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The Multiplex Networks of Strategic Alliances and Follower–Followee Relations Among U.S. Technology Companies

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Guided by the ecology theory, this study seeks to understand the interdependency between instrumental and identity resource domains that drives the formation of interorganizational networks. Corresponding to the conceptual distinction of instrumental and identity relations, this study examines the multiplex networks of strategic alliances and follower–followee relations. Eighteen years of alliances data of 150 U.S. technology companies were retrieved from the SDC Platinum database and matched with their current Twitter accounts to obtain the follower–followee network, and the two networks were evaluated with a multivariate exponential random graph model using XPNet. The results confirmed cross-network mechanisms at dyadic and triadic levels and showed that the liability of newness and niche similarity affected the formation of multiplex networks. Theoretical and practical implications of cross-domain multiplexity are discussed.

Keywords: ecology theory, multiplex networks, interorganizational networks, strategic alliance, follower–followee network

Strategic alliances enable organizations to share and exchange resources for codevelopment, and two decades of research on alliances has examined the antecedents, dynamics, and consequences of forming such partnerships (Bakker, 2016; Gomes, Barnes, & Mahmood, 2016). With the proliferation of digital technology, communication scholars are increasingly interested in studying how organizations build relations on social media, with a focus on the symbolic value of such relations (Shumate & O'Connor, 2010a; Shumate et al., 2013). These two types of relations echo the substantive differentiation of network ties between information pipes and identity prisms (Podolny, 2001); transactions and social bonds (Baldassarri & Diani, 2007); instrumental and identity ties (Gonzalez-Bailon, 2009); and instrumental and expressive ties (Simpson, 2015).

From an ecological perspective, these two forms of relations illustrate that both resource and identity are essential factors influencing organizational survival and growth. To survive in competitions, organizations need to draw resources from niches, which are restrained environmental resource spaces that sustain the growth of organization populations (Aldrich & Ruef, 2006; Baum, 2002; Hannan & Freeman, 1984). At the same time, organizations also rely on socially codified identity niches for legitimacy (Pólos, Hannan, & Carroll, 2002). Because resource niches and identity niches both drive organizational changes (Dobrev, 2007; Dobrev, Ozdemir, & Teo, 2006; Freeman & Audia, 2006; Ingram & Yue, 2008), it is

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theoretically imperative to consider the interdependency of the formation of interorganizational networks in the two domains.

In network terms, the dependency of different types of relations is known as multiplexity, which captures the fact that nodes are usually embedded in qualitatively different relations, and these relations influence each other in the phases of formation and dissolution (Lazega & Pattison, 1999; Lazega, Bar-Hen, Barbillon, & Donnet, 2016). However, because of modeling restrictions, only a limited number of studies are devoted to interorganizational network multiplexity, and the interdependency between networks in resource and identity domains is not well understood (Kadushin, 2012; Lee & Monge, 2011; Lomi & Pattison, 2006; Simpson, 2015).

To address such theoretical and methodological gaps, this study seeks to examine the strategic alliances among computer equipment and computer programming companies and the follower–followee relations among them on Twitter. The strategic technology alliances among companies aim to produce technological innovation and knowledge transfer (Hagedoorn & Schakenraad, 1994). The follower–followee network on social media is a communicative tool for companies to manage their public presentation of interorganizational affiliations (Fu, 2019; Shumate & O'Connor, 2010a). This article argues that strategic alliances are examples of instrumental relations for the purpose of sharing resources and generating innovative knowledge, whereas follower–followee relations among companies on social media are examples of identity relations for the purpose of strengthening legitimacy, acknowledgment, and identity. With the purpose of examining the formation of multiplex networks in instrumental and identity domains, the findings from this study indicate that the two types of networks are interdependent and influenced by organizational age and niche similarity.

The present article is organized as follows. First, the ecology theory is reviewed to provide the rationale for multiplex interorganizational networks, and relevant literature on alliances and follower–followee networks is reviewed. Then, existing studies on multiplex networks and ecology concepts are reviewed to derive hypotheses. Alliances and follower–followee network data of computer equipment and computer programming companies are analyzed with a multivariate network model. This article concludes by discussing the implications of findings and putting forward future research directions.

The Ecology Theory and Multiplex Interorganizational Networks

Rather than approaching organizations as agents capable of maximizing performances, organizational ecologists view organizations' founding, survival, competition/collaboration, and demise through the lens of evolutionary selection (Baum, 2002; Hannan & Freeman, 1977, 1984). Resource niches depict the economic conditions under which organization populations can be sustained in competitions (Hannan & Carroll, 1992). Organizations that depend on similar economic resources over time evolve into a legitimated form with a socially acknowledged identity and symbolic meanings (Pólos et al., 2002). As summarized by Freeman and Audia (2006), organizations occupy not only niches in sociodemographic space and technological space, but also niches in ideology and identity space. For instance, whether similar organizations will compete or cooperate is not solely determined by economic relationships; it is also determined by social identity strengthened through affective relationships (Ingram & Yue, 2008). Firms' exiting market niches triggers mimicry from peer firms because they share the same identity; however, as the number of exiting firms increases, the collective identity collapses, and more resources are released, which makes remaining firms less incentivized to exit (Dobrev, 2007). In short, the duality of resource and identity is fundamentally embedded in the ecological framework.

