The Process of Ecosystem Emergence for an Enabling Technology: The 5G Case

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Abstract: This study aims to investigate how the process of ecosystem emergence occurs with the advent of 5G technology, focusing on the challenges and opportunities for Mobile Network Operators (MNOs) in the enterprise market. For this purpose, an exploratory and qualitative multiple-case study was conducted, involving key players in the Italian 5G industry. The research analyses the roles and interactions necessary for creating a 5G ecosystem, emphasising the importance of cooperation among numerous stakeholders due to the complexity and specificity of 5G applications. The results indicate that 5G can be defined as an Enabling Technology (ET), However, it is still lacking the pervasiveness in terms of wide applicability associated with General-Purpose Technologies (GPTs). The successful development of a 5G ecosystem requires dual co-orchestrators: MNOs and intermediaries. MNOs alone are unable to properly manage the ecosystem due to the diverse and specific nature of 5G applications. Intermediaries by their side, provide essential technical and business expertise, supporting MNOs in creating value across various sectors. The study provides insights into the evolution of business models for companies leveraging 5G technology. It emphasises the need for strategic collaboration among stakeholders to maximise the potential of 5G, offering guidance for businesses on how to adapt and thrive in this emerging ecosystem. The originality of this study lies in its integration of two literature streams, the ecosystem one and the enabling technologies one. This research contributes to both literature streams by highlighting the co-orchestration model necessary for 5G. It underscores the challenges and characteristics of orchestrating an ecosystem driven by enabling technology, offering valuable perspectives for both academia and industry practitioners.

Keywords: 5G technology, Enabling technology, Ecosystem emergence, Orchestrator

1. Introduction

The fifth generation of mobile networks (5G) not only offers incremental performances to its predecessor 4G, but also opens possibilities for applications in the B2B market, unlocking multiple opportunities for both the offer and the demand sides. 5G, which can be considered an enabling technology (ET) (Teece, 2018; Gambardella et al., 2021), is struggling with its adoption, especially in the enterprise market, where it promises numerous opportunities but use cases with clear benefits have not been found yet. MNOs, the long-standing focal players in the telecommunications industry (Gooderham et al., 2022), are struggling to propose 5G business solutions, even if they are the actors supposed to drive this technology's adoption, especially in some countries, like Italy, where they own the main source of value for the system (e.g., 5G network frequencies' licences in mid-band 3.6-3.8 GHz). Yet, the 5G environment is complex, characterised by multiple players engaging in overlapping activities.

This complexity suggests that 5G business solutions could be developed through an ecosystem. Given its status as an ET, 5G can be applied across various verticals, yet MNOs often lack the specific competencies required to meet the demands of these diverse applications. The existing ET literature is sparse, particularly regarding how inventors and vendors of such technologies can create and capture value (Gambardella et al., 2021). While these technologies have traditionally been studied from a macroeconomic perspective, there is a growing interest in their strategic implications (Conti et al., 2019).

In recent years, ecosystem literature has increasingly focused on how companies adopt new technologies and the importance of co-creating value (Jacobides et al., 2018). Despite this, empirical investigations into the orchestration mechanisms in ecosystem emergence remain limited (Jacobides et al., 2018; Lingens et al., 2021; Thomas et al., 2022). This gap in the literature underscores the need to explore how the process of ecosystem emergence occurs in 5G technology.

Therefore, this study aims to analyse the emergence of the 5G ecosystem and to investigate the mechanisms of value creation and capture within this context. By integrating insights from the literature on ET and ecosystems,

this research seeks to provide a comprehensive understanding of the 5G ecosystem's structure, the roles of different actors, and the dynamics of their interactions.

To address this, the study poses the following research questions: How does the process of ecosystem emergence occur in the context of 5G technology? What roles do various actors play in the 5G ecosystem, and how do these roles evolve?

This study is original in its approach, combining two distinct literature streams, the one on ET and the one on ecosystems, to explore the strategic adoption of 5G. Unlike previous research that often focuses on discrete technologies targeting specific uses (Kapoor & Lee, 2013; Hannah & Eisenhardt, 2018), this paper examines 5G as a multifaceted ET with broad applications across various industries.

