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MANAGERIAL PERSPECTIVE

Towards a Conceptual Framework for Modeling the Dynamics of Coopetition within a Technological Ecosystem

SUMMARY

This study develops a conceptual framework for analyzing coopetition within technological ecosystems. Building on the premise that coopetition can be studied by analyzing networks of blocking relations between firms' patent portfolios, we explore triadic isomorphism based on Wasserman and Faust's (1994) methodology. Such triads are considered to hold information about the network as a whole. We analyzed over 170,000 patents in the telecommunications industry to assess scenarios for triadic dynamics. Our results reveal that coopetition has become the new normal in technological ecosystems, with a tendency to spread both vertically and horizontally across industry boundaries. This paper contributes to coopetition theory by offering a methodology to analyze the complex dynamics of competition and cooperation in converging technological landscapes.

This working paper is presented as a managerial perspective and intended for business leaders, corporate strategists, senior policymakers, academic researchers, and consultants involved in organizational development, crisis response, and transformation planning.

KEYWORDS Coopetition · competition · collaboration · patents · technological ecosystems · network analysis · telecommunication · triads · complex technologies · blocking citations · digital platforms · innovation networks

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1. Introduction

Recent headlines in business press highlight how patents remain at the heart of strategic maneuvering across industries: pharmaceutical companies battling emerging generic drug manufacturers, technology giants acquiring patent portfolios from established firms like Kodak or Nortel, companies like Nokia and Apple reaching agreements after protracted legal disputes, and platform owners establishing patent licensing programs to control technological ecosystems.

These strategic moves occur in a context where two significant trends intersect: converging technologies and increasingly innovative business models (Baden-Fuller & Haefliger, 2013; Kohler, 2022). Morgan (1996) proposed using the organism metaphor to describe organizations, emphasizing the need to understand situations in new ways. Extending this metaphor to reflect higher complexity, researchers have adopted the ecosystem concept to represent converging industries as communities of organisms interacting with one another and their

environments. Technological ecosystems (Naughton, 2012; Kapoor, 2018) and technological convergence (Bainbridge & Rocco, 2005; Curran et al., 2022) involve complex strategic analyses in many industries, making it increasingly difficult to understand competitive dynamics and strategic advantages.

Furthermore, such ecosystems often become arenas for entangled coopetitive relationships that blur strategic perspectives. In a recent paper, Hannah & Eisenhardt (2018) highlighted the need for enhanced theoretical conceptualization and new discussions on coopetition phenomena, particularly in dynamic technological environments. Bouncken et al. (2020) emphasized the importance of investigating coopetition in platform-based ecosystems where competition and cooperation occur simultaneously.

This study proposes a conceptual framework based on the idea that coopetitive dynamics in complex technologies developed within technological ecosystems can be studied by analyzing the network of blocking relations between firms' patent portfolios. We build on and extend previous work in coopetition theory (Gnyawali & Charleton, 2018) and patent network analysis (Graevenitz et al., 2011; 2013) to develop a novel methodology for analyzing these dynamics.

The next section discusses prior research in coopetition, strategic patenting, and the triadic approach. In Section 3, we detail the methods used in this study and introduce our field of study. Section 4 presents the network statistics. The final section concludes our study, discusses possible limitations, and provides implications for future research and practice.

2. Theoretical background

2.1. Coopetition dynamics

Hergert and Morris (1988) reported the explosion of cooperative agreements in the 1980s as a response to contextual factors such as rising technological complexities and globalization (Powell, 1987; Prahalad & Hamel, 1994). Following ambiguous results from these strategies, researchers warned about potentially ambivalent positions, including alternate forms of competition (Hamel et al., 1989), learning races (Hamel, 1991), or even weakened competitive positioning (Porter & Fuller, 1986). Koot (1988) emphasized the dualistic nature of cooperation.

In examining strategic networks, Grabher (1993) reflected on the dualistic roles of relations within networks, bringing both collaboration and competition. According to Madhavan et al. (2004), coopetitive relations emerge under countering and cooperating motives in existing alliance networks. The role of competition remains important as motivation for seeking new partners, technologies, and products (Kogut, 1993). Peng and Bourne (2009) suggested that two organizations would simultaneously compete and cooperate when each possesses complementary but distinctly different resource sets, and when competition occurs in domains separate from cooperation. While early research focused on factors leading competitors to cooperate, other scholars explored the effects of coopetition on industry competitive structure and its use as an entry barrier (Treacy, 2007; Hoffmann et al., 2018). Drivers such as shortened product lifecycles, technological convergence, and rising R&D costs have accelerated coopetition adoption (Gnyawali & Park, 2009; Bouncken & Kraus, 2013). Park and Ungson (2001) argued that alliances with strong rivalry were more likely to fail due to challenges in developing trust-based relationships, creating efficient governance structures, sharing knowledge, resolving organizational differences, and developing coherent strategies. However, new technological and market factors have created conditions for widespread adoption of coopetitive strategies.