Monge, Heiss, and Margolin (2008) applied this ecology framework to network transformation, where exploring linking partners entails variation, and links with high fitness are selected and retained. In particular, linkage fitness could be evaluated in multiple dimensions, that is, the capacity to provide important resources and the efforts needed to sustain the link (Monge et al., 2008). As they argued, network structuring requires assessing the mutual influences of different network structures (Monge et al., 2008). Therefore, it is essential to account for the interdependencies of different networks when studying the evolution of organization populations and communities.

Given that networks are viewed as mechanisms for accessing, exchanging, and consuming resources, scholars propose that the functional differentiation of interorganizational networks depends on the economic resources or identity resources channeled through these relations. Podolny (2001) viewed networks as either pipes or prisms of the market. Networks could be pipes through which "market stuff" flows, that is, information, opportunities, and transactions; networks could also be prisms, to serve as "an informational cue on which others rely to make inferences about the underlying quality of one or both of the market actors" (Podolny, 2001, p. 34). Baldassarri and Diani (2007) distinguished between instrumental ties (transactions) and identity ties (social bond), with the former driven by access to resources and the latter by identity homophily. Similarly, Gonzalez-Bailon (2009) argued that links among websites were both recommendation of quality as instrumental ties, and acknowledgement of common interest as identity ties. Expanding on this distinction, Shumate and Contractor (2013) proposed four types of interorganizational communication networks: affinity, flow, representational, and semantic relations (also see Shumate et al., 2013). Among these four types of relations, affinity and flow ties have a focus on the transmission of information, whereas representational and semantic relations stress the interpretation of symbolic meanings (Shumate & Contractor, 2013).

This article adopts this theoretical distinction and proposes two types of networks: the strategic alliances network and the follower–followee network. Strategic technology alliance is defined as "cooperative agreements for reciprocal technology sharing and joint undertaking of research between independent actors that keep their own corporate identity during the collaboration" (Gilsing, Lemmens, & Duysters, 2007, p. 227). Studies of antecedents and consequences of strategic alliances clearly focus on instrumental resources. For antecedents, alliances formation is mainly driven by access to diverse knowledge (Kogut & Zander, 1993; Sampson, 2007) and influenced by firm attributes such as crowded and prestige positions (Stuart, 1998), capability complementarity, status similarity, and social capital (Chung, Singh, & Lee, 2000). For outcomes, researchers have found that alliances can provide firms with critical collaborative resources when the locus of innovation is in interorganizational networks (Powell, Koput, & Smith-Doerr, 1996); increase efficiency in the application of knowledge (Grant & Baden-Fuller, 2004); benefit start-ups if alliances can provide access to diverse and nonredundant knowledge and reduce learning race hazards (Baum, Calabrese, & Silverman, 2000); and enhance organizations' exploratory innovation capability if the alliances network is diverse and dense (Phelps, 2010).

On the other hand, the follower–followee network on social media is a type of identity network with the purpose of symbolically displaying affiliations to the public (Fu, 2019; Shumate & Lipp, 2008; Shumate & O'Connor, 2010a). Following the logic of representational networks, the benefits of follower–followee relations are not derived from the information flow between the partners involved, but from communicating the relations to external stakeholders (Shumate & Contractor, 2013). With various communicative tools on social media for organizations to engage with stakeholders (Gurman & Ellenberger, 2015; Lovejoy, Waters, & Saxton, 2012), organizations build different types of representational networks—this is, hyperlink networks (Pilny & Shumate, 2012); mention, retweet, and reply networks on Twitter; tagging and comment networks on Facebook (Lai, She, & Tao, 2017); and follower–followee networks (Fu, 2019). These online networks do not necessarily mirror the actual relationships among organizations, but they create communicative opportunities for organizations (Lai et al., 2017), and serve as endorsements that facilitate the exchange of status, authority, and collective identity (Ackland & O'Neil, 2011).

Thus, this article argues that strategic alliances for innovation are forms of instrumental ties, which are, in general, enduring collaborative relations and inherently involve information exchange and resource sharing (Shumate et al., 2013). In comparison, the follower–followee relations on Twitter are forms of identity ties for acknowledgement and endorsement. It is worth noting that alliances do not exclude showing identity, and likewise, follower–followee relations do not exclude information exchange. Despite such overlap, the differences are evident. The meaning of innovation alliances lies in the two parties involved in a dyadic relation. The economic motivation to benefit from alliances overweighs and precedes the symbolic motivation to benefit from the external interpretation of such relations, and the formation and dissolution of alliances are highly contingent on factors including the resources that collaborative partners could offer, the compatibility of partners' resources, and innovation outcomes (Chung et al., 2000). In contrast, the purpose of following another organization is mainly to send an information cue to the public about the status, identity, and image of an organization. There is barely any cost to receiving a tie, and connecting to already well-connected nodes usually implies legitimacy, which makes such networks exhibit a highly skewed distribution of degrees (Shumate & Contractor, 2013).