The main contributions of this study are manifold. First, it provides a framework to explain the mechanism of ecosystem emergence in the 5G context. Second, it offers a detailed representation of the 5G ecosystem, giving also practical insights for MNOs and other stakeholders on how to effectively navigate and leverage it. Finally, this study enhances the theoretical discussion on enabling technologies and ecosystems, contributing to academic knowledge of the two literature streams.

2. Literature Review

2.1 5G as an Enabling Technology

The concept of General-Purpose Technologies (GPTs) was introduced by Bresnahan & Trajtenberg in 1995, defining them by three key characteristics: pervasiveness, ongoing technical improvement, and enabling complementary innovations in various application sectors. Essentially, GPTs have a profound impact on the entire economy, continuously improve, and inspire innovations across diverse fields (Teece, 2018). The difference between enabling technologies (ET) and GPTs is the fact that the former are upgradable, adaptable technologies with widespread applicability but no measurable economy-wide impacts (Teece, 2018).

5G technology is widely recognised by scholars as an ET (Teece, 2018; Rathje & Katila, 2021; Adner & Lieberman, 2021). To become a GPT, 5G must become pervasive in use in multiple markets since the emergence of 5G is not solely confined to the telecommunications industry; rather, various vertical industries are poised to leverage wireless communication (Dolgui & Ivanov, 2022). In this context, it becomes imperative to pay closer attention to opportunities that extend beyond MNOs, even if they are the historical focal actor supposed to drive this technology's adoption (Ghezzi 2012; Ghezzi et al., 2015), especially in some countries where they own the main source of value for the system (5G network frequencies' licences in mid-band). According to Knieps & Bauer, 2022, the telecommunication ecosystem has become less MNOs-centric, and it encompasses a wide range of stakeholders with diverse goals and interests.

2.2 Interconnected Business Model and Business Ecosystem

The essence of the business model is to define how the company creates value, captures it and profits from its products or services (Teece, 2010). Scholars emphasise that the shift to interconnected business models offers a multi-level perspective, enabling analysis ranging from individual firms to broader network interactions, thus highlighting the intricate value architectures within commercial relationships (Jocevski et al., 2020). Furthermore, the interconnected business model perspective acquires particular significance when considered in relationship with digital technologies (Nylund et al., 2022). The "interconnected Business model" concept is closely related to previous discussions on business ecosystems and value networks (Jocevski et al., 2020).

Value networks can be seen as a system of interconnected and interplaying BMs of different firms operating in the industry (Ghezzi, 2013). Indeed, with the value network concept, value is co-created by a combination of players (individuals, groups, or organisations) in the network (Ghezzi et al., 2009; 2013). The ecosystem could be defined as a network of organisations that jointly create an innovative value proposition for the client that a single firm could not offer by itself (Lingens & Huber, 2021).

In the recent literature, value networks and ecosystems are treated by some scholars almost as synonyms (Clarysse et al., 2014), while others try to evidence differences between the two structures. Indeed, while an ecosystem can be visualised as a network, it stands apart due to its potential to span across various sectors and the presence of a set of distinctive, asymmetrical connections that are established at the group level by specific complementarity (Jacobides et al., 2018). Finally, some other researchers see the ecosystem concept as an evolution of a value network (Cavallo et al., 2021). Regarding value creation and capture processes, while constructs as value networks place emphasis merely on value creation, the ecosystem one focuses also on the

"demand side" and value appropriation (Cavallo et al., 2018). Indeed, within an ecosystem, value is collaboratively created, captured, and distributed to optimise the total value gained and allocated, benefiting not just the focal firm but also all participants within the ecosystem (Yrjölä et al., 2022). A point of contact between the two literature streams is the orchestrator figure, which is mentioned and considered crucial for the development of both value networks (Dellyana et al., 2018) and ecosystems (Adner, 2017), especially in the case of ecosystem emergence, where misalignment between the actors involved may generate high transaction costs (Cavallo et al., 2018; Thomas et al., 2022)

Therefore, a comprehensive analysis of this actor becomes essential when deep-diving into discussions about value networks and especially ecosystems. This involves exploring the specific role the orchestrator plays within the ecosystem and identifying potential actors capable of taking this role. Lingens & Huber (2021) highlighted that the orchestrator is the actor in charge of defining partner activities, with the most extensive overall view of the ecosystem, and the player capable of favouring alignment within an ecosystem as well as ensuring fair value sharing and proper value creation.

