer a broader range of products to users.

If technology standards are adopted by the committee, then the industry-wide transition to these standards and subsequent user adoption may completely devalue a central firm's prior investments in these complementary assets (Taylor & Helfat, 2009). The cornerstone of advantage for the centrally positioned firm in the commercialization network is the *lack* of a system-wide standard—it is the absence of the standard that creates the very need (and value) for such complementary boundary-spanning relationships. In contrast, the very rationale for a technological standard is to achieve convergence across the entire industry on how different components of the system should interoperate. With the adoption of a standard, any particular firm only needs to design its product to the standards specification to *automatically* obtain the same interoperability or complementary benefits that a central firm has achieved from investing in its network of commercialization ties. This creates strong disincentives for firms occupying central positions in the commercialization network to support the quick passage of the standard. Even though the passage of the standard may, ultimately, be unavoidable, central firms may choose to contest the standard because the nature of the consensus-driven decision-making process makes it vulnerable to these delays (Simcoe, 2012), allowing them to continue to exploit current network positions. With sufficient time, these firms may even be able to leapfrog the standard by introducing the next generation of technologies that can then tap into existing relationships to preserve their advantage.[19] Therefore:

> *Hypothesis 2. The more central a focal firm is within the commercialization network of member firms, the higher its opposition to the standard.*

Joint Influence of the Two Network Positions

In the preceding hypotheses, we argued for distinct and opposing effects for a firm's knowledge network position and for its commercialization network position on its strategic behavior in the standards committee. Since member firms are simultaneously connected via knowledge ties and via commercialization ties, how do these distinct strategic network resources *jointly* interact to influence firm behavior? This interaction is best exemplified by considering firms peripheral in the knowledge network but central in the commercialization network. For these firms, as discussed in Hypothesis 1, the industry-wide adoption of a standard that they are in a weak position to control is likely to cause technological competence erosion. Such firms are faced with choosing between two difficult alternatives should the standard emerge—either reinvest to align their own technologies with what the standard mandates, or adopt a non-conforming strategy and "go it alone" against the industry standard. For such firms, the need to protect interfirm commercialization investments in complementary technol-

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[18] For example, in our sample, firms that made hard disk drives entered into strategic alliances with firms that made disk controllers to ensure that their products interoperated with one another (e.g., the alliance between Seagate Technology and Adaptec). Similarly, system software firms entered into alliances with PC makers to market compatible systems (e.g., VMware's alliance with Dell). Some of these alliances were targeted at specific product markets (e.g., VMware's alliance with HP to integrate its software ESX 3i with different models of HP ProLiant servers).

[19] The relationship between a firm's existing ties and, consequently, its narrow view of technological change has been highlighted in prior research—for instance, Christensen and Bower (1996) have found that existing commitments to downstream customers and upstream suppliers restricts the ability of firms to adapt to technological change. We hypothesize on a similar dynamic in standards-setting committees, with the distinction being that firms actually have the option to block technological change before it occurs. Similarly, research on networks has also suggested that certain kinds of institutional changes have the potential to rupture the value of existing network relationships, and that firms that are more embedded in these relationships risk losing their competitive advantage when such change occurs (Uzzi, 1997).

ogies becomes even more critical. Faced with an inevitable decline in the future value of their current technological capabilities, firms peripheral in the knowledge network are likely to attempt to appropriate the most value that they can out of their current commercialization network. This will be reflected in a higher rate of opposition to the proposed standard, which is magnified by the strength of the firm's position in the commercialization network.

The same logic applies to firms on the other end of the spectrum—those central in the knowledge network but peripheral in the commercialization network have more to gain and less to lose by supporting the standard, and, thus, are likely to exhibit a lower rate of opposition to the standard. Therefore:

> *Hypothesis 3. Knowledge network centrality will negatively moderate the effect of commercialization network centrality on a firm's opposition to the coordinated standard. Specifically, the more peripheral the firm's knowledge network position, the greater the positive effect of commercialization centrality on its rate of opposition.*

METHODOLOGY

Data Sources

Table 2 summarizes the variety of different sources for the study's data, the variables and measures that were constructed from these data, and the method of construction.

Measures

Dependent variable. "Firm's vote on a ballot measure"—to capture a firm's opposition to the standard, we collected data from the standards subcommittee archival records on all the 241 different ballot measures, across the three subcommittees, and across the 14-year study period. Since we obtained this data from the very first year of operation of these subcommittees, left censoring is not an issue. For each ballot, we first identified the year the ballot occurred and the specific technical subset to which it was related. We also identified the working groups responsible for developing the particular technical subset.[20] We then manually extracted the record of all the firms' votes for this ballot, mapping individual votes to unique member firms already identified based on the membership roster. There were four different voting choices that firms could make—"yes," "abstain," "yes with comments/conditions," and "no." We assigned ordinal values of 0 (yes), 1 (abstain), 2 (yes with comments/conditions), and 3 (no) to these votes.[21]

Independent variables. Our main independent variables are the measures of the firms' positions in the two strategic networks and the interactions between these positions. We operationalized both knowledge and commercialization ties with strategic alliance data by interrogating Dow Jones & Company's search tool Factiva for the alliance announcements for each member firm.[22] Our search included the entire range of formal agreements; following prior research, we used five-year moving windows to define these ties (e.g., Gulati & Gargiulo, 1999; Gulati, 1999), and our first year of record for alliances was 1989 (to appropriately match the first observed year for the dependent variable, which is 1994). We carefully cleaned the data to remove duplicate ties (by flagging duplicate alliance announcements between the same member firms that appeared close in time to each other) and ties that were rumored but did not materialize, resulting in a total of 10,389 uniquealliances with 3,365 dyadic alliance ties between member firms.[23]

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[20] The standards subcommittees are organized into several working groups. Each working group is responsible for a specific technical subset of the overall standard. Member firms are free to join any working group and contribute to the standard. We provide more details on the working groups when we discuss the control variables, below.

[21] Our particular ordering of votes was based on the idea that the underlying construct captured in the vote was the level of firms' opposition the standard. Thus, although we tested the robustness of our models to this ordering, our interpretation of the standard committee's rules indicated that the level of effort required to address and resolve objections from a "no" vote was higher than that required to address a "yes with comments" vote, which, in turn, was higher than that required to address an "abstain" vote—as there was really no effort to address a "yes" vote, this was assigned the base value of 0.

[22] As Lavie (2007) and Schilling (2009) have shown, the Securities Data Company's "SDC Platinum" data on alliances covers only a small subset (less than 50%) of the alliance population and is therefore inappropriate to accurately construct an alliance network. By including all leading news sources, Factiva provides a more comprehensive dataset to track alliances.

[23] Multilateral alliances (with more than two member firms) were elaborated to include all dyadic tie combinations amongst the participating firms.