The Endogenous Factors Driving the Formation of Multiplex Networks

Researchers of networks generally acknowledge that ties have manifold interdependences (Lazega & Pattison, 1999; Rank, Robins, & Pattison, 2010), corresponding to Baker and Faulkner's (2002) concept of "networks of interlocking domains" (p. 520). Powell, White, Koput, and Owen-Smith's (2005) inspection of the network dynamics of biotechnology industry includes four types of relations: basic research, finance, licensing intellectual property, and sales and marketing. Lomi and Pattison (2006) demonstrated the tendency for supply, technology transfer, and equity networks to co-occur in the transportation manufacturing industry. Lee and Monge's (2011) findings of ICT industries supported the existence of multiplex ties, such that two organizations engaged in implementation were also more likely to have knowledge sharing ties. Ferriani, Fonti, and Corrado (2013) examined the multiplex dynamics between economic ties (buyer–supplier relationships) and social ties (guidance and personal advice). Simpson (2015) studied the multiplex dependency among five relations: hyperlinks, "like" relations on Facebook, following relations on Twitter, overlap of followers, and copresence at ministerial meetings. Lai and colleagues (2017) examined how organizations were engaged in multiplex relations on different social media platforms and found that organizations' network positions remained consistent.

In previous studies, researchers suggested the rationale behind this multiplexity phenomenon was a strategy of redundancy to secure resources (Laumann & Marsden, 1982), accumulation of organizational learning opportunities (Powell et al., 2005), and exploitation of advantages or expertise in one field to access resources in other fields (Lee & Monge, 2011). The current article argues that the coexistence of alliances ties and follower–followee ties is also expected to secure instrumental and identity resources, both of which are critical for organizations' survival and performance from an ecological perspective. Thus, the following hypothesis is proposed.

H1: For the alliances network and the follower–followee network of technology companies, the existence of ties in one type of network would increase the likelihood of tie formation between the same pair of companies in the other type of network.

Lomi and Pattison (2006) stressed the local character of interorganizational networks—such that the global structure is constructed through bottom-up local dependencies and patterns involving only local actors—because organizations are usually only able to strategically respond to local neighborhoods rather than global structures (Pattison & Robins, 2002). As a basic mechanism in social networks, the tendency for nodes with common partners to establish connection could be viewed as a result of avoiding risks in forming or altering ties when there is insufficient information about the other party's capability and credibility (Lomi & Pallotti, 2013). In alliances formation, referrals from the common third parties play an important role in providing information on the competencies, needs, trustworthiness, and reliability of potential partners (Gulati, 1998; Gulati & Gargiulo, 1999).

Cross-level triadic dependency is a fundamental mechanism of multiplexity. Lee and Monge (2011) found that sharing multiple common third parties increased the likelihood of multiplex ties in implementation and knowledge-sharing networks, and such embedded magnitude increased with collaborative experience and expansion of the community. Similarly, Simpson (2015) found triadic closure between hyperlink and "like" networks. Bringing in time dimension, Shipilov and Li (2012) showed that the formation of horizontal ties (producer–producer) in the future is not only dependent on past horizontal ties, but also more influenced by past vertical ties (producer–consumer).

Following the logic of multiplex triads, the current article hypothesizes this triadic mechanism to exist across alliances and follower–followee networks. Because of the fundamental differences between the two networks, two separate hypotheses are proposed to examine the different network formation mechanisms. Sharing the same third parties in the alliances network makes the two companies more likely to be connected in the follower–followee network; this is because the alliances network assumes a high level of investment and entails accumulation of familiarity and trust, which in turn makes companies more likely to publicly endorse each other. Although following ties involve lower stakes than alliances ties, sharing the same third parties indicates mutual understandings in displaying public affiliations; this signals the real relations among organizations. Based on these rationales, the following hypotheses are proposed:

H2a: *The existence of multiple shared partners in the alliances network increases the likelihood of tie formation between the two companies in the follower–followee network.*

H2b: *The existence of multiple shared partners in the follower–followee network increases the likelihood of tie formation between the two companies in the alliances network.*

The Exogenous Factors Driving the Formation of Multiplex Networks

In ecological processes, age is critical for organizational survival (Bakker & Josefy, 2018; Hannan & Freeman, 1984; Stinchcombe, 1965). The logic of liability of newness assumes that new organizations suffer from higher risk of mortality compared with established organizations (Stinchcombe, 1965). The mortality hazard for new ventures is found to peak during their first year of founding and gradually diminish (Wiklund, Baker, & Shepherd, 2010). Scholars argue that one reason is new organizations' lack of embeddedness and legitimacy (Stinchcombe, 1965). As Hannan and Freeman (1984) argued, longevity itself is a powerful indication of legitimacy, and new organizations are generally weaker in garnering public support and establishing legitimacy. Thus, for identity relations, younger organizations have fewer symbolic resources to offer and are likely to be peripheral in the network.