3. Methodology

The research is based on a multiple-case study (Eisenhardt, 1989) for investigating the process of 5G ecosystem emergence. One of the opportunities enabled by 5G is the establishment of 5G Mobile Private Networks (5G MPN). These networks comprise dedicated wireless infrastructure utilising 5G technology to furnish tailored and secure communication services for specific organisations or entities in different verticals (es. Manufacturing, Logistics, Healthcare). However, even though it represents a first concrete opportunity that does not require public coverage (which might require public funding intervention for implementation, considering the geographical extension and the type of investment), the market in Italy is currently stagnant. There are only a few proactive pioneering companies from different verticals that are investing to implement use cases. Moreover, 5G technology adoption signifies an important shift in the traditional value chain structure, requiring a high degree of collaboration among various entities. The exploratory multiple-case study approach included direct interviews with eight employees who worked on 5G at a strategic level within their company, representing three of the many types of actors present in the 5G B2B context: IT integrators, technology vendors and end users. It has been taken the choice not to include MNOs in the interviews since secondary sources and informal speeches regarding their role were exhaustive and consistent in outcomes. The companies were selected because they had already been involved in 5G B2B projects. Interviews were carried out during the solar year 2023 and the scripts were validated with industry experts before conducting the interviews. After having collected a significant number of quotes and data from 11 semi-structured interviews and more than 20 secondary sources (collecting 140 pages of transcripts and 527 minutes of interviews), a systematic analysis was conducted. A within-case analysis was carried out to gain familiarity with the data, and then a cross-case analysis was useful for comparing all the information gathered (Eisenhardt, 1989). Subsequently, quotes were grouped in first, second and overarching dimensions (Figure 1). Taking together the analysis based on informants' codes (1_{st} order) and the one rooted in academics-based themes (2_{nd} order), permitted a qualitatively rigorous illustration of the connections between data and the research topic (Gioia et al., 2013). Regarding the case selection, according to the Eisenhardt method, there is no rule about the number of cases selected (Eisenhardt, 2021), rather the selection must be driven by the possibility of observing the phenomenon under research. Here below the coding tree obtained from the interviews is reported (Figure 1).

