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Fuss or gain more benefits? The cross-level impact of platform on a complementor's performance

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Abstract

To adapt to digitalization challenges and growth, many complementors are joining multi-sided platforms (hereafter, referred to as platforms) that form an ecosystem to co-create and appropriate value. Do complementors gain benefits from joining platforms? Theoretical arguments and empirical results remain mixed. As a nested concern, this study proposes a cross-level framework to illustrate how the performance of complementors is influenced by their capabilities and platform competitive advantages simultaneously. To run hierarchical linear modeling (HLM), each platform was paired with at least four complementors that formed platform-level data. Empirical data from 33 platforms and 154 of their complementors indicated that the higher potential in value co-creation of a platform is, the stronger the competitiveness of the platform. The capabilities of the complementors had a positive impact on their performance. The competitiveness of a platform had a positive direct cross-level impact on the performance of complementors. However, platform competitiveness demonstrated a negative cross-level moderating effect on the positive relationship between capabilities and the performance of a complementor.

Keywords: Platform, complementor, value co-creation, value appropriation, hierarchical linear modeling.

1. Introduction

Digital technologies create a new organizational form that is referred to as a multi-sided platform (hereafter referred to as a platform), such as Uber, Amazon, and Alibaba, that redefines the model and dynamics of value creation and value appropriation in which the ways of goods and services distribution are changed (Adner, 2017; Cutolo, Hargadon, & Kenny, 2021; Li, Chen, Yi, Mao, & Liao, 2019). The platform describes the business model that connects multi-sided markets and facilitates economic exchange between two or more groups through networking and has become an important issue in economics, information science, strategic management, supply chain management, and marketing (Amit & Han, 2017; Laamanen, Pfeffer, Rong, & Van de Ven, 2018; Reischauer & Mair, 2018; Täuscher & Laudien, 2018; Thomas, Autio, & Gann, 2014; Zhao, von Delft, Morgan-Thomas, & Buck, 2020). By mediating a multi-sided market, a platform can introduce new transaction mechanisms more quickly and at a lower cost that enhance the efficiency and effectiveness of business transactions (Zhao et al., 2020). Platforms provide a large base of potential customers with mechanisms for easy searching and interaction that leads to joining platforms and is viewed as necessary for growth and survival. Complementors may gain benefits through direct and indirect network effects that are provided by a successful platform (Adner, 2017; Lan, Liu, & Dong, 2019). However, the growing power of platforms may create a dangerous situation for their complementors by leveraging the power to pursue their self-interest (Cutolo, Hargadon, & Kenny, 2021). Many complementors contribute their resources to platforms without a return on value (Boudreau & Jeppesen, 2015). The beneficial effects of platform embeddedness have been questioned. Does the complementor appropriate more value from the platform embedded relationship? Although many studies have explored the business models of platforms that provide many innovative insights, whether embedded in a platform can enhance the performance of complementor remains a debated and unanswered question.

After a systematic and careful literature review, this study highlights the following research gaps regarding the impact of platforms on the performance of complementors. First, a platform's success depends on the engagements in value co-creation of all complementors (Lan et al., 2019; Saadatmand, Lindgren, & Schultze, 2019). The platform itself does not create value; it needs to rely on complementors and customers to co-create value. For example, Uber does not own vehicles, and relies on drivers to offer cars and driving services (Zeng Khan, & De Silva, 2019). Most prior studies focus on the role of value co-creation (Kyprianou, 2018; Reischauer & Mair, 2018; Sebastian & Weill, 2020; Täuscher & Laudien, 2018) and/or the role of platforms (Rong, Lin, Burström, Butel, & Yu, 2018; Zhao et al., 2020) but fall short of explaining how a complementor captures value (Zhu & Liu, 2018) and how a platform affects a complementor's performance (Matinheikki, Pesonen, Artto, & Peltokorpi, 2017). Sebastian and Woerner (2020) suggest that a successful platform would need to develop a mutually beneficial relationship with its complementors by sharing benefits and information. However, to compete with other platforms, a platform needs to attract and enlarge its installed base quickly, to lock into these large numbers of users, and to reduce the likelihood of competing imitating platforms (Cennamo & Santalo, 2013). By linking multi-sided markets, platforms can charge one or more side markets to lower (subsidize) the price of the other side market to boost transaction volumes (Belleflamme & Pietz, 2019; Dushnitsky, Piva, & Rossi-Lamastra, 2022; Thomas et al., 2014). Therefore, platforms can set a lower price to penetrate the market. Complementors usually play the role of being charged. For example, Airbnb emphasizes the low price of their products (Zervas, Proserpio, & Byers, 2017) to enhance customer-based growth and then uses this customer base to make profits by charging other markets. RealNetworks, the dominant media streamer, offers media players for free to end-users but charges content providers (McIntyre & Srinivasan, 2017). The benefits of complementors are often sacrificed.

Second, platforms can capture more value by leveraging the power of network positions, which results in value distribution asymmetry (Rietveld & Schilling, 2021). Platforms earn profits by charging subscription fees, transaction fees, and other fees on each transaction (Dushnitsky et al., 2022; Parente, Geleilate, & Rong, 2018). A complementor needs to pay annual access and other charges in exchange for transactional opportunities that erode its profit. The platform can allocate different fees to different sides of the multi-sided market. The more price-sensitive side of the multi-sided market should be charged lower fees to attract participants (Dushnitsky et al., 2022). For its own interest, a platform can recover its loss by allocating fees to these “other-side” participants. A platform establishes many rules that may harm the performance of complementors. For example, Uber allocates subscription fees only to drivers. eBay charges only sellers. A complementor can be pushed out of the market for the platform to enter into its product space (Zhu & Liu, 2018). A platform may also limit the selling price leading a complementor to lose strategic pricing flexibility (Cutolo et al., 2021). Platforms own and control customer relationships and prevent off-platform contact; hence, complementors may suffer from building and maintaining long-term customer relations and deepening concerns about being blocked without warning (Cutolo et al., 2021). Complementors play the roles of value co-creator and beneficiaries simultaneously (Ekman, Raggio, & Thompson, 2016). However, value tension, in which platforms and complementors need to collaborate to co-create value and simultaneously compete in value appropriation with each other (Chou & Zolkiewski, 2018; Raza-Ullah, Bengtsson, & Kock, 2014), may reduce the benefits that complementors can gain from joining a platform. Thus, platforms can have a positive and/or negative impact on the performance of complementors.