The logic of liability of newness also explains firms' alliances building for innovation purposes. Younger companies generally have a poorer knowledge and infrastructure base from which to conduct innovation (Sørensen & Stuart, 2000), whereas older companies are found to have a higher rate of innovation, especially in knowledge-intensive industries (Luo & Deng, 2009). In alliances building, younger companies usually find it difficult to establish new partnerships and have fewer alternatives because they lack accumulated trust through past collaborations (Morse, Fowler, & Lawrence, 2007). In comparison, older companies are more desirable because forming alliances with established organizations would reduce competitive pressure (Aldrich & Fiol, 1994) and allow for better access to capital markets (Lerner, Shane, & Tsai, 2003) and product markets (Hill & Rothaermel, 2003). Hence, it is also more difficult for younger organizations to establish instrumental relations.

In the present context, more established companies would be more central in both alliances networks and follower–followee networks because collaboration with them could lead to both resources and legitimacy. By contrast, younger companies are unlikely to have multiplex ties because they have neither resources nor legitimacy to offer each other.

H3: *The younger the two technology companies, the smaller the likelihood of forming multiplex ties across alliances and follower–followee networks.*

An organization community is defined as "co-evolving organizational populations joined by ties of commensalism and symbiosis through their orientation to a common technology, normative order, or legal-regulatory regime" (Aldrich & Ruef, 2006, p. 243). An organization community functions as a buffer for environmental disruptions because it redistributes resources when some populations face resource exhaustion (Bryant & Monge, 2008). *Commensalistic relations* refers to relations among similar populations on a spectrum ranging from competition to mutualism, and *symbiotic relations* refers to mutual interdependence among dissimilar populations (Aldrich & Ruef, 2006). Both commensalistic and symbiotic relations facilitate the diffusion of entrepreneurial opportunities and increase the founding rate of organizations in a community (Audia, Freeman, & Reynolds, 2006).

This article argues that niche similarity affects the formation of two networks differently. For strategic alliances, research collaboration is a form of growth commensalism, in which competitors collaborate to share research risks and benefits in order to grow their shared resources and exclude resources from others (Ingram & Yue, 2008). A few rationales explain why similar organizations would collaborate in alliances. First, similar companies are more efficient in identifying and allocating knowledge in each other's repertoire (Luo & Deng, 2009). The concept of absorptive capacity stresses the importance of sufficient knowledge similarity in facilitating interorganizational learning in strategic alliances (Lane, Koka, & Pathak, 2006). Second, similar companies are more likely to benefit from collaboration outcomes because they have the necessary infrastructure to implement innovation outcomes. Empirical results show that a moderate degree of partners' similarity in knowledge relatedness contributes to focal firms' innovation (Ahujia & Katila, 2001; Luo & Deng, 2009), and organizations sharing similar geological and resource spaces are more likely to form instrumental ties of implementation and knowledge sharing (Lee & Monge, 2011). Thus, this article argues that technology companies with niche similarity are more likely to form strategic alliances as a form of mutualism.

H4a: Technology companies with similar niches are more likely to form ties in the alliances network.

Similarity in both resource and identity domains is likely to trigger competition. To reconcile between resource niches and ideology niches, Simons and Ingram (2004) argued that ideology similarity would lead to either collaboration or competition contingent on the overlap of resources—that is, if organizations share similar key resources, ideology similarity would evoke competition. Similarly, Dobrev and associates (2006) found that a new population sharing overlap with an established population in both resource and identity niches would face both resource competition and identity comparison.

In contrast, dissimilar organizations could establish symbiotic relations. Building on the distinction between resource and identity niches, Shumate and O'Connor (2010a) proposed the symbiotic sustainability model, which posits that dissimilar organizational populations could establish mutually beneficial representational relationships symbolized to and co-constructed by stakeholders. Based on this model, dissimilar organizations without resource overlap are less likely to compete, and dissimilar organizations without identity overlap can associate themselves with different identity niches to mobilize capital. The formation of such representational networks could be driven by factors such as capability to mobilize resources, current network positions, influences from competitors, and occupation of economic industries and social issue industries (Shumate, Hsieh, & O'Connor, 2018; Shumate & O'Connor, 2010a, 2010b). Following this logic, dissimilar firms are less likely to compete on social media for attention from similar audiences, and following dissimilar firms potentially brings benefits such as knowledge, presence, and identity in different communities (Lovejoy et al., 2012). Thus, this article argues that technology companies with niche dissimilarity are more likely to follow each other on social media to build symbiotic relations.