TABLE 2
Variables, Measures, and Data Sources

Variables	Measures	Data Sources
Dependent variable		
Firm's vote on a ballot	Coded as 0 = yes; 1 = abstain; 2 = yes with conditions/comments; 3 = no	INCITS ballot database
Independent variables		
Knowledge network centrality	(1) Degree centrality in exploratory alliance network of member firms, with edges weighted by number of distinct exploratory ties between firms (five year moving window)	Factiva for alliance announcements
	(2) In-degree centrality in patent citations network of member firms (five year moving window)	NBER patent data
Commercialization network centrality	Degree centrality in an commercialization alliance network of member firms, with edges weighted by number of distinct commercialization ties between firms (five year moving window)	Factiva for alliance announcements
Control variables		
Participation in working group associated with ballot	Cumulative firm-representatives' attendance at working group meetings[a]	INCITS working group documents
Patent stock on standard's technologies	Stock of firm's patents on technologies emerging from the standard	Derwent
Patent stock (overall)	Stock of firm's patents in relevant broad technological categories related to standard[a]	NBER patent data
Patent stock diversity	Number of distinct technological classes reflected in firm's patent stock[a]	NBER patent data
Citations to patent stock	Number of citations to firm's patent stock from patents not owned by member firms[a]	NBER patent data
Knowledge insularity	Number of citations firm makes to own patents[a]	NBER patent data
External alliances (to firms not on standards committee)	Count of alliances to non-members[a]	Factiva
Size	Firm's assets and firm's revenues in $bn[b]	Standard & Poor's Compustat database, Dun & Bradstreet's Hoover's database, Corporate Technology Directory (Corptech)
Financial slack	Firm's Debt and Firm's Cash in $bn[b]	Compustat
Financial performance	Net income in $bn	Compustat
Sector size	Sector's revenues (sector defined by primary four-digit SIC)[b]	Compustat, Hoover's, Corptech

[a] Square root of measure to alleviate skewness.
[b] Natural log of measure to alleviate skewness.

For each alliance, we coded the announcement date and the unique member firm identifier for each member firm that was in the alliance. As Factiva does not automatically distinguish between knowledge and commercialization alliances, we followed the procedure used by Lavie and Rosenkopf (2006); that is, manually reading the announcement of each alliance to determine its category.[24] Specifically, if the alliance involved a new knowledge-generating agreement (e.g., R&D, technology co-development), then we categorized it as a knowledge network tie, whereas, if the alliance involved an agreement based on existing technologies, including interoperability testing and certification, joint marketing, original equipment manufacturer/value-added reseller, licensing, or production, then we coded it as a commercialization tie. Although both types of ties may involve a technology component, what distinguishes knowledge ties from commercialization ties is a focus on developing new and relatively uncertain technologies oriented towards the future.[25] The following is an example of an announcement that we coded as a commercialization tie, despite the presence of a technology component, as it clearly involved combining current complementary solutions rather than generating new ones (Katila & Ahuja, 2002):

> Adaptec, Inc. (NASDAQ: ADPT), a global leader in storage solutions, today announced that Seagate Technology (NYSE: STX) has combined Unified Serial Controllers from Adaptec with its own Cheetah15K 146 GB Serial Attached SCSI (SAS) disk drives to deliver a comprehensive SAS Evaluation Kit to Seagate system builders and resellers.

Similarly, the following is an example of an alliance agreement that we coded as a knowledge tie, as the focus is clearly on joint development of next-generation products and technologies:

> International Business Machines Corp. has forged a major alliance with rival electronics giants Siemens AG of Germany and Toshiba Corp. of Japan to develop the next generation of computer memory chips. The companies said yesterday they will cooperate in the development of 256-megabit chips that will have 16 times more capacity than the chips commonly in use. . . . The 256-megabit chips likely would be used in future generations of small, powerful personal computers and workstations. The advanced semiconductor should be ready by the end of the decade, the companies said.

In all, 38% of our member alliance ties were coded as knowledge ties and 62% were coded as commercialization agreements.

"Knowledge network centrality" and "commercialization network centrality"—for each subcommittee and year, we first identified knowledge network ties between two firms if we coded at least one knowledge alliance between them in the relevant five-year window. We then calculated a degree centrality measure for each firm using the number of such ties as edge-weights to account for the strength of these relationships (Miura, 2012).[26] We similarly derived commercialization network centrality, using commercialization ties instead of knowledge ties.

In addition to knowledge generation alliances, knowledge flows between firms are also revealed in patent citations, which document the technological antecedents of inventions (Benner & Tushman, 2002). Following several studies that have used patent citations to measure such knowledge flows (e.g., Mowery, Sampat, & Ziedonis, 2002; Rosenkopf & Almeida, 2003; Stuart, 1998), we also computed an alternate measure of knowledge network centrality using U.S. National Bureau of Economic Research (NBER) citation data (Hall, Jaffe, & Trajtenberg, 2005). From the full patent dataset, we extracted patents that member firms owned (matching on the assignee names) and then filtered these further using technological categories relevant to the industry.[27] We then used a five-year moving

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[24] A research assistant with considerable technical knowledge about computer hardware and data storage carried out the coding. It was then repeated by one of the co-authors for a random subsample of 10% of the member firm alliances. Inter-rater agreement was 88.5%, with Cronbach's alpha of .81 and Cohen's kappa of .75.

[25] We encountered 64 "hybrid" member firm alliances that had some elements of knowledge generation and commercialization—our results are robust to the inclusion of these alliances in the regression models.

[26] Since alliances are bilateral arrangements, we treated the networks as undirected.

[27] These included the HJT (Hall, Jaffe, and Trajtenberg) category 2 (Computers and Communications), with subcategories Communications (21), Computer hardware and software (22), Computer peripherals (23), Information storage (24), Electronic business methods and software (25), and the HJT category 4 (Electrical and Electronic), with subcategories Electrical devices (41), Measuring and testing (43), Power systems (45), semiconductor Devices (46), and Miscellaneous electrical/electronic (49).

window of cross citations between these patents (Katila & Ahuja, 2002; Phelps, 2010; Stuart, 1998) to define the citation ties and calculated an in-degree centrality measure for every member firm.[28,29]

Control variables. Fixed effects are used to control for unobserved heterogeneity across both firms and ballots. We also use a number of variables to control for observable time-varying factors that may influence firms' strategic behavior with respect to specific ballots, subcommittees, or years. For ballot-specific effects, "Participation in working group associated with ballot" controls for the stake that a firm has in a particular ballot. Since ballots are heterogeneous with regard to the technical issues being debated, some firms may have higher stakes in particular ballots. To construct this variable, we first assembled all the standards-related document files from the committees' archival records. Based on the document titles of these files, we identified the subset of 2,185 documents that constituted working group meeting minutes, which mapped on to 63 distinct working groups. We automated the parsing of each document to estimate the extent to which the firm was involved in each working group meeting. We used two different measures—counting the overall number of occurrences of the firm's name (and possible variants) in these documents and counting the number of firm representatives that attended the meeting (by parsing only the attendance section of the minutes documents).[30] Since the standards development process was sequential and path dependent, and because some working groups had multiple ballots over time, we used a cumulative stock of this measure.