Finally, a platform is a nested whole that consists of nodes and links with vertical and horizontal relationships (Aarikka-Stenroos & Ritala, 2017) and constitutes multi-level heterogeneous relationships among artifacts, persons, processes, and interfaces (Ramaswamy

& Ozcan, 2018). The focus of platform research can be individual firms, dyadic relationships, supply chain relationships, and platform ecosystems (Jacobides, Cennamo, & Gawer, 2018; Möller & Halinen, 2017; Rong et al., 2018), with multiple levels of interaction—micro, meso, macro, and mega (Ekman et al., 2016; Frow, McColl-Kennedy, & Payne, 2016). Interactions among actors may occur simultaneously at different levels; therefore, value tension can occur at multiple levels, such as individual customers, complementors, and platforms, which can go beyond dyadic relationships and extend to the broader context of the whole platform ecosystem. Although a complementor can join more than one platform with multi-homing strategies (Cutolo et al., 2021), this study recognizes the multi-level and nested nature of the relationships among complementors' capabilities, platforms' competitive advantages, and complementors' performance. Research in organizational contexts with a single-level framework may overlook macro and nested bias (Foss, 2009) and the impact of a platform on complementors. To address the nested concerns, a cross-level framework is needed that grasps the impact of a platform on a complementor's performance.

Although embeddedness can be an antecedent for value co-creation (Laud & Karpen, 2017), many complementors contribute their resources to a platform without capturing appropriate value in return (Boudreau & Jeppesen, 2015). Does the embeddedness relationship provide benefits to complementors? Our framework contributes to platform research by using hierarchical linear modeling (HLM) to clarify the cross-level positive and negative effects of a platform competitive advantages on complementors' performance. The following study examines and reviews important literature to establish the conceptual framework and research hypotheses. In the methodology section, we describe the sample and data collection and the measures used. We report the empirical results and present the conclusions, followed by the research limitations and future research directions.

2. Literature review and hypothesis development

2.1 Value co-creation and value appropriation tension in a multi-sided platform

A multi-sided platform is a hub for value exchanges that connects two or more markets of users and producers and mediates their transaction through interactions (Cennamo & Santalo, 2013; Jacobides et al., 2018; Lan et al., 2019; Täuscher & Laudien, 2018; Zhao et al., 2020). Value proposition defines the configuration of activities in a platform (Adner, 2017). A platform reflects a business logic in which multilateral actors need to interact to realize value propositions by increasing connectivity and interdependence. Platforms are organized around a set of value propositions (Li et al., 2019), in which value is interdependent and co-created by all actors that underlie the theoretical foundation of platform ecosystems (Adner, 2017). Value co-creation describes the process of resource sharing and integrating among multiple actors through joint problem-definition, joint problem-solving, and complex interaction to achieve benefits for all actors (Chowdhury, Gruber, & Zolkiewski, 2016; Frow, McColl-Kennedy, & Payne, 2016; Grönroos & Voima, 2013; Laud & Karpen, 2017; Marcos-Cuevas, Nätti, Palo, & Baumann, 2016; Pinho, Beirão, & Patrício, 2014; Santos, 2021). Complementors and other actors in a platform form an ecosystem where they interact with each other to find opportunities to co-create value and co-evolve toward the direction that is set by the platform (Lombardo & Cabiddu, 2017; McIntyre & Srinivasan, 2017; Rong et al., 2018). The benefits of one side on a platform are determined by the size of the other side, that is, the effect of the indirect network (McIntyre & Srinivasan, 2017; Nambisan, Zahra, & Luo, 2019; Parente et al., 2018).

Tension illustrates a simultaneous action with paradoxical but interdependent elements that potentially generate stress, discomfort, conflict, threat, and risk (Cunha & Putnam, 2019; Panayiotou, Putnam, & Kassinis, 2019; Raza-Ullah, 2020). The contradictory yet mutually dependent elements form the core of the tension (Schad, Lewis, Raisch, & Smith, 2016), which can manifest in the forms of behavioral tension (competition vs. cooperation), structural tension

(flexibility vs. rigidity), psychological tension (long-term vs. short-term orientation), and value tension (creation vs. appropriation) (Fang, Chang, & Peng, 2011; Obloj & Zemsky, 2015; Tóth, Peters, Pressey, & Johnston, 2018; Zhang & Du, 2018). Value tension describes value coopetition in which actors collaborate in value co-creation but compete in value appropriation simultaneously, regardless of whether their relationship is horizontal or vertical (Chou & Zolkiewski, 2018; Xu & Hao, 2021). Value appropriation refers to the percentage of rent that an actor can reap from transactions with its skills, which is also the actor's share of the value created (Chou & Zolkiewski, 2018). In a platform mediating multi-sided markets, embeddedness facilitates value co-creation, but the platform and complementors compete with each other for value appropriation (Cutolo et al., 2021; Zhu & Liu, 2018). The platform is the most prominent growth strategy that emphasizes the role of value co-creation through the engagement and interaction of all actors in the platform. However, mutual benefits from value co-creation for all actors is unlikely, as the various actors interact in many different ways that increase the opportunities of suboptimal outcomes for one or more of the actors (Chowdhury et al., 2016). Tensions that stem from value co-creation and value appropriation in a platform ecosystem are cross-organizational boundaries that can simultaneously have positive and negative impacts on the performance of complementors (Jarzabkowski, Bednarek, Chalkias, & Cacciatori, 2019; Obloj & Zemsky, 2015; Wang & Miller, 2020; Zhang & Du, 2018). The interplay between cooperation in joint value creation and competition in value capturing has remained under-researched (Hoffmann, Lavie, Reuer, & Shipilove, 2018).

2.2 Value co-creation potential and platform competitive advantages

A platform represents a hub and/or a center that connects and controls the multi-sided markets that facilitate each other's transactions (Zhao et al., 2020). A platform plays the role of attracting complementors to join, matching buyers and sellers, facilitating the exchange of value through establishing platform architectures, reducing information asymmetry, and setting

the rules and standards of the game. Value co-creation is the dominant logic for platform business. A platform engenders a synergetic effect in which all actors are involved in the process of resource integration to co-create value through interaction (Kleinaltenkamp, Karpen, Plewa, Jaakkola, & Conduit, 2019; Lombardo & Cabiddu, 2017; Marcos-Cuevas et al., 2016; Ramaswamy & Ozcan, 2018). By increasing efficiency in value exchange, a platform functions as an interface that facilitates value co-creation with customers and complementors (Cennamo & Santalo, 2013; Lombardo & Cabiddu, 2017; Marcos-Cuevas et al., 2016; Thomas et al., 2014).