H4b: Technology companies with dissimilar niches are more likely to establish ties in the follower–followee network.

Method

Data Collection

Alliances data of technology companies were obtained through the SDC Platinum database. The starting date was January 1, 2000, and the most recent deal was made on May 1, 2018. In total, 2,454 alliance deals were retrieved for participant companies with the first three digits of the standard industrial classification (SIC) equaling 357 (computer equipment) or 737 (computer programming and data processing). These two broad categories of companies were selected because they represent different populations bounded within the community of computer-related high technology. Several conditions were set to subset the data to control heterogeneity. First, a deal was selected if all participant companies and their respective parent companies had SIC codes starting with 357 or 737. Therefore, if computer equipment or computer programming companies collaborated with companies belonging to other industrial categories, this deal was excluded. Second, to control for multinational heterogeneity, alliances were selected only if all participating companies were U.S. companies; thus, no cross-border deals were included. Third, because the focus of the alliance was collaboration among technology companies for innovation, the deal was included only when "research & development services" or "software development services" was indicated in the activity description. Finally, only "completed/signed" deals were included. These conditions yielded a smaller sample of 728 companies.

For multiplex network analysis, the nodes need to be the same across two layers of networks. The researcher manually checked each company's Twitter account to ensure that it was the company's official Twitter account by comparing the trademark with company information obtained from other sources, including official websites, LinkedIn, and CrunchBase. A total of 284 companies were found to have official Twitter accounts. Because an alliance deal could only be included when all participant companies still existed and had Twitter accounts when the data were collected, the final data set consisted of 150 companies engaged in 104 alliances deals. For the alliances network, deals with more than two participants were set as cliques. The obtained network was dichotomized on 1, because XPNet cannot be used with valued networks. The final alliances network had 150 vertices with 103 undirected edges, with a density of .009 and a transitivity score of .019.

The follower–followee network was constructed by retrieving the following relations among the 150 companies using the Twitter Application Programming Interface on January 27, 2019. The retrieved follower–followee network had 811 directed edges, which included 156 pairs of mutual ties. For multiplex network modeling, the two networks need to be either directed or undirected at the same time. The directed following ties were thus transformed into undirected ties using the "collapse" algorithm in *igraph* package in R, where one undirected edge was created for each pair of vertices with at least one directed edge (Csardi & Nepusz, 2006). The final follower–followee network had 655 undirected edges, with a density of .058 and a transitivity score of .333. The two networks are visualized in Figure 1.

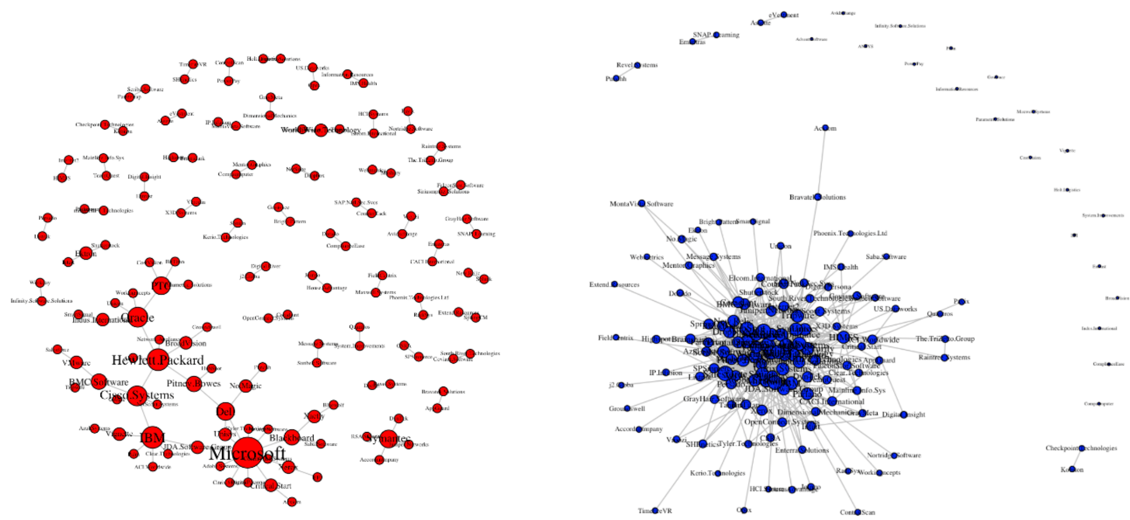


Figure 1. Alliances network (red) and follower–followee network on Twitter (blue) among U.S. technology companies (N = 150).