We included "Patents on standard's technologies" to account for the differences in standard-specific technological competencies across firms. Since some firms' technological competencies may map more closely to the emerging standard, these firms may also have greater stakes in its ballot measures. To calculate this measure, we compiled a set of technological keywords specific to the standards subcommittees, deriving these from the published standards and from reading through subcommittee charters.[31] Then, using the Derwent World Patents Index[32] (e.g., Pavitt, 1985), we compiled the set of patents for which the description contained one or more of these keywords. Finally, we matched the names of the patent assignees with the member firm sample and calculated a patent stock for each member firm.[33]

In each year, we accounted for the breadth, depth, importance, and insularity of a firm's technological investments and its financial position. These variables are "Patent stock (overall)," "Patent stock diversity," "Citations to patent stock," and "Knowledge insularity"—and their construction is described in greater detail in Table 2. As firms with more liberal opportunities may be less resistant to the standard than firms that occupy competitive niches (e.g., Ahuja, 2000; Stuart, 1998), we also include "Overall sector size (assets)," using a sum of the assets of all listed firms in the firm's SIC code. We include "Size," "Financial slack," and "Financial performance" to control for effects of performance and financial resources. Finally, we also control for "External alliances (to firms not on standards committee)," as these might influence firms' voting patterns (Gomes-Casseres, 2003; Leiponen, 2008).

Estimation

Level of analysis. Our analysis is at the "firm-vote level"—in other words, we pooled all firms' votes across all ballot measures that the firms voted on. We chose the firm-vote level rather than the firm-year level because the technical agenda underlying ballot measures varies over time and over subcommittees—thus, each measure solicits firms' votes on a different subset of technical issues with respect to the standard.[34]

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[28] We used the patent application year for the time window since this reflects the establishment of the tie.

[29] Since patent citations are unidirectional, we treated the networks as directed.

[30] In the results shown, we used the latter measure—the results are robust to the use of the first measure as well.

[31] For example, keywords for T13 subcommittee included "Advanced Technology Attachment," "ATAPI," and "Serial ATA."

[32] The Derwent database allows searching patents by technological keywords—a facility not available with the NBER patent data.

[33] We also included a control for the number of "Proposals"—this variable dropped out in our regressions.

[34] Were we to aggregate the votes up to the firm-year level, we would be making the unrealistic assumption that identical issues are deliberated across all ballots. Also, notwithstanding the fact that our ultimate interest is in firms' overall strategic behavior, rather than behavior on specific technical issues, modeling at the firm-vote

Model. We model the firm's vote on a ballot as:

$$Y_{ijk} = f\big(X_{ij}\beta + Z^1_{ijk}\gamma + Z^2_{ij}\delta + Z^3_i\theta + u_i + v_j + w_k\big) + \epsilon_{ijk}$$

where "i" indexes the firm, "j" indexes the subcommittee, and "k" indexes the ballot measure. Y is a firm's vote on a ballot measure in a subcommittee and $\boldsymbol{X}$ is a vector of firm covariates specific to the subcommittee (the positions in knowledge and commercialization networks, as well as the interaction between them). $\boldsymbol{Z}^1$, $\boldsymbol{Z}^2$, and $\boldsymbol{Z}^3$ are vectors of firm covariates specific to both the subcommittee and ballot (1), specific only to the subcommittee (2), and independent of subcommittee and ballot (3). u_i, v_j, and w_k are unobserved firm, subcommittee, and ballot effects, respectively. ε_{ijk} is a random disturbance term.

Our estimation uses an ordered logistic regression model (the "ologit" command in Stata, the data analysis and statistical software program), which assumes the ε_{ijk} to be independent and identically distributed random variables that follow an extreme value distribution (i.e., a logistic distribution function).

Unobserved heterogeneity. As is the case with most non-experimental studies, one concern is that our results could be biased because of unobserved heterogeneity. We recognize and attempt to control for two kinds of unobserved heterogeneity. The first kind arises because some firms may be more predisposed than others towards opposing or accepting the standard because of reasons that are not observable or measurable.[35] To alleviate this concern, we include "firm fixed effects" (a dummy variable for each firm) in all our main models.[36] The second kind of unobserved heterogeneity arises because some ballot measures may result in greater opposition from firms than others, due to factors that are independent of our hypothesized predictors or included controls. To alleviate this concern, we also include "ballot fixed effects" (a dummy variable for each ballot measure).[37] Finally, we also lag the independent variables and controls by one year to mitigate the risk of simultaneity or reverse causality, and include "year fixed effects."[38]

RESULTS

Table 3 lists the sample statistics and correlations (all independent variables are mean centered). The high correlations between the two alliance centrality measures are not surprising, as we would expect firms active in one alliance sphere to also be active in the other.[39] The correlation between the "Knowledge network centrality (patent citations)" measure and the "Commercialization network centrality" measure is, however, moderate. Therefore, one additional advantage of this alternate measure is that we can alleviate collinearity concerns if we obtain consistent results with both sets of measures.

Table 4 displays the results of the main regressions used to test the hypotheses. In Models 1–5, we use the alliance-based measure for "Knowledge network centrality," and, in Models 6 and 7, we use the citation-based measure. Model 1 is a controls-only model. Models 2–4 show the results from the stepwise addition of independent variables to the controls-only model. All models include firm fixed effects, and we add ballot fixed effects in Model 5 and Model 7. The improvements in log-likelihood across successive models are significant (likelihood ratio test), and show that the stepwise addition of variables improves model fit.

A negative coefficient for a variable in these regressions indicates support for the standard, while a positive coefficient indicates opposition. Hypothesis 1 stated that the more central a focal firm is within the knowledge network, the lower will be its opposition to the standard. The coefficient for the variable "Knowledge network centrality" is negative and strongly significant in Models 2–6 and

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level does allow us the flexibility to control for these differences across ballots (as we have described in the preceding section on control variables).

[35] For instance, some firms may adopt a more open strategy of knowledge sharing and cross-firm collaboration—such strategies may be correlated with central network positions and a higher support for open standards.

[36] Firm fixed effects models also automatically include time invariant effects specific to the sector or industry.

[37] By including ballot fixed effects, subcommittee fixed effects are automatically included (to control for unobserved heterogeneity in voting behavior across T10, T11, and T13). We confirmed this in our regressions when the dummy variables for the subcommittees dropped out of the regressions.

[38] As network scholars have suggested, one way to alleviate concerns around the endogeneity of network measures is to use time-varying data that allow the use of lag structures and the incorporation of fixed effects in the regression models (Stuart & Sorenson, 2007).

[39] Variance inflation factors calculated after a pooled linear regression were below the threshold of 10 (e.g., Davidson, Jiraporn, Kim, & Nemec, 2004).