Platforms are external resource bundles that derive advantages from network externalities or the so-called network effects (Li et al., 2019). Platform competition emphasizes the role of network effects (Rong et al., 2018). A network effect determines the competitive position of the platform (Nambisan et al., 2019; Parente et al., 2018; Zhao et al., 2020). In the age of a platform-based market, information is available whereby suppliers can link with customers directly (Rong et al., 2018). If a platform plays the role of an information asymmetry eliminator that reduces market failure, the competitive advantage of such a platform can be easily imitated (Zeng et al., 2019). The success of a platform depends on the ability to integrate resources to co-create value that attracts customers and complementors to join the platform and drive more interaction (Bruce, Wilson, Macdonald, & Clarke, 2019; Zhu & Liu, 2018). The competitive advantages of a platform come from multilateral complementarities, mutual dependence, and collective actions that result in joint value creation (Adner, 2017; Jacobides et al., 2018; Shipilov & Gawer, 2020). Thus, the potential of value co-creation should be one of the key determinants of platform competitive advantages that drive a strong network effect (McIntyre & Srinivasan, 2017). The competition between rival platform ecosystems is the competition of value proposition and joint value creation (Adner, 2017). Actors connect to one another through a chain of transactions that ultimately results in an economy of scale and the production of

value (Gans & Ryall, 2017). Network externality is thus driven by the resources of network members (Zeng et al., 2019). Therefore, a strong network externality or network effect is the key to the competitive advantage of platforms (Cennamo & Santalo, 2013; Chen, Shaheer, Yi, & Li, 2019; Li et al., 2019; McIntyre & Srinivasan, 2017; Ozalp, Cennamo, & Gawer, 2018), especially the indirect network effect (Zhu & Iansiti, 2012). There is a higher likelihood of realizing a network effect when the potential of value co-creation of a platform is elevated. Thus, we expect that network externality depends on the potential for value co-creation on the platform. The greater the potential for value co-creation on the platform, the greater the realization of network effect in terms of strengthening the competitive advantage of the platform.

H₁: The potential of value co-creation has a positive impact on the competitive advantages of the platform.

2.3 The relationship between the capabilities and performance of the complementors.

The resource-based perspective suggests that heterogeneous resource endowments controlled by a firm are the source of competitive advantage and performance differences (Amit & Han, 2017; Barney, 1991; Davis & DeWitt, 2021; Jacobides et al., 2018). Service is the application of competences (Vargo, Maglio, & Akaka, 2008). Value co-creation within a platform ecosystem emphasizes the value that is co-created jointly and reciprocally in interactions among providers and beneficiaries through the integration of resources and the application of competence (Vargo et al., 2008). However, complementors own and control complementary assets and resources that the platform needs to integrate for value co-creation. Based on its resources and capabilities, a complementor delivers its goods and services that result in performance output.

However, digitalization reshapes how business opportunities are found and exploited, extending the scope of resource use (Amit & Han, 2017). In a digitally enabled world, the

function of platforms is to bridge the needs and resources of value co-creators. The performance of a complementor is the outcome of its unique competency. Thus, the more capable an actor is, the higher the performance that can be enjoyed by the actor. This study proposes the following hypothesis.

H₂: The capability of the complementor has a positive impact on its performance.

2.4 The cross-level effect of platform competitive advantage on complementor performance.

Connections among actors and embeddedness are essential for value co-creation (Huang, Kang, & Chiang, 2020; Laud & Karpen, 2017) and for enabling actors to benefit from platforms. A platform is looking for a network effect to attract massive web traffic to enhance commerce and information creation and distribution (Kelley & Thams, 2021). Platform-level competitive advantages are important because they orchestrate the collective actions of all participants and result in cross-level direct and moderating effects that may influence the value co-creation and appropriation of complementors.

2.4.1 The cross-level direct impact of platform competitive advantages on complementor performance.

Competition is no longer a competition between rivaling firms but between platform ecosystems with the characteristic of winner-take-all (Cennamo & Santalo, 2013; Lan et al., 2019; McIntyre & Srinivasan, 2017; Rong et al., 2018; Täuscher & Laudien, 2018). Strong indirect network externality is one of the major characteristics of multi-sided platforms that demonstrates collective power (Nambisan et al., 2019), leads the effect of winner-takes-all and sustains the platform business (Zhao et al., 2020). The competitive advantages of a platform ecosystem where a complementor is embedded are valuable, rare, inimitable, and non-substitutable resources that hold potential as a source of competitive advantage (Gibson, Gibson, & Webster, 2021). A high tide floats all boats. Platform-specific advantages can be a resource that enhances the performance of complementors. The collective resources and

capabilities of a platform support the competitive advantage of the platform ecosystem (Das & Teng, 2000). Platforms can bridge and connect collective resources and capabilities that a complementor can reach and access to enhance its performance (Amit & Han, 2017; Huang et al., 2020).

A complementor can benefit from sharing common benefits, that is, synergistic value creation by the whole platform ecosystem to enhance its performance (Arslan, 2018; Khanna, Gulati, & Nohria, 1998). In the platform ecosystem, value is not created *via* exchange but is co-created through interlinked actors and resources (Chowdhury et al., 2016). Each participant in the value co-creation process needs to bring in specific resources (Paswan, D'Souza, & Rajamma 2014) and put in platform-specific investments (Boudreau & Jeppesen, 2015; Zhu & Liu, 2018). An actor participates in the process of value co-creation by providing operand and operant resources (Aarikka-Stenroos & Ritala, 2017; Paswan et al., 2014; Vargo et al., 2008). Then, value is appropriated when it is co-created by the actors in the platform ecosystem as a whole. Value appropriation refers to the percentage of rent that an actor can reap from transactions using its skills, which is also the actor's share of the value created (Chou & Zolkiewski, 2018). An actor can then capture value that it co-creates with others on the platform through revenue, profit, and referrals. A complementor can share more from the created value jointly when its platform is home to more users.