Measures

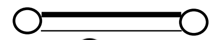
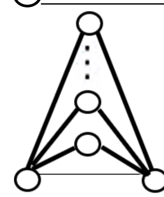
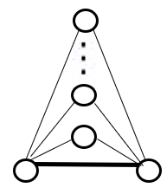
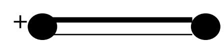
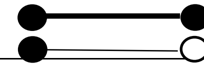
Niche similarity. Two companies were considered to occupy similar niches if they shared the first three digits of SIC. SIC codes have been widely used in organization studies to define the boundary of organization population (Carroll & Hannan, 2000) and identify market niches (Echols & Tsai, 2005). Niche similarity is considered as being in the same broad category of either computer equipment companies (357) or computer programming and data processing companies (737).

Organization age. The ages of the companies were measured using their founding years. Up to 2019, the mean firm age is 24.72 years, with a standard deviation of 17.71 years. The oldest company in the sample is Xerox, founded in 1906, and the youngest company is Kobiton, founded in 2016. Network degree and organization age show positively significant correlation, although the correlation in the alliances network is stronger (r = .41, p < .001) than the correlation in the follower–followee network (r = .21, p < .01). This indicates that older organizations are more embedded in both networks.

Model Specification and Analysis

The alliances and follower–followee networks were analyzed with the exponential random graph model (ERGM), which accounts for the endogenous dependencies with dyadic, triadic, and higher order configurations and simultaneously allows for the testing of exogenous covariates (Wang, Robins, & Pattison, 2009). For multiplex network analysis, it is necessary to account for both within-network endogeneity and cross-network endogeneity. The XPNet program, which is a multirelational version of the PNet program, allows researchers to simultaneously investigate different relations among the same set of vertices and, more important, to specify the cross-network interdependence mechanisms (Wang et al., 2009). The model specification process is guided by Wang et al. (2009), and structural configurations in the hypotheses are visualized in Table 1.

Table 1. Visual Presentation of XPNet Parameters.

Legend			
Network A			
Network B			
Node with attribute			
Node without attribute			
Graph statistics			
Hypothesis	Mechanism	Parameter	Illustration
H1	Multiplex dyadic tie	*EdgeAB*	
H2a	Multiplex transitivity	*AT-ABA*	
H2b	Multiplex transitivity	*AT-BAB*	
H3	Sum of founding years	*Sum-found-AB*	
H4a	Niche similarity	*Match-SIC-A*	
H4b	Niche dissimilarity	*Mismatch-SIC-B*	

Note. This table was adapted from Wang et al., 2009.

The alliances network was set as Network A, and the follower–followee network was set as Network B. Following previous studies of multiplex networks, graph density was fixed to facilitate the modeling process, and hence *edge-A* and *edge-B* parameters were not included in the model (Yap & Harrigan, 2015). As a cross-level dyadic mechanism for undirected networks, *edge-AB* refers to the co-occurrence of ties from the two networks. If significant, this parameter indicates that the existence of a tie between two companies in one network would increase the probability of tie formation between the same pair of companies in another network. For cross-network transitivity mechanisms, *AT-ABA* and *AT-BAB* refer to the higher order cross-network clustering. If significant, *AT-ABA* means that if two companies shared multiple partners in the alliances network, they were more likely to form a tie in the follower–followee network. Similarly, *AT-BAB* means that if two companies shared multiple partners in the follower–followee network, they were more likely to form a tie in the alliances network.

For exogenous covariates, *sum-found-AB* was to test if two younger companies were less likely to have multiplex ties. If negative and significant, two younger companies were less likely to have multiplex ties across alliances and follower–followee networks. *Match-SIC-A* and *mismatch-SIC-B* could test whether having the same first three SIC digits would make organizations more or less likely to form ties in the two networks. If *match-SIC-A* was found to be positively significant, companies were more likely to form commensalistic ties in the alliances network; if *mismatch-SIC-B* was found to be positively significant, companies were more likely to form symbiotic ties in the follower–followee network.

Other within-level and cross-level structural configurations were included to improve the model fitting. *Star-A* and *Star-B* were included to account for the skewed degree distributions in two networks; *AT-B* was included to account for local clustering in the follower–followee network; and *2-Star-AB* represented the same node connecting to different others in the two networks (Table 2).

Results

The final model was considered converged if all convergence *t* ratios were below .1 (Robins, Snijders, Wang, Handcock, & Pattison, 2007), indicating reliability of parameter estimates (Table 2). H1 tested the likelihood of tie formation across two networks. The parameter *edge-AB* was found to be significant, $Estimate_{edge\text{-}AB}$ = 22.098, *SE* = 1.204, $p < .001$, indicating the co-occurrence of multiplex ties across the two distinctive networks. H1 was supported.

Table 2. Parameter Estimates for the Converged Multiplex ERGM of Alliances Network (A) and Follower–Followee Network (B) Using XPNet (N = 150).