Gnyawali et al. (2011) demonstrated that coopetition serves as a specific mechanism for addressing technological challenges and driving innovation. Furthermore, coopetition tends to spread from technology leaders to smaller firms, expanding the market while allowing dominant firms to appropriate larger shares of cooperative benefits. This phenomenon has been further documented in platform-based innovation ecosystems (Cennamo & Santaló, 2019; Hannah & Eisenhardt, 2018). Ritala and Hurmelinna-Laukkanen (2009) indicated that coopetition increases value-creation potential but decreases value-appropriation potential in innovation. In coopetition dynamics, network externalities enhance the relationship between common knowledge and value creation potential, but this relationship is eroded by restricted knowledge sharing. These dynamics have been further explored in the context of digital platforms and digital transformation strategies (Teece, 2018; Cozzolino et al., 2021). This delicate balance is particularly evident in telecommunications and the "smartification" of devices. Coopetition in this field functions as the primary mechanism for driving innovation, embodied in "complex" technologies developed by multiple companies from different industries forming a technology ecosystem (Yami & Nemeh, 2013; Hannah, 2022).

2.2. Strategic patenting and complex technologies

Strategic patenting has emerged as a natural phenomenon in "complex" technologies (Bessen, 2003; Somaya, 2012). Technologies are complex when final products embody innovations developed by different companies from various industries, causing rights fragmentation and demanding cooperative mechanisms to regulate relationships between competitors. Development of these technologies is incremental, with different competitors appropriating each innovative step. Rights fragmentation creates areas of dense overlapping rights called "patent thickets" (Graevenitz et al., 2011; Harhoff, 2004; Teece, 2018). Patent thickets are resolved through litigation or cooperative arrangements such as cross-licensing, patent pools, or standards (Merges, 1999; Shapiro, 2001; Lerner & Tirole, 2002; Vakili, 2016).

Numerous studies have examined the structure and extent of strategic patenting, arguing that beyond the original rationale of protecting technological knowledge, companies use patenting for various strategic motivations. Most studies fall into two non-mutually exclusive categories: inward-oriented capacity building or outward-oriented, proactive, performative market building. A patent offers dual value for companies:

- It protects valuable technology and establishes a company as a technology leader (Fontana et al., 2009; de Rassenfosse, 2013; Somaya, 2003; Appio et al., 2021).
- It has strategic value, ensuring freedom to operate and access to markets and technology (Grimpe & Hussinger, 2008; Guellec et al., 2012; Kang & Motohashi, 2021).

The inward-capacity-building approach represents a classical patenting perspective. The firm develops local knowledge and patents it to safely embed technology in products. Patents function as resources for product development, with value largely idiosyncratic and firm-specific. They cannot serve as security but merely as technological components valorized primarily locally.

Conversely, the outward market-building approach follows a more comprehensive and proactive view of patenting. Patents transcend being merely technological components of a firm's products to become integral competitive tools for blocking or allying with coopetitors or generating revenue streams. They are no longer idiosyncratic but may hold currency value in transactions or serve as securities (UK Patent Office, 2013; EPO, 2021).

2.3. The triadic approach and coopetition

Patent blocking citations provide insight into competitive battles between companies at both technological and strategic levels in industries where technological advancement occurs incrementally and is protected through patents. Blocking citations are documents that fully or partially challenge the novelty and/or inventiveness of a patent application, creating a network of blocking relations between companies.

In a blocking relations network, each company strives to improve its network position—blocking competitors from key areas and attempting to reciprocate if blocked to limit competitor influence and growth (Guellec et al., 2012; Kang, 2020). Simultaneously, in the ICT sector, companies are guided by bargaining motives when applying for patents (Blind et al., 2006; Kang & Motohashi, 2021). They seek to block companies that block them to negotiate technology access through cross-licensing agreements. Another cooperative mechanism is the sponsorship of standards and formation of technology alliances, which may generate "unintentional" blocking relations stemming from technology's inherent complexity.