TABLE 3
Descriptive Statistics and Correlations

Variables	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 Firm's vote on ballot	0.44	0.81	1																		
2 Knowledge network centrality (R&D alliances)	0	0.53	0.09	1																	
3 Commercialization network centrality	0	0.76	0.11	0.84	1																
4 Knowledge net. centrality (R&D alliances) × Commercialization network centrality	0	4.63	0.06	0.86	0.79	1															
5 Knowledge network centrality (patent citations)	0	0.27	0	0.47	0.49	0.29	1														
6 Knowledge net. centrality (patent citations) × Commercialization network centrality	0	0.64	0.09	0.86	0.97	0.84	0.55	1													
7 Participation in working group associated with ballot	0	3.79	0.18	0.2	0.23	0.2	0.26	0.25	1												
8 Patents on standard's technologies	0	1.99	0.08	0.45	0.53	0.34	0.5	0.53	0.21	1											
9 Patent stock (overall)	0	25.31	0.06	0.61	0.61	0.46	0.71	0.66	0.15	0.41	1										
10 Patent stock diversity	0	2.76	0	0.46	0.45	0.26	0.82	0.48	0.11	0.42	0.82	1									
11 Citations to patent stock	0	85.14	0.02	0.54	0.63	0.44	0.79	0.69	0.15	0.58	0.84	0.72	1								
12 Knowledge insularity	0	35.90	0.05	0.6	0.7	0.5	0.72	0.75	0.16	0.56	0.88	0.69	0.93	1							
13 External alliances (to firms not on standards committee)	0	2.40	0.11	0.71	0.75	0.66	0.37	0.74	0.16	0.3	0.6	0.38	0.53	0.61	1						
14 Size (assets)	0	2.20	−.01	0.43	0.49	0.27	0.7	0.49	0.05	0.43	0.61	0.7	0.67	0.62	0.34	1					
15 Size (revenues)	0	2.24	−.02	0.43	0.49	0.28	0.74	0.5	0.07	0.43	0.61	0.72	0.69	0.64	0.35	0.96	1				
16 Financial slack (cash)	0	3.23	0.01	0.51	0.56	0.41	0.5	0.58	0.07	0.56	0.45	0.48	0.6	0.57	0.36	0.68	0.67	1			
17 Financial performance (net income)	0	3.48	0.02	0.42	0.42	0.37	0.2	0.4	0.08	0.18	0.29	0.19	0.26	0.31	0.42	0.22	0.23	0.27	1		
18 Financial slack (debt)	0	0.92	−.03	0.3	0.36	0.25	0.52	0.42	0.05	0.48	0.51	0.51	0.67	0.58	0.2	0.75	0.72	0.67	0.15	1	
19 Sector size	0	1.16	0.03	0.31	0.31	0.19	0.37	0.32	0.08	0.33	0.43	0.48	0.43	0.38	0.25	0.47	0.43	0.45	0.14	0.44	1

TABLE 4
Ordered Logistic Regression Results

Variables	1	2	3	4	5	6	7
Independent variables							
Knowledge network centrality (R&D alliances)		−0.41*** (0.11)	−0.71*** (0.14)	−0.42** (0.18)	−0.53*** (0.19)		
Commercialization network centrality			0.35*** (0.10)	0.47*** (0.11)	0.62*** (0.12)	0.85*** (0.26)	0.85*** (0.27)
Knowledge network centrality (R&D) × Commercialization network centrality				−0.04** (0.02)	−0.04** (0.02)		
Knowledge network centrality (Patent citations)						−0.86** (0.37)	−0.76* (0.45)
Knowledge network centrality (Patent citations) × Commercialization network centrality						−0.97*** (0.28)	−0.86*** (0.30)
Controls							
Participation in working group associated with ballot	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.13*** (0.01)	0.08*** (0.01)	0.13*** (0.01)
Patents on standard's technologies	0.05* (0.03)	0.07** (0.03)	0.07** (0.03)	0.07** (0.03)	0.07** (0.03)	0.05 (0.03)	0.05 (0.03)
Patent stock (overall)	0.01 (0.01)	0.01 (0.01)	0.02* (0.01)	0.02* (0.01)	0.02** (0.01)	0.01 (0.01)	0.02* (0.01)
Patent stock diversity	−0.11 (0.07)	−0.10 (0.07)	−0.08 (0.07)	−0.09 (0.07)	−0.07 (0.07)	−0.10 (0.07)	−0.08 (0.07)
Citations to patent stock	0.01*** (0.00)	0.01*** (0.00)	0.01** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)
Knowledge insularity	−0.01** (0.01)	−0.02*** (0.01)	−0.02*** (0.01)	−0.02*** (0.01)	−0.03*** (0.01)	−0.02** (0.01)	−0.02*** (0.01)
External alliances (to firms not on standards committee)	−0.10*** (0.03)	−0.08** (0.03)	−0.09*** (0.03)	−0.09*** (0.03)	−0.12*** (0.03)	−0.11*** (0.03)	−0.13*** (0.03)
Size (assets)	0.25*** (0.08)	0.23*** (0.08)	0.22*** (0.08)	0.22*** (0.08)	0.21** (0.09)	0.24*** (0.08)	0.24*** (0.09)
Size (revenues)	−0.07 (0.09)	−0.08 (0.09)	−0.11 (0.09)	−0.12 (0.09)	−0.17* (0.10)	−0.16 (0.10)	−0.20** (0.10)
Financial slack (cash)	−0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.02 (0.02)	0.01 (0.02)	−0.01 (0.02)	−0.01 (0.02)
Financial performance (net income)	−0.00 (0.01)	−0.00 (0.01)	−0.01 (0.01)	−0.00 (0.01)	−0.00 (0.01)	−0.00 (0.01)	−0.00 (0.01)
Financial slack (debt)	−0.12 (0.10)	−0.13 (0.10)	−0.12 (0.10)	−0.14 (0.10)	−0.12 (0.10)	−0.12 (0.10)	−0.12 (0.10)
Sector size	0.04 (0.14)	0.08 (0.14)	0.10 (0.14)	0.11 (0.14)	0.06 (0.15)	0.17 (0.14)	0.09 (0.15)
cut 1 Constant	2.72*** (0.61)	2.67*** (0.61)	2.55*** (0.61)	2.42*** (0.62)	4.14*** (0.81)	2.32*** (0.62)	4.06*** (0.82)
cut 2 Constant	4.08*** (0.61)	4.03*** (0.61)	3.91*** (0.62)	3.78*** (0.62)	5.64*** (0.81)	3.69*** (0.62)	5.55*** (0.82)
cut 3 Constant	5.03*** (0.62)	4.98*** (0.62)	4.86*** (0.62)	4.74*** (0.62)	6.67*** (0.81)	4.64*** (0.62)	6.58*** (0.82)
Observations	9,120	9,120	9,120	9,120	9,120	9,120	9,120
Firms	135	135	135	135	135	135	135
Ballots	241	241	241	241	241	241	241
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ballot fixed effects	No	No	No	No	Yes	No	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−7139	−7132	−7127	−7123	−6680	−7128	−6691
Chi-square	1504	1518	1529	1536	2421	1527	2400
Pseudo-R2	0.0953	0.0962	0.0969	0.0973	0.153	0.0967	0.152

Notes. Dependent variable is firm's vote on a ballot measure, coded as 0 = yes, 1 = abstain, 2 = yes with comments/conditions, 3 = no. All independent variables are lagged by one year. Firm votes are pooled across all years. Models 1–5 use alliance data to construct the knowledge network; models 6 and 7 use patent citation data.