Platforms can serve as advertising, communication, matching, and certificating buyers and suppliers (Jean, Kim, Zhou, & Cavusgil, 2021; Li et al., 2019). A complementor can enjoy benefits from the spillover effect of a competitive platform ecosystem, such as learning, shared reputation value, and goodwill signaling, that overcome information asymmetry and enhance the likelihood of customer reach (Boudreau & Jeppesen, 2015; Cenamor, Parida, & Wincent, 2019; Kelley & Thams, 2021; Wan & Wu, 2017; Zhang & Du, 2018). Therefore, we expect

that the competitive advantages of platform ecosystems can have a positive cross-level direct impact on complementors' performance.

H₃: The competitive advantage of the platform has a positive impact on the performance of the complementors.

2.4.2 The cross-level moderating effect of platform competitive advantages on the capability-performance relationship of the complementor.

Interfirm competition in value capturing may harm the capability-performance linkage. There are two levels of competition in value appropriation: competition between a platform and its complementors and competition among complementors in a platform ecosystem (Teece, 2018). Although value co-creation can enhance the likelihood of value capture, it also gives a platform stronger ability to bargain for a share of that co-created value (Asmussen, Foss, Foss, & Klein, 2021). The value competition within the platform ecosystem may harm the positive capability-performance relationship for the following reasons.

First, value co-creation practices have light and dark sides, and some elements that negatively affect the process of value co-creation, include conflict, dependency, opportunistic behavior, and power (Chowdhury et al., 2016). In an ecosystem, firms need to rely on each other to jointly deliver goods and services that create value for customers (Hannah & Eisenhardt, 2018). The tension faced by platforms and complementors can be the intention that each actor wants to internalize the benefits from network externalities (Teece, 2018; Zhu & Liu, 2018). More capable complementors can compete for bottlenecks and hold the central position, creating entry barriers in the platform ecosystem. There are limited incentives to attract a firm with excellent capabilities to pay a high fee to join the platform. When the product or service of a complementor is successful, to secure the position of centrality, the platform and other complementors may have motivations to launch a similar product so that the product or service of the complementor may be excluded from the platform (Cennamo, 2018; Zhu & Liu, 2018).

The imitation and opportunistic behavior of platforms and other complementors may also frustrate a capable firm in joining platform ecosystems, making platform-specific investments, and co-creating value. When capable complementors do not make platform-specific investments, the total co-created value that can be shared is reduced as well. The positive relationship between capabilities and performance can be reduced when the total co-created value is reduced.

Second, resource dependence is the source of bargaining power that determines whether a complementor converts its capabilities into profits. Platform embeddedness is a business relationship that can be viewed as a strategic response to resource dependence between platforms and complementors (Xu & Hao, 2021). The degree of interdependence forms the basis of power differences and determines value creation and value appropriation (Chou & Zolkiewski, 2018; Dyer, Singh, & Hesterly, 2018). When the resource contributions of complementors strengthen a platform's competitive advantages to outcompete other platform ecosystems and dominate the downstream, the platform thus has considerable bargaining power over its complementors (Wang & Miller, 2020). A platform can leverage its power advantage that helps it share more value than its complementors (Chowdhury et al., 2016; Zhang & Du, 2018).

Third, the network position advantage is another source of bargaining power. The brokerage position provides an opportunity for a platform to access benefits of the structure hole, which increases the bargaining power of the platform. An actor who has a relatively strong position in the platform ecosystem can capture a higher share from the co-created value in the platform ecosystem. Platform hubs are the center of business relationships that dominate centralized activities with bargaining power (Matinheikki et al., 2017). Leveraging the position advantage, platform hubs can have more bargaining power to obtain a greater share of the created value in a platform ecosystem (Ellegaard, Medlin, & Geersbro, 2014; Gans & Ryall,

2017). Therefore, a platform can leverage its position advantage in the platform ecosystem with some isolation mechanisms that reduce the positive relationship between the capabilities and performance of a complementor. As the competitive advantages of a platform increase, the platform hub can have more control and bargaining power. Although complementors may want to maintain a good relationship with the platform, total suppression of conflict has lost its vitality (Obadia & Robson, 2021). Thus, the positive relationship between the capability and performance of complementors can be weakened when the platform is competitive.

Finally, competition operates at two different levels: within and across platform ecosystems (Adner, 2017). Within the platform, ecosystem competition affects the value distribution and capture (Adner, 2017). A platform with high potential in value co-creation will attract more complementors to join the platform ecosystem, which results in strong competitive advantages. However, more complementors will intensify the intra-competition within the platform ecosystem, which increases the likelihood of knowledge and resource spillover and imitation. Although complementors maintain relationships with the platform, they may limit their resource commitment and engagement in value co-creation, which reduces the common benefit of sharing (Arslan, 2017; Wang & Miller, 2020). To avoid disintermediation, a platform will not share customer information with complementors, which will limit the opportunities and actions for complementors to establish and maintain long-term customer relationships. Complementors deliver those products that generate the most revenue for platforms that can be most exposed to value appropriation risks (Wang & Miller, 2020). Thus, the competitive advantages of a platform ecosystem may weaken the positive relationship between the capabilities and performance of complementors.

H4: The competitive advantage of the platform ecosystem lessens the positive relationship between capability and performance of the complementors.

Accordingly, the research framework of this study is shown in Figure 1.

- Insert Figure 1 about here -

3 Method

3.1 Sample and data collection

The unit of analysis of this investigation included the platform level and firm level. A two-stage survey was employed. First, platforms and complementors that provided peer-to-peer (p-to-p) services were contacted by e-mail or telephone to explain the purpose of the survey and to invite marketing and sales managers to participate in this investigation. After a detailed website search, we found 108 platforms in Taiwan that provided shopping, food delivery, ticket booking, and moving services. A total of 33 questionnaires were collected from the platform, which yielded a 30.56% valid response rate. When we received the questionnaire from the platform, second-stage data collection from the complementors was initiated. This investigation sent questionnaires to the complementors whose contact information was derived from the corresponding platform. To fulfill HLM requirements, we stopped the follow-up procedure when four complementors of a platform returned their questionnaires (Mass & Hox, 2004; Liao & Chuang, 2004). After a seven-month follow-up (November 2020 to May 2021), we obtained 165 questionnaires from the complementors. However, for missing data, we deleted 11 questionnaires from the sample that led to 154 valid complementors.