Companies seek to establish blocking positions guided by competitive motives but reciprocate based on mixed competitive and cooperative motives. Importantly, reciprocation needn't occur using the same technology. A reciprocated relationship (mutual blocking) reduces competitive pressure and allows companies to benefit from each other's resources, creating a tradeoff between establishing asymmetric positions and accessing external resources. Following Gnyawali et al. (2001), a company with high centrality in an alliance network engages in high-volume competitive actions, whereas structural autonomy relates to diverse competitive actions.

While decisions firms must make are relatively well studied in dyadic interactions, the picture becomes more complex with triadic relations. Triads have been examined in coopetition literature in alliance networks between competitors (Madhavan et al., 2004), attempting to identify factors influencing triad formation (transitivity) in non-directed networks as coopetition factors. Another research stream analyzes supply chain networks (Wu et al., 2010; Dubois & Fredriksson, 2008; Peng et al., 2010; Wilhelm, 2011).

Madhavan et al. (2004) proposed that transitivity in non-directed alliance networks results from closing structural holes caused by interplay between countering and clustering motives. Under the countering (competition) motive, companies establish connections to counter a third company's superior network position to which both are connected. Under the clustering (cooperation) motive, relationships form to share and combine resources. This simultaneous interplay defines coopetition in an industry.

In directed blocking relations networks, the equivalent of Madhavan's tie in a triad is the formation of a reciprocal relation. Following literature on coopetition and strategic patenting, we posit that in a directed network of blocking relations:

- Reciprocated relations represent coopetition.
- A company's high centrality relates to improved access to external resources and performance.
- Effects of coopetition on technology convergence (and vice versa) can be explored by differentiating interaction patterns between companies from different industries.

A reciprocated relation in a triad can emerge through countering and clustering motives for closing structural holes. We consider this the process of competition creating coopetition—emergence of a triad through formation of a bi-directional tie between A and B when both have relations with a third company C. Conversely, a coopetitive relationship can lead to triad formation. We consider this the process of coopetition creating competition—emergence of a triad when a bi-directional tie between A and B "attracts" some relation with a third

company C. By "some relation," we mean competitive relation by default but allow for coopetitive relation among two actors. When a fully transitive triad results (three actors with reciprocated relations), formation matches that in non-directed networks, representing coopetition creating coopetition.

Numerous transition patterns exist between dyads and triads and between various triad configurations. Based on theoretical understanding of coopetition, we conceptualize scenarios to test.

2.3.1 Competition creating coopetition

Scenario 1a: Starting position triad 4-021D C blocks A and B (C→ A and C→ B). A and B are competitors arriving in a technology after C. They could balance their positions by:

- Each individually reciprocating C (C↔A and C↔B) or
- Cooperating to limit C's advantageous position.

This cooperation could develop a (different) technology conferring superior competitive advantage over C. When C attempts to enter that technology, it would be blocked (C↔A and C↔B, triad 11-201). A and B appropriate gains from coopetition.

Alternatively, if A and B lack capacity for such a powerful alliance, they might share resources to improve their network position against C. This improvement could occur through cross-licensing agreements (C→A, C→B and A↔B—triad 12-120D). A and B establish a mutually blocking relation, allowing access to each other's technology and reducing C's pressure.

Scenario 2a: Starting position triad 5-021U C is blocked by A and B (A→C and B→C), meaning C attempts entry into technology already developed (separately) by A and B:

- C can reverse the pattern (reciprocate one or both relations) only with superior advantage
- Triad closure is A and B's choice and depends on competition between them (triad 13-120U)
- C could catalyze triad closure under technology convergence conditions

Scenario 3a: Starting position triad 6-012C A blocks C, which blocks B (A→C and C→B). C occupies a bridge position:

- C and B can individually attempt to reverse the pattern
- A and B establish mutual relations if C appropriates all mediation gains

Scenario 4a: Starting position triad 7-111D or 8-111U A and B have a reciprocated tie, and only B has a competitive relation with C:

- C and B can individually attempt to reverse the pattern
- Establishing a coopetitive relation between A and C benefits A and deteriorates B's position

Scenario 5a: Starting position triad 9-030T or 10-030C A special case of competitive triads where any actor (A, B, or C) has different incentives to reciprocate ties that would allow access to another company's technology.