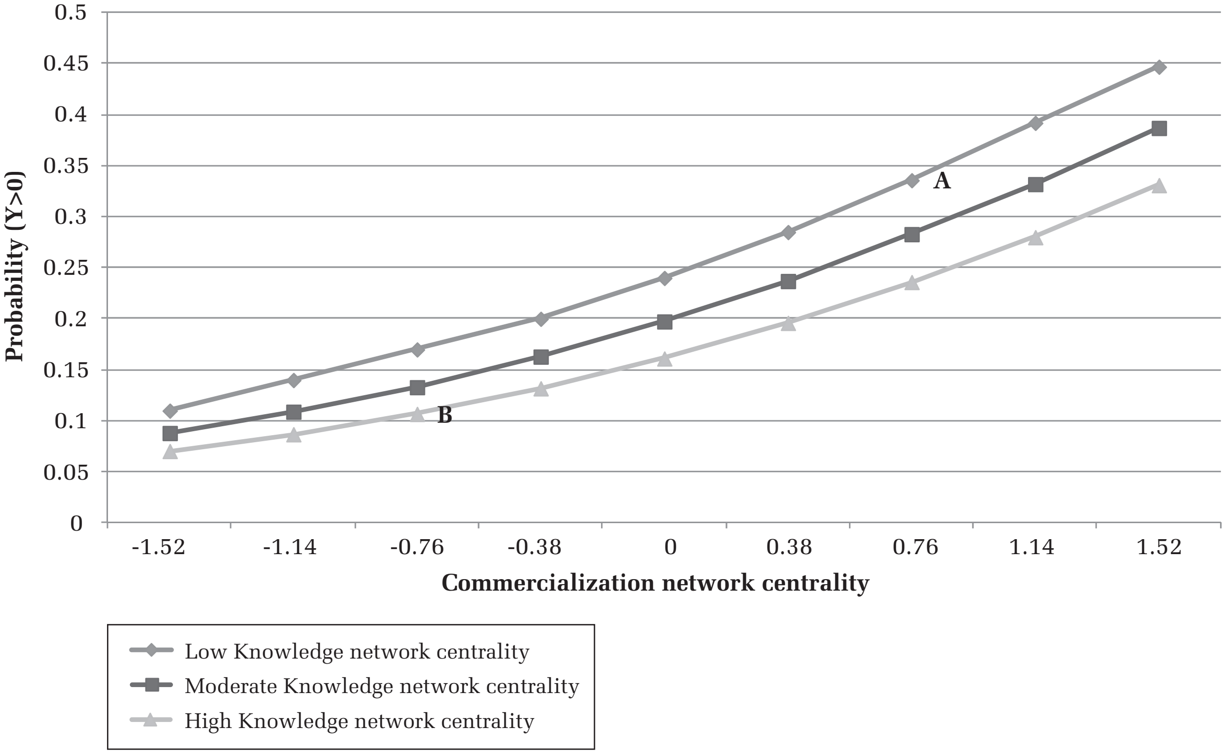
Standard errors in parentheses.

* $p < .10$

** $p < .05$

*** $p < .01$

FIGURE 1
Graph of Dependent Variable (Y-Axis) vs. Commercialization Network Centrality (X-Axis) for Different Levels of Knowledge Network Centrality



Notes. Low knowledge network centrality = mean −1 *SD*; moderate knowledge network centrality = mean; high knowledge network centrality = mean +1 *SD*. Y-axis measures the probability that the dependent variable is greater than 0 (i.e., vote is not an unconditional "yes"). Coefficient estimates are based on Model 5 in Table 4.

moderately significant in Model 7, indicating support for Hypothesis 1. A one-unit increase in "Knowledge network centrality" (approximately two standard deviations above the mean) decreases the odds of not voting "yes" by 0.41 times. Hypothesis 2 stated that the more central a focal firm is within the commercialization network, the higher its opposition to the standard. The coefficient for the variable "Commercialization network centrality" is positive and strongly significant in all the models, indicating support for Hypothesis 2. A one-unit increase in "Commercialization network centrality" (approximately 1.3 standard deviations above the mean) increases the odds of not voting "yes" by 1.85 times. Finally, Hypothesis 3 explores the joint effect of the two network positions—it stated that "Knowledge network centrality" would have a moderating effect on "Commercialization network centrality," such that the more technologically peripheral a focal firm is, the greater the effect of its commercialization network position on its opposition to the standard. The coefficient for the interaction term "Knowledge network centrality × Commercialization network centrality" is negative and significant, indicating support for Hypothesis 3. Figure 1 further examines this relationship graphically. For the same "Commercialization network centrality" score, the likelihood of a firm not voting "yes" on the ballot is lower, and the higher its "Knowledge network centrality" score.

To examine the implications of the interplay between the two network positions in more detail, note that our arguments were motivated by the logic that the effect of network multiplicity on firms' strategic behavior would be more prominent when the effects of the firm's knowledge network position align with those of its commercialization network position. In other words, when the firm is central in one network but peripheral in the other, we would expect a clear and unambiguous effect on its voting pattern. Table 5 demonstrates empirical evidence for this logic.

We subdivided the firms into four quadrants based on their two network positions (Low–Low centrality, Low–High centrality, High–Low centrality, and High–High centrality)[40] and included an indicator variable for each quadrant in the regression. Models 2, 3, and 5 demonstrate support for our logic—the coefficient for "Low knowledge centrality AND High commercialization centrality" is positive and significant, while the coefficient for "High knowledge centrality AND Low commercialization centrality" is negative and significant. Further bolstering our arguments, we do not see any effects for firms in the Low–Low quadrant or the High–High quadrant—since the effects of the two network positions are in opposition for these firms, an overall effect is therefore not discernible.

Figure 1 further illustrates this dynamic—the likelihood that a firm does not vote "yes" is approximately three times higher if a firm is central in the commercialization network and peripheral in the knowledge network (point "A" on the graph) than if it is peripheral in the commercialization network and central in the knowledge network (point "B" on the graph).[41]

Alternative Explanations

One additional concern regarding unobserved heterogeneity could be that a particular firm's voting choice on a particular ballot may be affected by the relationship between the set of technological issues being decided upon in the ballot and the firm's technological orientation. For instance, if the ballot's technological agenda is distant from or not relevant to the firm's technological area, then the firm may be less inclined to vote against it. Unfortunately, to directly assess this concern empirically requires not only advanced technical skills in the computer and data storage area, but also a disproportionate effort of reading through several thousand patents and several thousand working group meeting minutes to devise a measure. Moreover, even with true expertise in this area, the measure would still be subject to interpretation. However, our models included two proxy measures—"Participation in working group associated with ballot" and "Patents on standard's technologies"—that capture at least some portion of this heterogeneity, and reflect particular firms' stakes in particular ballots and subcommittees. Table 6 displays the results of a post hoc analysis, which includes the interactions of these measures with our independent variables.