Effects	*Estimates*	*SE*	*t ratio*
Alliances network (A)			
2-Star-A	−.092	.097	−.041
Match-SIC-A (H4a)	.038	.282	.036
Follower-followee Network (B)			
2-Star-B	.174*	.010	.049
3-Star-B	−.005*	.000	.012
AT-B	.455*	.084	.046
Mismatch-SIC-B (H4b)	.050	.029	.085
Bivariate			
Edge-AB (H1)	22.098*	1.204	−.030
2-Star-AB	−.007	.011	−.013
AT-ABA (H2a)	.350*	.175	−.011
AT-BAB (H2b)	−.108	.211	−.016
Sum-found-AB (H3)	−.005*	.000	−.029

Note. Parameters with * indicates that the estimate divided by standard error is larger than 2.

H2 tested the cross-network clustering effect that sharing multiple partners in one network would increase the likelihood of tie formation in the other network. For the two higher order cross-network clustering parameters, *AT-ABA* was found to be significant, $Estimate_{AT\text{-}ABA} = .350$, $SE = .175$, $p < .05$, but *AT-BAB* was not significant, $Estimate_{AT\text{-}BAB} = -.108$, $SE = .211$, $p > .05$. H2a was supported, but H2b was not supported.

H3 proposed that younger companies were less likely to have multiplex ties. The parameter *sum-found-AB* was found to be significant and negative, $Estimate_{sum\text{-}found\text{-}AB} = -.005$, $SE = .0003$, $p < .001$. This result indicated that the more recently founded the two companies, the less likely they were to have multiplex ties across the two networks. H3 was supported.

H4 proposed that companies with similar niches were more likely to form a tie in the alliances network, whereas companies with different niches were more likely to form a tie in the follower–followee network. The parameter *match-SIC-A* was not significant, $Estimate_{match\text{-}SIC\text{-}A} = .038$, $SE = .282$, $p > .05$, whereas the parameter *mismatch-SIC-B* was marginally significant, $Estimate_{mismatch\text{-}SIC\text{-}B} = .050$, $SE = .029$, $p = .085$. These results showed that technology companies would be marginally more likely to form symbiotic relations in the follower–followee network, but not necessarily form commensalistic relations in the alliance network. H4a and H4b were not supported.

Goodness of fit tests how closely the estimated model matches the observed networks, both for parameters included in the model and for additional network dimensions (Atouba & Shumate, 2015; Robins, Pattison, & Wang, 2009). Goodness of fit diagnostics for the current model showed that all the parameters included in the model had convergence *t* ratios less than .1 in absolute values, and the model could also well represent nonestimated but essential network configurations. The complete GoF table is shown in supplement (https://drive.google.com/file/d/1vLbKVUdGEqywV1Qu-rg0XT2PKAThH5pj/view?usp=sharing).

Discussion

The ecology theory acknowledges the importance of both economic resources and identity resources for organizational survival (Aldrich & Ruef, 2006; Baum, 2002). Such theoretical distinction is consistent with the differentiation between instrumental and identity relations for interorganizational networks (Baldassarri & Diani, 2007; Podolny, 2001; Shumate & Contractor, 2013). It would be a theoretical oversight, therefore, if the interdependency of the two domains was not taken into account when evaluating how interrelated organizations acquire critical resources from the environment. To address this question, relational multiplexity provides both a theoretical perspective and an empirical tool to model such cross-domain interdependency. Using strategic alliances and follower–followee relations as empirical examples, this study seeks to examine the interconnectedness and distinction of the two types of relations.

The findings from this study supported relational multiplexity in instrumental and identity domains on dyadic and triadic levels. To be more specific, on the dyadic level, the results showed that having a tie in one network increased the likelihood of tie formation in the other network; on the triadic level, having multiple shared partners in alliances network would increase the likelihood of tie formation in the follower–followee network, but not the other way around. The rationale for multiplexity is to accumulate trust, resources, and positional advantages (Laumann & Marsden, 1982; Lee & Monge, 2011; Powell et al., 2005).

As argued by Lee and Monge (2011), multiplex interdependency offers strategic opportunities for organizations to choose partners and exploit network positions in one network to gain an advantage in the other network. In the current context, relational multiplexity is also a vehicle to sustain and acquire both instrumental and identity resources. It is worth noting that sharing the same partners in the follower–followee network does not increase the chance of tie formation in the alliances network. This is possibly because alliances and follower–followee networks assume remarkably different levels of investment, risks, and outcomes. Forming a strategic alliance with another organization is a critical strategic decision that assumes significant commitment. By contrast, the decision to follow other organizations requires much less investment. Although follower–followee relations could signal actual interfirm relations and provide communicative opportunities for public display of status and identity (Ackland & O'Neil, 2011; Lai et al., 2017), referrals through common third parties in such relations did not indicate sufficient assurance and trust required for innovation alliances.