2.3.2 Coopetition creating competition

Starting position is always a mutual blocking relation between A and B

Scenario 1b: Starting position triad 3-102 Coopetitive efforts between A and B lead to encroaching on C's technology, resulting in (one or both) being asymmetrically blocked by C. C enjoys lasting competitive advantage. Whether C is a direct competitor or outside the core industry is noteworthy. In the latter case, coopetitive efforts between A and B drive technology convergence.

Scenario 2b: Starting position triad 3-102 Coopetitive efforts between A and B "attract" C, which is blocked from entry. The "attraction" could result from A and B developing lucrative technology. C lacks competitive advantage to reverse the pattern.

Scenario 3b: Starting position triad 3-102 Coopetitive efforts between A and B are mediated by C, which acts as a bridge.

Scenario 4b: Starting position triad 3-102 "The friends of my friends are not my friends." Coopetitive efforts between A and B lead to coopetition between B and C, but not between A and C. B accesses both A and C's technologies, occupying a superior position.

2.3.3 Coopetition creating coopetition

Scenario 1c: Starting position triad 11-201 A has coopetitive relation with C, C has coopetitive relation with B. Coopetitive relation between A and B will form following countering or clustering motives.

Scenario 2c: Starting position triad 3-102 Coopetitive efforts between A and B lead to establishing coopetitive relations with C either separately or together. Possible homophily effect or spreading of coopetition from giant firms to smaller ecosystem actors (Gnyawali et al., 2011; Cozzolino et al., 2021).

Testing validity and transition paths of all possible scenarios requires considerable research effort for future exploration. In the current study, we apply simple statistical methods to enumerate existing triads in a network to illustrate triad pattern significance in the smartphone domain.

3. Method

We construct a blocking relations network based on cumulative blocking citations (X and Y references) received by firm portfolios of patent families (Graevenitz et al., 2011). X and Y references are documents cited by European Patent Office (EPO) patent examiners that fully or partially challenge novelty and/or inventive step of patent applications. Patents can be granted with X and Y references, but from a strategic perspective, they can be opposed (Harhoff & Reitzig, 2004), rendering technological space protection weak. If applicants redesign claims to limit impact, they are effectively blocked from desired space. Main interaction patterns between companies can be derived using the triad significance profile (TSP). A triad represents connection patterns between three actors. While dyadic connections provide insights into network density and reciprocity in social settings, triads are considered the "DNA" of networks—the smallest non-trivial building blocks containing information about the entire network (Wasserman & Faust, 1994; Heider, 1958; Festinger, 1957).

Various natural networks, including gene regulation networks, protein signaling networks, electronic circuits, the World Wide Web, word adjacency in language groups (Milo, 2002), and agricultural product trade (Shutters & Muneepeerakul, 2013), exhibit significant over- and under-representation of certain connection patterns, forming a distinctive TSP.

A network's TSP compares triad frequency in the original network to frequency in randomized networks (at least 1,000) with similar characteristics—the same number of nodes and incoming, outgoing, and mutual connections. Network motifs constituting the TSP are those appearing in the original network more frequently than in

randomized networks with higher probability.

Statistical significance is measured by Z-score, indicating how many standard deviations a score falls above or below the sample mean:

$Z = (N_{real} - \langle N_{rand} \rangle)/\sigma_{rand}$

Where $\langle N_{rand} \rangle$ and σ_{rand} represent mean and standard deviation of the pattern across randomized networks. The z-score vector is normalized to length 1 to emphasize relevant pattern significance and enable comparison with other networks.

Over-representation of certain patterns in transcription networks suggested that "network motifs" contain information about network functional properties and their evolution (Milo, 2002). Moreover, networks that evolved for similar functions share common architectures grouped into superfamilies.

The TSP of blocking relationships in patenting activity has been presented in studies on patent thickets and their effects on SME patenting incentives (UK Patent Office, 2013; EPO, 2021). For telecommunications, severely affected by patent thickets, a persistent TSP shares features with World Wide Web and social interactions networks, except for distinct under-representation of motif 12 (triad 15-210). The same triad is distinctly underrepresented across complex technologies, suggesting strategic patenting activity.

Recently, researchers have questioned the connection between network patterns and functions (Ingram et al., 2006; Knabe et al., 2008). Pattern functions can vary by context and connections to other patterns (Taylor & Restrepo, 2011). Following these critiques, we don't assign particular functions to specific patterns but treat TSP results as representing main interaction patterns between companies and momentary "snapshots" of industry coopetition dynamics.