In Model 1, we interact "Participation in working group associated with ballot" with both network centrality variables, and, in Model 2, we interact "Patents on standard's technologies" with these variables. Importantly, our main effects are robust to this inclusion. Further, the results suggest that firms indicating a high interest (stake) in the ballot via either of these two measures will decrease their expected levels of opposition when they are more central in the knowledge network. This supports our theorizing, in Hypothesis 1, that centrality in the knowledge network reflects both control and acceptance of the technological change imposed by the standard. In contrast, the level of commercialization network centrality is either not significant or slightly positive on the level of expected opposition. This supports our theorizing in Hypothesis 2 that argues for the effect of a commercialization position that is independent of technological considerations of the standard.

Robustness Checks

We also carried out an extensive set of robustness checks to test the sensitivity of our assumptions regarding model specification, variable construction, and choice of measures. Several of these results are reported in the appendix (Table A1), and we summarize them here. In Model A1, we use an alternate ordinal ranking for the dependent variable (0 = yes, 1 = yes with comments/conditions, 2 = abstain, and 3 = no). In Models A2–A4, we use an ordinary least squares model, a logistic specification (without rank ordering the dependent variable; i.e., 0 = yes, 1 = everything else), and an ordered probit specification, respectively. In Model A5, we use Bonacich's eigenvector centrality (e.g., Gulati & Gargiulo, 1999) instead of degree centrality. We also carried out tests without the inclusion of firms disconnected from thetwo networks, with the inclusion of 64 hybrid ties and by limiting the study period to 2007, 2006, and 2005,

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[40] The mean of each centrality measure was used to demarcate the boundaries of the quadrants.

[41] "Central" is represented in the graph (Figure 1) by the firm for which the network centrality score is mean +1 standard deviation. "Peripheral" is represented in the graph by the firm for which the network centrality score is mean −1 standard deviation.

TABLE 5
Analyzing the Interaction between Knowledge Network Centrality (Alliances) and Commercialization Network Centrality: Ordered Logistic Regression Results

	Models									
Variables	**1**		**2**		**3**		**4**		**5**	
Independent variables										
Low knowledge centrality AND Low commercialization centrality	−0.00	(0.09)								
Low knowledge centrality AND High commercialization centrality			0.18*	(0.10)					0.21*	(0.12)
High knowledge centrality AND Low commercialization centrality					−0.25**	(0.11)			−0.20*	(0.11)
High knowledge centrality AND High commercialization centrality							0.07	(0.12)	0.14	(0.14)
Controls										
Participation in working group associated with ballot	0.13***	(0.01)	0.13***	(0.01)	0.13***	(0.01)	0.13***	(0.01)	0.13***	(0.01)
Patents on standard's technologies	0.05*	(0.03)	0.05*	(0.03)	0.04	(0.03)	0.05*	(0.03)	0.05	(0.03)
Patent stock (overall)	0.02*	(0.01)	0.02*	(0.01)	0.02	(0.01)	0.02*	(0.01)	0.02	(0.01)
Patent stock diversity	−0.09	(0.07)	−0.09	(0.07)	−0.08	(0.07)	−0.10	(0.07)	−0.08	(0.07)
Citations to patent stock	0.01***	(0.00)	0.01***	(0.00)	0.01***	(0.00)	0.01***	(0.00)	0.01***	(0.00)
Knowledge insularity	−0.02***	(0.01)	−0.02***	(0.01)	−0.02***	(0.01)	−0.02***	(0.01)	−0.02***	(0.01)
External alliances (to firms not on standards committee)	−0.11***	(0.03)	−0.12***	(0.03)	−0.11***	(0.03)	−0.11***	(0.03)	−0.12***	(0.03)
Size (assets)	0.25***	(0.09)	0.23***	(0.09)	0.23***	(0.09)	0.25***	(0.09)	0.21**	(0.09)
Size (revenues)	−0.11	(0.10)	−0.11	(0.10)	−0.11	(0.10)	−0.12	(0.10)	−0.12	(0.10)
Financial slack (cash)	−0.02	(0.02)	−0.02	(0.02)	−0.02	(0.02)	−0.02	(0.02)	−0.02	(0.02)
Financial performance (net income)	−0.00	(0.01)	−0.00	(0.01)	−0.00	(0.01)	−0.00	(0.01)	−0.00	(0.01)
Financial slack (debt)	−0.12	(0.10)	−0.11	(0.10)	−0.12	(0.10)	−0.12	(0.10)	−0.11	(0.10)
Sector size	−0.02	(0.15)	−0.01	(0.15)	0.04	(0.15)	−0.01	(0.15)	0.06	(0.15)
cut1 Constant	4.50***	(0.81)	4.48***	(0.81)	4.47***	(0.81)	4.49***	(0.81)	4.43***	(0.81)
cut2 Constant	5.99***	(0.82)	5.97***	(0.81)	5.96***	(0.81)	5.98***	(0.81)	5.93***	(0.81)
cut3 Constant	7.02***	(0.82)	7.00***	(0.81)	7.00***	(0.81)	7.01***	(0.81)	6.96***	(0.81)
Observations	9,120		9,120		9,120		9,120		9,120	
Firms	135		135		135		135		135	
Ballots	241		241		241		241		241	
Firm fixed effects	Yes		Yes		Yes		Yes		Yes	
Ballot fixed effects	Yes		Yes		Yes		Yes		Yes	
Year effects	Yes		Yes		Yes		Yes		Yes	
Industry effects	Yes		Yes		Yes		Yes		Yes	
Log likelihood	−6699		−6697		−6696		−6699		−6694	
Chi-square	2385		2388		2390		2385		2394	

Notes. Dependent variable is firm's vote on a ballot measure, coded as 0 = yes, 1 = abstain, 2 = yes with comments/conditions, 3 = no. All independent variables are lagged by one year. Firm-votes are pooled across all years. All models include firm fixed effects, ballot fixed effects, and year effects.

Standard errors in parentheses.