Apart from endogenous cross-network mechanisms, this article confirmed the liability of newness, in that younger companies were less likely to have multiplex ties. A possible explanation is that younger companies are less embedded in interorganizational networks and thus are less known and trusted (Stinchcombe, 1965), so they would prefer to collaborate with established companies in the alliances network to access resources. Younger companies also have lower status and thus prefer to connect with established companies in the follower–followee network to gain legitimacy. Thus, multiplex ties among younger companies are unlikely to bring instrumental or identity benefits.

Guided by community dynamics, this article proposed that niche similarity influenced the formation of ties in two networks differently. For strategic alliances, the results show that companies from similar niche spaces were not more likely to form commensalistic relations in the alliances network. One explanation could be the coexistence of mutualism and competition in commensalistic relations (Dobrev, 2007; Ingram & Yue, 2008). Similar concepts are found in the studies of "co-opetition," which is defined as the simultaneous pursuit of collaboration and competition (Gnyawali & Park, 2011; Gulati, Wohlgezogen, & Zhelyazkov, 2012). Alliances between potential rivals bring more learning opportunities and restrict rivalry (Baum et al., 2000), but collaboration with competitors also entails the risk of knowledge leakage (Khanna, Gulati, & Nohria, 1998). Presumably, some moderators exist to differentiate companies that collaborate with similar others and companies that collaborate with dissimilar others in the alliances network, but the current version of XPNet could not account for moderating effects.

In the follower–followee network, companies with dissimilar niches had a marginal tendency to build symbiotic ties in the identity domain. Symbiotic relations within an interdependent community could buffer organizations against environmental changes (Bryant & Monge, 2008), and for representational networks, such symbiotic relations are communicated to stakeholders for capital mobilization (Shumate & O'Connor, 2010a). In the current case, the symbiotic relations among computer equipment and computer programming companies could be communicated to stakeholders to build an image of innovativeness by associating with the cutting-edge technology development in a different but highly relevant industry. A possible explanation for the nonsignificant result is that some organizations might also follow similar others to obtain industry updates.

By examining the ecological factors driving the formation of multiplex networks, this article contributes to the research of interorganizational communication networks. Although multiplexity is a fundamental concept in network studies (Barley, Freeman, & Hybels, 1992; Hartman & Johnson, 1989), formal theorizing in this field is limited (Kadushin, 2012; Powell et al., 2005), and only a small number of recent studies have leveraged the method advancement and empirically tested multiple networks (Lee & Monge, 2011; Simpson, 2015). Existing network literature stresses the presence and absence of ties, and less attention is given to the investment required to maintain ties (Monge et al., 2008). Relational multiplexity is such an organizational strategy to maintain ties through redundancy and solidarity (Laumann & Marsden, 1982).

This article also extends the ecology theory by exploring the interdependency of instrumental and identity domains. Organizational ecologists have long focused on the importance of economic resources for organization fitness, but have been attaching more and more importance to identity (Pólos et al., 2002). There's also a growing research interest in integrating resource niches and identity niches to explain complex ecological mechanisms (Dobrev et al., 2006; Freeman & Audia, 2006; Ingram & Yue, 2008). This study further extends such integration by showing that ecological factors such as age and niches do not affect the formation of one type of relation alone, but multiple types of relations through interorganizational and interdomain dependencies.

To mention a few practical implications, technology companies could rely on relational multiplexity to strategically choose partners in an effort to obtain both types of critical resources, and they could increase their structural advantages in one domain by investing in the other domain. Moreover, because younger companies are less motivated to strengthen bonds with other younger companies through multiplex ties, one possible way to break out of the liability of newness is to exploit relational opportunities (i.e., shared partners) in one domain to build relations with established companies.

This study has a few limitations. Strategic alliances and follower–followee relations are only examples of instrumental and identity relations. The mechanisms discussed in this article could shed light on our understanding of how these two general types of networks are formed, but should not be taken for granted. Rarely is a relation solely one type to the exclusion of the other, and specific relations usually involve unique properties and contingencies. The choice of these two types of relations also restrains the sample of companies included in the empirical analysis. To examine the multiplex relations among computer companies, the alliances sample was streamlined to include only those with official Twitter accounts at the time of data collection. To make a more generalizable claim regarding the interdependency of instrumental and identity relations, future research could examine and summarize multiple relations in each domain and then make the comparison to see if hypotheses can be supported across different relations.

Future research could also consider the changes of companies over time—that is, how multiplex relations and organizational changes coevolve over time from a longitudinal perspective. The time dimension is left out in the current study because the follower–followee network on Twitter is collected as a snapshot, and no time stamps can be retrieved. The current multivariate ERGM could empirically examine the traces left by endogenous and exogenous mechanisms that drive the formation of multiplex networks, but could not test tie dissolution or how the changes of one network function as antecedents of another network (Ferriani et al., 2013; Lai et al., 2017; Shipilov & Li, 2012). Future research could account for the time dimension to capture the complete evolutionary trajectories of organization communities.

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