We run TSP against a network of blocking citations between companies in the smartphone domain from January 1, 2000, to April 1, 2014. We use an "expert-enhanced" Thomson Innovation DWPI patent index (TI DWPI) and search by keywords, DWPI classification classes, and smartphone-related "Use" fields. The "Use" field contains expert evaluations of possible end product ranges for technologies.

This approach extracts a comprehensive sample of research efforts by companies from telecommunications, computing, semiconductors, consumer electronics, and other sectors that form technology ecosystems through supply chain agreements and technology/market alliances to deliver complex technologies embodied in products and complements. We collect X and Y references at DWPI family level and construct a blocking relations network between companies. Company A blocks Company B if at least one A patent is cited as blocking citation (X or Y) for a B application, creating a directed network of blocking relations.

The network reflects:

- Dyadic, triadic, and multiple coopetition
- Horizontal and vertical coopetition in supply chains (Gnyawali et al., 2008; Padula & Dagnino, 2007; Hoffmann et al., 2018)

Since companies can receive blocking citations from various fields, we believe the method captures technology convergence boundaries.

4. Results

Our patent sample contains 33,644 patent families (over 170,000 individual patents) held by 3,039 companies. The 70,228 blocking citations against them represent 10% of all family citations and come from 8,009 companies. Over 80% (2,561) of companies in the original sample have been affected during the sample period.

We filtered the network based on these criteria:

- Companies have at least 10 patents in the sample
- Companies have been blocked by at least 10 patents from another company
- Companies have blocked another company with at least 10 patents

The resulting dataset includes 704 companies, mostly from the original sample (547), covering most patent families (30,600), connected by 19% of connections from the original sample. We classified firms into 7 groups following Bloomberg industry classification.

Table 1. Network statistics

	Logit Estimate	P-value	As Percentage
Density	-4.25521	<1e-04 ***	1.40%
Reciprocity	3.35079	<1e-04 ***	96.61%

	Density effect	P-value	Reciprocity effect	P-value
Intercept	-3.9865166	<1e-04 ***	-4.0478526 (edges)	<1e-04 ***
Computer	1.9790486	<1e-04 ***	5.5838083	0.48178
Semiconductors	1.8511675	<1e-04 ***	4.3004298	0.00204 **
Telecom	1.2943779	<1e-04 ***	4.5137654	< 1e-04 ***
Internet	0.6077921	0.143	3.8226362	0.77203
Other electronics	0.3019301	<1e-04 ***	3.5541303	< 1e-04 ***
Software	0.1568876	0.305	2.5510425	0.16952
Other	-1.2707249	<1e-04 ***	-0.1881789	0.73759

Basic logistic regression statistics using the stanet package in R show that while density may not be high, reciprocity is. Companies within the same industry tend to interact more, except for the "Other" category. The computer industry leads in establishing and reciprocating within-boundary relations. Market leaders like Ericsson, Apple, Microsoft, and Nokia show the highest centrality scores.

The TSP was run using FANMOD software (Wernicke, 2006). Results are presented for both the full original sample and the reduced sample. The profile remains relatively stable despite filtering, indicating pattern significance.

Comparing results with existing superfamilies, the smartphone TSP shares features with World Wide Web and Social relations families, except for under-representation of pattern 9-030T and over-representation of 5-021U.

Results align with the telecommunications triad profile (1997-99 and 2003-2005) from the UK Patent Office, except for severe under-representation of pattern 7-111D and patterns 12-200 and 13-120U not "outperforming" 5-021U as in that study. Pattern 15-210, noted as possible evidence of strategic patenting

activity, is underrepresented but almost non-significant compared to other motifs.

Over-represented triads (5-021U, 6-021C, 12-200, 13-120U, and 16-300) suggest the existence of ranked company clusters interacting with each other. Triads 12-200 and 13-120U appear as stable network patterns.

Under-represented triads (4-021D, 7-111D, 11-201, and 14-120C) show significant non-random lack of these interactions.

Basic network statistics show low density and high reciprocity. This pattern is expected since firms have incentives for strategic positioning within technological areas rather than blocking everyone in the smartphone domain (pursuing maximum out-degree). Companies tend to connect and reciprocate within industries except for "Other" (automotive, chemical, energy companies, government agencies, universities). Core smartphone companies appear to encroach on their technologies and/or markets. The computer industry, which introduced smartphones to market, shows highest interconnectedness, explained by prevalent strategic patenting activity.