*$p < .10$

**$p < .05$

***$p < .01$

TABLE 6
Analyzing the Interaction between Firm's Network Positions and Its Stake in a Ballot: Ordered Logistic Regression Results

Variables	Models 1		Models 2	
Independent variables				
Knowledge network centrality (R&D alliances)	−0.65***	(0.16)	−0.51***	(0.18)
Commercialization network centrality	0.50***	(0.12)	0.40***	(0.13)
Participation in working group × Knowledge network centrality	−0.04**	(0.02)		
Participation in working group × Commercialization network centrality	0.01	(0.01)		
Patents on standard's technologies × Knowledge network centrality			−0.12***	(0.04)
Patents on standard's technologies × Commercialization network centrality			0.06*	(0.03)
Controls				
Participation in working group associated with ballot	0.14***	(0.01)	0.13***	(0.01)
Patents on standard's technologies	0.07**	(0.03)	0.07**	(0.03)
Patent stock (overall)	0.02**	(0.01)	0.03***	(0.01)
Patent stock diversity	−0.07	(0.07)	−0.07	(0.07)
Citations to patent stock	0.01***	(0.00)	0.01**	(0.00)
Knowledge insularity	−0.03***	(0.01)	−0.03***	(0.01)
External alliances (to firms not on standards committee)	−0.11***	(0.03)	−0.10***	(0.03)
Size (assets)	0.21**	(0.09)	0.19**	(0.09)
Size (revenues)	−0.17*	(0.10)	−0.16*	(0.10)
Financial slack (cash)	0.01	(0.02)	0.02	(0.02)
Financial performance (net income)	−0.00	(0.01)	−0.00	(0.01)
Financial slack (debt)	−0.11	(0.10)	−0.14	(0.10)
Sector size	0.05	(0.15)	0.02	(0.15)
cut1 Constant	4.17***	(0.81)	4.07***	(0.82)
cut2 Constant	5.66***	(0.81)	5.57***	(0.82)
cut3 Constant	6.70***	(0.81)	6.60***	(0.82)
Observations	9,120		9,120	
Firms	135		135	
Ballots	241		241	
Firm fixed effects	Yes		Yes	
Ballot fixed effects	Yes		Yes	
Year effects	Yes		Yes	
Industry effects	Yes		Yes	
Log likelihood	−6679		−6679	
Chi-square	2425		2425	

Notes. Dependent variable is firm's vote on a ballot measure, coded as 0 = yes, 1 = abstain, 2 = yes with comments/conditions, 3 = no. All independent variables are lagged by one year. Firm votes are pooled across all years in the sample. All models include firm fixed effects, ballot fixed effects, and year effects.

Standard errors in parentheses.

* $p < .10$
** $p < .05$
*** $p < .01$

respectively, to assess sensitivity to U.S. NBER patent data right-censoring[42] (results not shown). Our results were robust across these models.[43]

To empirically underscore the importance of including network multiplicity, we also ran the regressions with a composite measure of centrality (Model A6) where we constructed a single alliance network by pooling both types of ties. Not surprisingly, the coefficient of the composite alliance network centrality measure was insignificant, as we

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[42] NBER patent data is available only until 2006.

[43] Additionally, we reduced collinearity between the two independent variables by orthogonalizing them using the Gram–Schmidt procedure (e.g., Sine, Mitsuhashi, & Kirsch, 2006) (the "orthog" command in Stata software). This removes the common variance between the two variables and transforms them into uncorrelated measures. The effects for the orthogonalized centrality measures are consistent in comparable regression models (results available from authors).

would expect the individual effects from the underlying knowledge and commercialization networks to offset each other for a large part of the sample. We also conducted a principal component analysis of the two alliance network centrality measures, and included the component that accounted for 90% of the common variation (Model A7). Again, the insignificant coefficient of this component further highlights the necessity of accounting for multiplicity in the alliance construct.

DISCUSSION AND CONCLUSIONS

This study makes several important theoretical and empirical contributions to research on relational pluralism. The simultaneous consideration of multiple networks highlights the reality that the types of ties measured can shape network effects differentially, providing a stark contrast to most network studies that focus on a single type of tie, ignoring the pluralism embodied by firms (Shipilov & Li, 2012). That is, while prior studies typically focus on the implications of a firm's position in either a technological network (e.g., Stuart & Podolny, 1996) or its embeddedness in a relational network (e.g., Ahuja, 2000; Uzzi, 1997), here we show that firms' strategic decisions in the standards-setting arena are shaped by the opposing and interacting effects of their positions in *both* knowledge and commercialization networks.

Importantly, in our study, the effects of these two network types are neither symmetric nor merely additive, underscoring the importance of the function of the network ties themselves. Regarding symmetry, while knowledge network centrality is associated with favoring new standards, commercialization network centrality is associated with opposing them, thus cautioning us against generalizing effects of central network positions on behavior without regard to the specific network (and outcome) under consideration. Indeed, our results demonstrate that, while knowledge networks and central positions within these networks promote technological innovation in the form of compatibility standards, commercialization networks and central positions within this network can decelerate the pace of innovation. Regarding additivity, while each network generates significant main effects, their interaction demonstrates how the overlap of the two networks suggests a firm's overall disposition towards a ballot proposal. Specifically, firms with low knowledge centrality but high commercialization centrality are most likely to cast opposing votes, because the rents these firms appropriate are largely a function of their current alliance agreements that are rooted in the current standards. Given the insights derived from examining multiple types of networks simultaneously, it will be critical for future research to extend this approach by incorporating other forms of pluralism, such as the interpersonal networks constituted via mobility or common institutional affiliations such as graduate degree programs.

While our reported results on knowledge and commercialization networks clarify that using merely a single-mode network to predict conduct would be substantially underspecified, future research must further assess both differentiation within typical tie classifications as well as commonality across distinct tie classifications. Most research on the effects of alliance network position have focused either on R&D ties alone (e.g., Rosenkopf et al., 2001; Sampson, 2007) or a pooled combination of both R&D and commercialization ties (e.g., Gulati & Gargiulo, 1999; Koka & Prescott, 2002). Given this common practice of pooling knowledge and commercialization ties under the generic heading of alliance ties, two of our findings are particularly important. First, the pooling of these ties in our setting yields no discernible effect on standards voting as these two forces counterbalance each other. Second, the knowledge alliance position is more effectively proxied by patent citation position rather than commercialization alliance position, despite the fact that knowledge generation alliance ties are jointly volitional and considered symmetric while patent citation ties are asymmetric, more emergent, and less social in nature. Accordingly, future research should address the robustness of tie classifications that our field has taken for granted. Just as all alliances are not the same, neither are all director interlocks (e.g., inside versus outside director ties) and nor are all mobility ties (e.g., to client versus to competitor).

Of course, our findings may be particular to the type of industry we study and its specific dependent variables regarding conduct. Obviously, our choice of a systemic industry in which a great deal of technological competition occurs in the standards forum rather than purely in the market may limit the scope of our findings. Our dependent variable—opposition to a standard—is purely a function of this context, yet a clear indicator of a firm's strategic behavior as it attempts to create competitive roadblocks. While most dependent variables for network position studies have focused on performance outcomes such as innovation or financial measures, our study focuses on a standards-specific behavioral measure (voting) and finds that a single network predictor is insufficient to explain variation in this measure. Future research should seek to extend these ideas both in other industries and for other context-specific dependent variables.