3.2 Measurements

This investigation included two levels of constructs. Firm-level constructs included the capabilities of complementors and the performance of complementors. The potential of value co-creation and the competitive advantages of platforms were two platform ecosystem-level constructs. Indicators for these latent variables were accessed on a seven-point scale, which ranged from 1 (strongly disagree) to 7 (strongly agree).

3.2.1 Performance of the complementor

The measurement of the performance of complementors might need to consider the balance between long-term and short-term (Lavie, Stettner, & Tushman, 2010; Raisch & Birkinshaw, 2008), as well as the operational effects and efficiency of complementors embedded in the platform (Im & Rai, 2008). At the same time, platform embedding is regarded as a cooperative relationship in a multi-sided market. The measurement of the performance of the complementors needs to consider the impact of the inter-organizational relationship. Therefore, the satisfaction of the past three years was adopted in (1) revenue growth rate, (2) profit growth rate, and (3) market reputation (Cenamor et al., 2019; Ge, Huang, & Kankanhalli, 2020). Revenue growth was a relatively long-term dynamic result. Market reputation is the result of short-term and long-term interaction on the platform (Afuah, 2013). The value of Cronbach's alpha of this construct was 0.88.

3.2.2 Capabilities of complementors

Complementors use existing resources, skills, and knowledge to develop products and services (Kyprianou, 2018) that contribute to platforms for value co-creation (Bruce et al., 2019; Vargo et al., 2008). For value co-creation, resources and capabilities also serve as the criteria for platforms to select their complementors (Matinheikki et al., 2017). Following previous studies, the capability of complementors was measured by examining the perception of managers with regard to the ability in (1) on-time delivery, (2) quickly changing the product mix, and (3) quickly processing customer orders. The value of Cronbach's alpha of this construct was 0.79.

3.2.3 The potential of value co-creation of the platform

Value co-creation requires complementors to invest in tangible or intangible resources (Bruce et al., 2019), which emphasizes joint involvement and action in resource integration (Kleinaltenkamp et al., 2019; Matinheikki et al., 2017; Nambisan et al., 2019; Pinho et al., 2014;

Ramaswamy & Ozcan, 2018). A platform ecosystem is the pool of complementary resources and a configuration of resources (Pinho et al., 2014; Reischauer & Mair, 2018). Complementarities, the bundles of complementary products and services that are provided by complementors, are one of the crucial sources that construct the potential value creation of E-business (Amit & Zoot, 2001). The more resources actors invest in collective actions in the platform, the more co-created value that the platform can deliver (Matinheikki et al., 2017). Thus, the potential for platform co-creation of value comes from the sum of individual actors involved in the value co-creation process and the quality of resource integration (Bruce et al., 2019; Kleinaltenkamp et al., 2019). Following the aggregation procedure, this investigation aggregated the capabilities of complementors into a platform-level proxy which is the indicator of the potential for co-creation of value.

3.2.4 Competitive advantages of the platform ecosystem

The network effect is the source of platform competitive advantage. Therefore, the number of installed-base customers and market share are often regarded as proxy variables of platform performance or competitive advantage (Cennamo & Santalo, 2013; Li et al., 2019; Zhu & Iansiti, 2012). Therefore, this study used the number of platform users as the proxy of the competitive advantage of the platform ecosystem. We used log transformation of this variable in the analysis.

3.2.5 Control variable

The maturity of the platform might affect the number of users and the degree of technical stability (Cennamo & Santaló, 2019). A new platform is unlikely to attract a large number of complementors and other actors in a short period, which limits the positive indirect network effect. Thus, at the platform level, this study controls the platform age as the proxy, which measures the months since the establishment of the platform (Cennamo & Santalo, 2013).

3.3 Reliability and validity

The results of confirmatory factor analysis (Table 1) were also used to test the construct validity of our firm-level measurements. The measurement model presented an acceptable overall model fit ($\chi^2=13.46$ ($p=0.097$), $df=8$, $\chi^2/df=1.68$, $GFI=0.97$, $AGFI=0.93$, $RMSEA=0.07$, $CFI=0.99$). We evaluated the internal consistency by the value of composite reliability (CR) and squared multiple correlation (SMC). The CR value of both constructs exceeded 0.70. Except for one SMC value of 0.49, which was slightly lower than 0.50, the SMC value of other items were greater than 0.50. Thus, these results provided evidence of the internal consistency of our constructs (Bagozzi & Yi, 1988). The square root of the average variance extracted were compared with the correlation coefficient in the corresponding columns and rows (Fornell & Larcker, 1981). Table 2 shows the means, standard deviations, and zero-order correlation coefficients of each construct. The square root of each AVE for all constructs (diagonal elements) was greater than the correlation coefficient in the corresponding columns and rows. The results confirm that our measurements of level 1 constructs had adequate discriminant validity.

The potential of platform value co-creation was a platform-level construct, which was aggregated by the evaluations of the platform itself and complementors. We used ICC (1), ICC (2), and r_{wg} to assess the reliability and validity of the construct at the platform ecosystem level. The r_{wg} of the potential value co-creation of the platform was 0.95, which was above the threshold of 0.70. The ICC (1) of this survey was 0.45 (>0.12), and the ICC (2) was 0.80 (>0.70). These results mean that good discriminant validity exists in our measurements at the platform ecosystem level.

- Insert Table 1 and Table 2 about here -

Common method variance (CMV) is considered a serious issue if systematic and pervasive inflation of observed relationships appears (James, Gent, Hater, & Corey, 1979).

Variables based on self-reports from the same source increase the risk of CMV (Podsakoff, Mackenzie, & Podsakoff, 2003). This study collected data from both the platforms and complementors. The correlation between the capabilities and performance of the complementors was not too high ($r=0.23$). Therefore, CMV was not a significant concern in this investigation.

4 Results

We conducted a hierarchical regression analysis to test Hypothesis 2 of this study (Table 3). Model 1, which included platform age as a control variable, showed that the model fit was significant ($F=4.52$, $p<0.05$). Platform age had a negative impact on platform ecosystem competitive advantages ($\beta=-0.40$, $t=-2.13$, $p<0.05$). Model 2 included the potential of value co-creation as an independent variable. Both the model fit ($F=5.95$, $p<0.01$) and ΔR^2 ($\Delta R^2=0.04$, $p<0.01$) were significant. The results showed that the potential for value co-creation had a positive impact on platform ecosystem competitive advantage ($\beta=0.26$, $t=2.68$, $p<0.01$). The largest VIF value of this model was 1.001, which was smaller than three; thus, multicollinearity was insignificant. Therefore, H_1 in this study was supported.