The TSP method doesn't differentiate between scenarios or transition patterns, so results require cautious interpretation. However, understanding the smartphone TSP through our conceptual lens offers valuable insights.

Under-representation of triads 4-021D, 7-111D, and 11-201, coupled with random presentation of 8-111U, suggests "Competition creating coopetition" scenarios may no longer drive the smartphone domain, except for scenario 2a. This could indicate that while these scenarios previously drove dynamics, the industry now focuses on managing coopetition. Under-represented triads suggest firms avoid lone tie reversal and seek larger alliances, possibly due to technology development uncertainty, appropriation risks, and substantial R&D sunk costs.

Over-representation of triads 12-120D, 13-120U, and 16-300 indicates prevalence of coopetition strategies in telecommunications, functioning both as subordinating mechanisms (13-120U) and power reactors (12-120D) for technology development and convergence. We find evidence that coopetitive efforts spread across industries, supporting "coopetition creating coopetition" scenarios.

While our methods and results cannot exhaustively capture the complexity of smartphone coopetition scenarios, interacting factors, and outcomes, they illustrate the rich complexity embodied in blocking relations networks that can support future statistical hypothesis testing. More sophisticated modeling can explore assumptions, factor influences, and interplays to advance coopetition knowledge.

5. Discussion

As our results show, the trajectory from competition to coopetition is underrepresented in our sample, as coopetition has clearly become the norm. This is unsurprising since elements identified as coopetition drivers—rising importance of standards, technological complexity, platform dominance—have intensified in recent years. For Gueguen (2009) and more recently Cennamo and Santaló (2019), companies now share common strategic destinies within ecosystems.

Patent wars in technological ecosystems demand new analytical frameworks for strategic analysis, as narrowly defined industry boundaries prove inadequate. Since Porter's (1979) seminal work, industry has been the focused unit for strategic analysis. Well-defined industries provided keys to discovering success factors and adapting market strategies. The emergence of resource-based (Wernerfelt, 1984) and knowledge-based (Grant, 1996) firm views didn't alter this perspective. However, technological ecosystems require transversal industry views that include technology holders as key players.

In converging technologies, these technology holders cannot be viewed merely as suppliers or "complementors." Their patent power can paralyze technological development or jeopardize industry rents (Holman, 2006; Teece, 2018).

Within telecommunications ecosystems, we observe a hypercompetition variant. D'Aveni (1994) proposed we have entered an era of rapid, unstable competition with unsustainable advantages. This evolution aligns with the need for dynamic capabilities, defined by Teece et al. (1997) as abilities to integrate, build, and reconfigure internal and external competences for rapidly changing environments. Unlike internet intrusion across industries, technological ecosystem emergence profoundly changes competitive rules. While internet technology itself wasn't a game changer (Porter, 2001), it accelerated convergence.

Telecommunications represents a dynamic field with applications across sectors including transport, agriculture, health, and others. This situation demands relevant analytical frameworks and sets the stage for innovative coopetitive strategies.

6. Conclusion

This paper presents a conceptual framework for understanding coopetition dynamics within technological ecosystems. Based on the premise that coopetitive dynamics in complex technologies can be studied by analyzing blocking relations networks between firms' patent portfolios, our analysis of over 170,000 patents demonstrates the new complexity of technological ecosystems where coopetition has become the norm.

Our method shows that defining industries for analysis amid converging technologies presents challenges, and a technological ecosystem approach offers more comprehensive insights.

While the method's validity should be tested in other industries, it could be improved in various ways. Our current study doesn't address the assumption that companies can enter blocking relationships over the same or different technological areas, best addressed through bipartite network analysis. Different companies play various ecosystem roles, and running TSP discriminating between these roles could provide valuable insights.

Deeper analysis of coopetitive strategies within groups between both complementors and competitors is needed, as is study of position performance impacts within ecosystems and groups. Dividing the sample into time intervals could help detect major competitive positioning shifts, and the method could be applied to more narrowly defined areas. While these improvements add analytical dimensions, they increase complexity.

Future research should examine transition paths between different triad configurations and their relationships to technology convergence and firm performance. Additionally, researchers could explore how digital platforms affect traditional industry boundaries and coopetition dynamics, particularly in the context of increasing digital transformation across sectors (Cozzolino et al., 2021; Teece, 2018).

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