This paper also makes an important distinction specific to multifirm settings such as standards committees: Although firms that are central in an alliance network are posited to possess relational capital and interfirm trust (e.g., Kale, Dyer, & Singh, 2002; Koka & Prescott, 2002; Gulati & Singh, 1998; Gulati, 1995b), the value of accumulated social capital may be limited in a standards-setting committee, particularly when a firm cannot control membership, define the technical agenda for discussion, or cast more than one organizational vote. With engineers as participants, formal criteria for evaluating proposals are primarily based on technical knowledge and excellence (Rosenkopf et al., 2001). Although the standard itself may be strategic to firms, the process of developing it has a "bottom-up" flavor (see Rosenkopf et al., 2001). Tactics of politics and influence, including lobbying outside the confines of formal meetings, may backfire. Thus, a firm's alliance network position may not readily translate into advantageous technical committee decisions. Future research may seek to uncover additional arenas in which the typical finding that centrality leads to positive effects is refuted.

More generally, this setting is one in which the value-creating potential of alliance networks is constrained by the institutional relationships forced by standards committee membership and participation. Accordingly, the opportunities to extend this research are considerable. Future research might examine, for example, the effects of diverging votes or changing committee participation amongst longstanding alliance partners. In summary, our focus on multiple network positions and their effects on strategic behavior in technological standards committees has allowed us to demonstrate how typical findings on the typical association between centrality and outcome variables can be dramatically altered by the choice of network tie, industry context, and strategic behaviors under study. Acknowledging and comparing these choices across studies of ties, contexts, and behaviors will allow for the development of stronger, mid-range theories about how network structure affects conduct for firms embedded in a host of interorganizational relationships.

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APPENDIX

TABLE A1

Robustness Checks

Variables	Models[a]													
	A1		A2		A3		A4		A5		A6		A7	
Knowledge network centrality (R&D alliances)	−0.54***	(0.19)	−0.15***	(0.06)	−0.49***	(0.19)	−0.30***	(0.11)	−0.87*	(0.53)				
Commercialization network centrality	0.51***	(0.12)	0.23***	(0.04)	0.35***	(0.12)	0.35***	(0.07)	2.55***	(0.70)				
Knowledge network centrality × Commercialization network centrality	−0.03*	(0.02)	−0.01***	(0.00)	−0.03*	(0.02)	−0.02**	(0.01)	−4.08**	(2.06)				
Alliance centrality (pooled alliances)											−0.02	(0.06)		
Alliance centrality (principal component)													−0.04	(0.04)
Participation in working group associated with ballot	0.07***	(0.01)	0.06***	(0.00)	0.05***	(0.01)	0.07***	(0.01)	0.13***	(0.01)	0.13***	(0.01)	0.13***	(0.01)
Patents on standard's technologies	0.06**	(0.03)	0.02**	(0.01)	0.07**	(0.03)	0.04**	(0.02)	0.05*	(0.03)	0.05*	(0.03)	0.06*	(0.03)
Patent stock (overall)	0.01	(0.01)	0.01***	(0.00)	0.01	(0.01)	0.01***	(0.01)	0.03**	(0.01)	0.02*	(0.01)	0.02*	(0.01)
Patent stock diversity	−0.03	(0.07)	−0.03	(0.02)	−0.05	(0.07)	−0.05	(0.04)	−0.10	(0.07)	−0.09	(0.07)	−0.09	(0.07)
Citations to patent stock	0.01***	(0.00)	0.00**	(0.00)	0.01**	(0.00)	0.00**	(0.00)	0.01***	(0.00)	0.01***	(0.00)	0.01***	(0.00)
Knowledge insularity	−0.02***	(0.01)	−0.01***	(0.00)	−0.02***	(0.01)	−0.02***	(0.00)	−0.02***	(0.01)	−0.02***	(0.01)	−0.02***	(0.01)
External alliances (to firms not on standards committee)	−0.07**	(0.03)	−0.04***	(0.01)	−0.06*	(0.03)	−0.06***	(0.02)	−0.11***	(0.03)	−0.11***	(0.03)	−0.10***	(0.03)
Size (assets)	0.20**	(0.09)	0.05*	(0.03)	0.28***	(0.09)	0.10**	(0.05)	0.21**	(0.09)	0.25***	(0.09)	0.25***	(0.09)
Size (revenues)	−0.28***	(0.10)	−0.00	(0.03)	−0.23**	(0.10)	−0.07	(0.06)	−0.11	(0.10)	−0.11	(0.10)	−0.11	(0.10)
Financial slack (cash)	0.01	(0.02)	0.01	(0.01)	0.01	(0.02)	0.01	(0.01)	−0.02	(0.02)	−0.01	(0.02)	−0.01	(0.02)
Financial performance (net income)	−0.01	(0.01)	−0.00	(0.00)	−0.03**	(0.01)	−0.00	(0.00)	−0.00	(0.01)	−0.00	(0.01)	−0.00	(0.01)
Financial slack (debt)	−0.13	(0.10)	−0.03	(0.03)	−0.16*	(0.10)	−0.07	(0.06)	−0.12	(0.10)	−0.12	(0.10)	−0.12	(0.10)
Sector size	0.16	(0.15)	−0.02	(0.04)	0.16	(0.15)	−0.00	(0.08)	−0.01	(0.15)	−0.01	(0.15)	−0.01	(0.15)
cut1 Constant	3.83***	(0.81)	—		—		2.31***	(0.42)	4.27***	(0.81)	4.49***	(0.81)	4.48***	(0.81)
cut2 Constant	4.23***	(0.81)	—		—		3.17***	(0.42)	5.76***	(0.81)	5.98***	(0.81)	5.97***	(0.81)
cut3 Constant	6.27***	(0.81)	—		—		3.73***	(0.42)	6.80***	(0.82)	7.01***	(0.81)	7.00***	(0.81)
Constant			0.09	(0.17)	−2.58***	(0.62)								
Observations	9,120		9,120		9,000		9,120		9,120		9,120		9,120	
Firms	135		135		135		135		135		135		135	
Log likelihood	−6775		—		−4697		−6669		−6687		−6699		−6698	
Chi-square	2232		0.25[b]		1422		2445		2409		2385		2386	

Notes. Standard errors in parentheses.

[a] Refer to article for description of models.

[b] R^2.

* $p < .10$

** $p < .05$

*** $p < .01$

Ram Ranganathan (ram.ranganathan@mccombs.utexas.edu) is an assistant professor of management in the McCombs School of Business at the University of Texas-Austin. He received his PhD from the Management Department of the Wharton School at the University of Pennsylvania. His research focuses on understanding firm strategy in settings of technological change. His work emphasizes the pressures firms face in adapting to such change as well as how they attempt to control future technological evolution by participation in multifirm alliances and standards-setting committees.

Lori Rosenkopf (rosenkopf@wharton.upenn.edu) is the Simon and Mildred Palley professor in the Management Department of the Wharton School of the University of Pennsylvania. She received her PhD in management of organizations from Columbia University. She studies interorganizational networks and knowledge flow in various high-tech industries by analyzing participation in technical committees, alliances, the mobility of technological professionals, and patents within technological communities.