- Insert Table 3 about here -

Complementors were embedded in platform ecosystems that formed nested networks (Möller & Halinen, 2017). The construct of potential value co-creation was formed by the aggregation process. This investigation checked the equivalence of the two platform-level constructs using ANOVA (Table 4). The results showed that two F values of ANOVA models were significant ($F_{\text{potential for value co-creation}}=4.45$, $p<0.001$; $F_{\text{competitive advantages of platform}}=175.18$, $p<0.001$), which indicated that the potential for value co-creation and competitive advantages of these platform ecosystems were different. In addition, we tested the homogeneity of the potential for value co-creation and competitive advantage of the 33 platforms. The F value of ANOVA test was 0.64 ($p=0.06$), which showed that the variance of the potential for co-creating

value and competitive advantage was insignificant. The results indicated that the homogeneity of the potential for co-creating value and the competitive advantage of each platform was not violated. Thus, the HLM procedure could proceed.

- Insert Table 4 about here -

We adopted HLM to test the cross-level effect of our conceptual framework. First, we estimated a null model without predictors, at either level 1 (the individual firm level) or level 2 (the platform ecosystem level), to compute firm performance regarding components within the platform ecosystem and components between the platform ecosystems. Second, the performance of the complementors was regressed on firm capabilities at level 1. During the next step, in the level 2 analysis, we used an intercepts-as-outcomes model to assess the cross-level direct effects of the competitive advantages of the platform ecosystem on a complementor's performance. The slopes-as-outcomes model enabled us to evaluate the cross-level interactive effects of the competitive advantages of the platform ecosystem on the performance of the complementor. The empirical results are reported in Table 5.

Null Model

The null model evaluated the level of significance regarding the variance between platform ecosystems. The chi-square value ($\tau_{00}=0.88$, $\chi^2=156.01$, $df=32$, $p<0.001$) showed significant variance among group components. The ICC (1) was 0.46, which indicated that 46% of the variance of a complementor's performance intention resided between platform ecosystems and that 54% of the variance resided within the platform ecosystem. The ICC (2) was 0.80. The ICC (1) was greater than 0.138, which highlighted that the independent variable had significant variance among platform ecosystems, so further discussion and research are required regarding the other predictive and dependent variables (Cohen, 1998).

Random Coefficient Regression Model

A random coefficient regression was used to assess whether there was a significant variance between groups in their intercepts and slopes. The γ_{10} provided evidence that the relationship between the independent variable (capabilities of complementors) and the dependent variable (performance of complementors) was significant. As shown in Table 6, the random coefficient model indicated that the capabilities of complementors significantly affected the performance of complementors ($\gamma_{10}=0.42$, $p<0.001$). Therefore, these results support Hypothesis 2. According to the results for τ_{00} ($\chi^2=112.75$, $df=27$, $p<0.001$), the variable for complementors capabilities indicated significant variance in its performance. Furthermore, there was sufficient intercept variance for the performance of the complementors, so we were able to use the intercepts-as-outcome model to discuss the direct effect of the platform ecosystem.

Intercepts-as-Outcomes Model

Because there was significant variance across platform ecosystems in level-1 intercepts, we tested cross-level effects. The competitive advantages of the platform had a cross-level direct effect on performance complementors ($\gamma_{01}=0.37$, $p<0.05$), which supported H₃. Because τ_{00} was significant ($\chi^2=79.26$, $df=25$, $p<0.001$), there remained an important variable on level 2 that could be explained by additional variables at the platform ecosystem level (Wech & Heck, 2004). Therefore, we proceeded with a slopes-as-outcomes analysis.

Slopes-as-Outcomes Model

There was significant platform ecosystem variance in the slopes that resided in the random coefficient regression model. The slopes-as-outcomes analysis showed that the competitive advantage of the platform ecosystem ($\gamma_{11}=-0.20$, $p<0.05$) moderated the relationship between the capabilities of a complementor and its performance. The obligatory precondition depended on significant random variance for platform competitive advantages ($\chi^2=80.31$, $df=25$, $p<0.001$)

in the moderation model. The moderators of the competitive advantages of platform ecosystems weakened the positive relationship between the capabilities of complementors and their performance. Thus, the empirical results supported H₄.

- Insert Table 5 about here -

5 Discussion and conclusions

5.1 Theoretical contributions

It is important to link with platform ecosystems that are driven by digital technologies (Amit & Han, 2017; Laamanen et al., 2018; Reischauer & Mair, 2018; Täuscher & Laudien, 2018; Teece, 2018; Thomas et al., 2014; Zhu & Liu, 2018). This study resolves the puzzle regarding the beneficial effects of embeddedness. Platform embeddedness can be a marketing channel collaboration between platforms and complementors. Most prior studies focus on the bright side of value co-creation that emphasizes the role of platform owners and leaders (Lan et al., 2019; Zeng et al., 2019). Although most platforms cannot create value without complementors to contribute complementary resources, skills, knowledge, assets, products, and services, few studies emphasize the simultaneous value co-creation and value appropriation and the role of complementors (Wang & Miller, 2020; Zhu & Liu, 2018). Thus, there are theoretical and empirical puzzles regarding the question: does a complementor appropriate more value from the platform embedded relationship? This investigation confirms that the potential of value co-creation, which aggregates the resources and capabilities of complementors, is the basis of platform competitive advantage. Complementors may gain fewer benefits as returns (Boudreau & Jeppesen, 2015). There is a light-side and dark-side to interorganizational relationship (Elfenbein & Zenger, 2017; Fang et al., 2011; Huang & Chiu, 2018; Obadia & Robson, 2021). Value co-creation activities may include some negative concerns that Chowdhury et al. (2016) refer to as the dark side of value co-creation. Santos (2021) suggests that we need to explore the link between simultaneity and the management of

coopetitive relationships. This study can contribute to the inter-organizational relationship, network, platform, and ecosystem literature by exploring the light-side and dark side of embeddedness concurrently.

There are multiple interactions between the platform and the complementor (Ekman et al., 2016). Thus, competition comes from different levels, which include the competition between platforms, competition between a platform and complementors, and the competition between complementors (Teece, 2018). Although the platform and its complementors are value co-creators in a platform ecosystem, they compete for value appropriation. Therefore, value tension can exist at multiple levels. By highlighting multi-level value tension that stems from the co-existence of value co-creation and value appropriation, this study shows the interplay between platform-level competitive advantages and firm-level performance. In a business ecosystem, platforms and complementors work cooperatively and competitively to satisfy customer needs (Burström et al., 2021). Limited empirical works analyze the impact of platforms on the performance of complementors by considering value tension. The impact of platform embeddedness on the performance of complementors is best understood from the ecosystem perspective. Platform competitive advantages are based on their potential for value co-creation, which is the aggregation of the resources and capabilities of complementors. The capabilities of complementors are the basis of platform competitive advantages and their own performance (Jacobides et al., 2018). Previous work advocates that complementors access multiple markets through the mediating of platforms that form a nested relationship (Laud & Karpen, 2017). Complementors can benefit from network externalities and platform spillover effects (such as learning and reputation signaling) to improve their performance directly (Cenamor et al., 2019; Kelley & Thams, 2021; McIntyre & Srinivasan, 2017; Nambisan et al., 2019; Wan & Wu, 2017; Zhang & Du, 2018). However, platform competitive advantages can weaken the positive relationship between the capabilities and performance of the

complementor. Using a cross-level model, we illustrate how the platform context influences the value co-creation and capture of the complementors. We propose a multi-level framework that can contribute to co-optition and tension literature by examining the positive and negative cross-level effects of the platform on the performance of complementors simultaneously.

Many theories address the antecedents and outcomes of value tension in inter-organizational relationships and generate many innovative insights. Most empirical work explores and confirms the direct impact of platforms (Jean et al., 2021); however, the cross-level moderating effects of platforms are overlooked. Our empirical results echo the loose coupling perspective and describe how systems are organized to reconcile the tension between coupling and looseness (Nambisan & Luo, 2021). Loose coupling may allow a complementor to pursue value co-creation and appropriation simultaneously by balancing the value tension.

5.2 Managerial implications

Our findings also generate some managerial implications for e-commerce, platforms and complementors. First, value tension arises in a platform ecosystem when value co-creation and capturing coexist and are interdependent. The value tension may transform into an embedded paradox (Holloway & Parmigiani, 2016). Considering the value tension, the decision for complementors is not joined into or put in specific investments for a platform but the portfolio of the channel. Tensions only exist as they are not functional or dysfunctional (Panayiotou et al., 2019). More is not always better (Obadia & Robson, 2021). Wang and Miller (2020) indicate that larger complementors (content providers) offer smaller proportions of their product portfolios that were sold on the platform. Larger complementors (content providers) are less likely to offer their competitive products on platforms to withhold their revenues (Wang & Miller, 2020). In digitalization economics, complementors cannot sidestep the emergence of platform-mediated markets. Thus, simultaneously maintaining coupling and looseness with platforms that combine linkages and retain distinctiveness (Nambisan & Luo, 2021) to take

advantage of the efficiency and reputation created by such platforms and to secure the positive relationship between capabilities and performance simultaneously is a key challenge for complementors. A capable complementor should maintain a reasonable level of dependence on the platform as an important sales channel. Revenue portfolios should be a crucial strategic mechanism to keep partnerships within a platform ecosystem.

Second, firms are increasingly engaging in joining platforms and networks to co-create value that aims to capture more value from embeddedness. However, the complementor needs to consider the impact of value appropriation risks on its performance when selecting a platform to form an ecosystem. Mutual goals do not always keep partners on the same path (Obadia & Robson, 2021). Tension is negatively associated with common benefits (Arslan, 2017). It is difficult to generate positive mutual results when a platform cannot balance the coopetition between value co-creation and appropriation (Santos, 2021). A platform is an ecosystem that is formed by multilateral actors with nonlinear interactions and nested relationships (Möller, Nenonen, & Storbacka, 2020). Although the higher homogeneity of platform actors leads to lower searching costs, it also intensifies intra-platform competition and value tension (Kretschmer, Leiponen, Schilling, & Vasudeva, 2022). To attract, select and coordinate multiple complementors with heterogeneous capabilities to join the platform and make platform-specific investments to sustain cooperation is crucial for platform development. Thus, a platform can balance the value tension by platform governance, such as diversifying the base of platform actors, deterring the opportunistic behavior of complementors, and encouraging complementors by selective promotion (Blasco-Arcas, Alexander, Söchammar, Jonas, Raithel, & Chen, 2020; Kretschmer et al., 2022; Rietveld, Schilling, & Bellavitis, 2019; Tantalo & Priem, 2016; Teece, 2018; Wang & Miller, 2020). Governance strategies allow a platform to empower all actors to jointly create value and maintain adequate control by facilitating the perception of partnership among all actors (Laczko et al., 2019). To enhance

platform stickiness, platform governance may also focus on developing other appropriate mechanisms and organizational routines that manage value co-creation and appropriation simultaneously within the platform ecosystem (Hoffmann et al., 2018).

Finally, Kozlenkova, Lee, Xiang, and Palmatier (2021) report that consumers are motivated by the benefits associated with the lowest level of their unsatisfied need on Maslow's hierarchy of needs when they participate in the platform. They evaluate products and services based on their functional benefits and price. Platforms use pricing strategies to attract these consumers to participate in the platform. Platform and complementors pay the costs to attract and retain these customers. However, multihoming makes these consumers and complementors switch platforms with lower and even no switching costs (Basaure, Vesselkov, & Töyli, 2020; Cutolo et al., 2021; Lansman & Stremersch, 2011). Thus, locking in, which customers and complementors have incentives to engage in repeat transactions and maintain and improve their association, is an important antecedent for the value-creating potential of platforms (Amit & Zott, 2001). Attracting and retaining participants by governance not by price, which increases customers' willingness to pay and lessens the opportunity costs of the complementors, should be an important issue and challenge faced by platforms.

5.3 Limitations and future research directions

Although we strive for rigor and objectivity, this study suffers from several limitations that further research can address. First, interaction is key for platforms to co-create value with their complementors and customers (Amit & Han, 2017; Ekman et al., 2016; Frow et al., 2016). Interaction can be the function of expected benefits. This study does not assess the impact of interaction quality between platforms and complementors. Future research may need to include this construct. Second, platform governance, which guides the behaviors of participants by setting rules and norms (Cenamor et al., 2019; Rietveld & Schilling, 2021), is another critical source for the competitive advantage of platforms. However, this investigation did not evaluate

the impact of the strategy of platform governance on the competitive advantages of a platform. Thus, the impact of platform governance is worth further exploration. Finally, most platforms and their complementors are unlisted companies. It is difficult to collect financial data to assess firm performance. However, some studies suggest that there is a high correlation between objective and subjective performance measurements (Ariño, 2003). Evaluating performance by objective data can be one future research direction.

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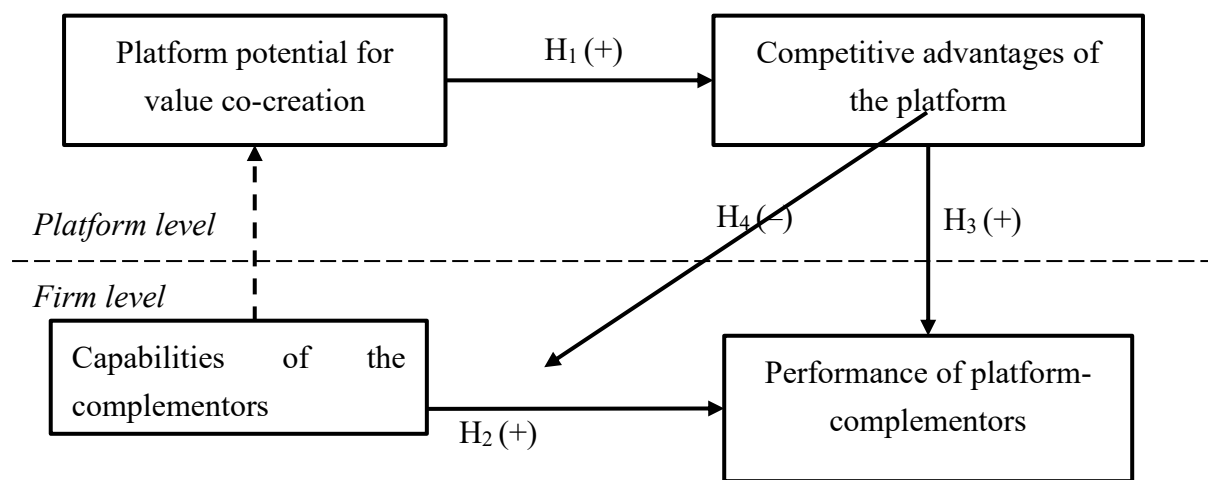


Figure 1 Conceptual framework of this research

Table 1 Confirmatory factor analysis results

Items	Means	SD	Factor loading	SMC	CR	AVE	Alpha
Capabilities of the complementors							
Has a strong ability in deliver on time	6.19	0.89	0.70	0.49	0.79	0.56	0.79
Has a strong ability in changing product mix quickly	5.87	1.21	0.77	0.59			
Has a strong ability in order processing	5.92	1.11	0.78	0.61			
Performance of complementors							
Satisfaction in the revenue growth rate	4.42	1.58	0.92	0.85	0.89	0.72	0.88
Satisfaction in profit growth rate	4.44	1.57	0.88	0.78			
Satisfaction in market reputation	4.91	1.40	0.73	0.54			
Model fit: $\chi^2=13.46$ ($p=0.097$), $df=8$, $\chi^2/df=1.68$, GFI=0.97, AGFI=0.93, RMSEA=0.07, CFI=0.99							

Table 2 The mean, standard deviation and correlation coefficient

Variables	Means	SD	1.	2.
Firm-level^a				
1. Capabilities of complementors	5.99	0.91	0.75	
2. Performance of complementors	4.59	1.37	0.23**	0.85
Platform-level^b				
1. Competitive advantages of platform	3.10	1.13		
2. Platform potential for value co-creation	5.99	0.90	0.19*	
3. Platform age	1.96	0.48	-0.17*	0.11

Note: ** p<0.01, * p<0.05; ^an (Firm-level) =154, ^bn (Platform-level) =33; Diagonal terms of firm level are the square root of AVE.

Table 3 The impact of platform potential for value co-creation on platform competitive advantages

	Model 1	Model 2
Platform age	-0.40* (-2.13)	-0.45* (-2.44)
Platform potential for value co-creation		0.26** (2.68)
R ²	0.03	0.07
Adjusted R ²	0.02	0.06
ΔR ²		0.04**
F value	4.52*	5.95**
Max VIF value	1.00	1.01

Note: n=33, *p<0.05, **p<0.01; t-value in parentheses. Standardized coefficients are reported.

Table 4 The variance of the platform potential for value co-creation and platform competitive advantages

		SS	df	MS	F-value	ρ
Platform potential for value co-creation	<i>SS_B</i>	65.19	30	2.17	4.45	0.00
	<i>SS_W</i>	60.03	123	0.49		
	<i>SS_T</i>	125.22	153			
Competitive advantages of platform	<i>SS_B</i>	189.89	30	6.33	175.18	0.00
	<i>SS_W</i>	4.44	123	0.04		
	<i>SS_T</i>	194.34	153			

Table 5 The cross-level effect of platform competitive advantages on the performance of complementors

	Null model	Random Coefficient Regression Model	Intercepts-as- Outcomes Model	Slopes-as- Outcomes Model
Firm level ^a				
Intercept (γ_{00})	4.57*** (0.18)	4.57*** (0.18)	4.57*** (0.18)	4.57*** (0.18)
The capabilities of the complementor (γ_{10})		0.42*** (0.13)	0.42*** (0.13)	0.45*** (0.12)
Platform level ^b				
Competitive advantages of platform (γ_{01})			0.37* (0.18)	0.37* (0.18)
Capabilities of the complementor×Competitive advantages of platform (γ_{11})				-0.20* (0.09)
Model deviance(-2LL)	493.65	488.34	482.18	480.55

Note: *** p<0.001, ** p<0.01, * p<0.05; Each model fills in the value (under the robust standard error) coefficient of the fixed effect (γ^s), Standard deviation in parentheses; ^an(firm level)=154; ^bn (platform level)=33