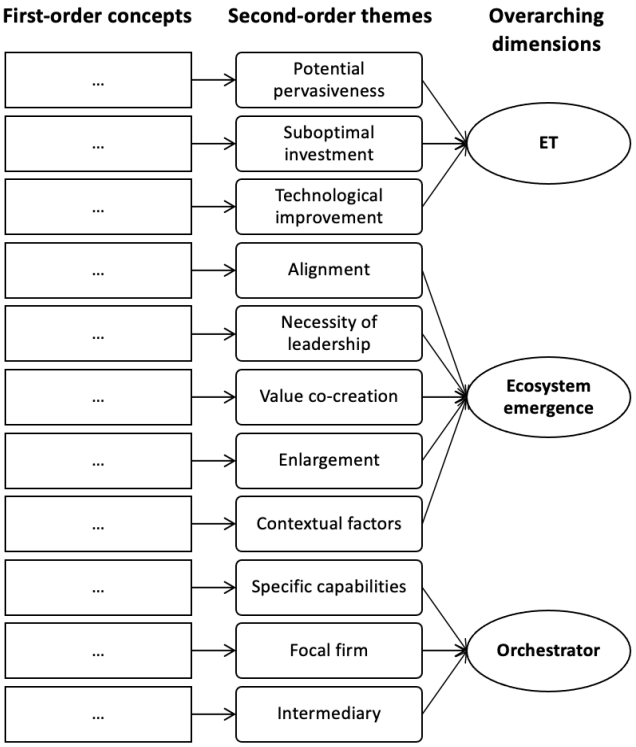

Figure 1: Coding tree structure

4. Findings

4.1 Enabling Technology

Practitioners unanimously recognise 5G as an ET, which facilitates novel solutions previously unattainable with other technologies, particularly in the enterprise sector. 5G enables the realisation of different deployments which are specific industry by industry. Based on what emerged from the interviews, it was possible to group the main activities needed for 5G deployment into three different layers: network infrastructure layer, network function layer, and service development layer. The first two include activities related to the physical deployment of the network, network hardware and software components, and network provisioning, which in the Italian case is only accessible by MNOs. The service development layer concerns all activities for providing connectivity and value-added services. As shown in Figure 2, although MNOs are the traditional focal actor of the industry, due to the numerous applications that 5G promises related to its ET nature, they don't possess all the complementary assets (both tangible and intangible) needed in the Service Development layer to manage the value proposition of the ecosystem. As mentioned by practitioners: "*It is the MNO who holds all the technology and infrastructure part, and so it is the one who can certainly be a bit of a leader, but it does not have the skills perhaps of others to provide solutions that are perfectly all-round*" (Network Architect 5G Network Solutions, IT Integrator 1). This is also evident from what end users have said, as they are proactively developing the first 5G MPN (Multi-Party Network) projects. The red arrows indicate that the flow of innovation originates from them, demonstrating that the value proposition is not as clear-cut.

4.2 Ecosystem Emergence

Considering that there is not a clear 5G value proposition and the actor's role is not defined, the 5G ecosystem is still in an emerging phase. This is recognised also by interviewees, especially concerning the fact that end users are proactively experimenting with 5G to understand how to leverage it. Due to the actual inability of the traditional focal firm to work alone due to the necessity of several complementary assets which differ among the different verticals, which is a new situation compared to the previous 3G and 4G technology, multiple actors need to collaborate to create value together. However, it is evident that, at the moment, the different players are not fully aligned. Therefore, the ecosystem lacks a single company acting as a leader which can align the different players towards a common value proposition and show end users solutions with an actual return on 5G investments. As stated by practitioners: "Probably the real problem is that there is no leader." (Senior Director, Technology Vendor 1).

4.3 Orchestrator

The proactive companies experimenting with 5G solutions would prefer a single contact point rather than many. However, none of the stakeholders involved have both the required business and technology competencies and all the other complementary assets needed. Who has the key resource (mid-band licences) struggles to be the sole orchestrator because 5G represents such an innovative technology that it is even difficult to design the correct value proposition oriented to value-added services rather than "just" connectivity. As mentioned by practitioners: "*The ability to translate business needs into technology requirements needed for the infrastructure is perhaps the biggest challenge MNOs have, because they are used to sell SIM connectivity*" (VP, Division Director - Communications, Media & Services, IT Integrator 2). Thus, there is an overlap between those who own the technology and the actual orchestrator, which, instead, appears as a dyad of actors. From the end user standpoint, among the actors with whom there have been the most interactions, two players have been recognised as possible orchestrators for the 5G ecosystem: the MNO, and the IT integrator. While the MNO is essential for every 5G project because it owns the network licences and has deep technology competencies, it is argued that it does not hold the necessary business capabilities to offer specific vertical solutions targeting end users' requirements. Even though recently telcos have been trying to acquire these competencies, they are struggling to do so because they have been focused on providing "just" connectivity. However, the real value coming from 5G adoption concerns the possibility of enabling several "value-added services" that end users still struggle to understand on their own, as just mentioned. Nevertheless, some interviewees recognise IT integrators as natural orchestrators since they possess technology competencies and complete business knowledge to cover the requirements of the different industries. However, also in this case their resources and competencies are not enough, due to the ET nature of 5G.

5. Discussion

Results revealed the chaotic actual situation in the 5G B2B context (Figure 2). There is overlap in value creation activities since different actors are trying to propose solutions, offering multiple services, also out of their core competencies. This perhaps is a symptom of the fact that there is confusion about the various possible 5G applications, and that supply and demand are struggling to find alignment, being the value proposition not clearly defined.

As stated in the literature, the missing element crucial for the emergence of ecosystems is alignment, which should be provided by the orchestrator, an actor also in charge of ensuring proper value creation (Lingens & Huber, 2021; Thomas et al., 2022). At the same time, findings suggest that the 5G B2B context is missing an actor with both deep technological and business competencies that can connect demand and offer and provide a solution which shows a real return to end users. This player, given the wide applicability of ET, should also have a specific understanding of multiple industries. According to interviewees, this firm would be the ideal orchestrator, however, no one seems to hold all the necessary characteristics.

Within ecosystems, the actor expected to be the orchestrator is the focal firm (Mann et al., 2022). In the empirical setting, this player is the MNO, since it stands in a central position, is linked to almost all the actors, and holds the main source of value (Cavallo et al., 2021). However, MNOs, even if they have all the necessary technology requirements, are missing vertical domain competencies to understand the context of the client and propose customised solutions to end users, especially because 5G is targeting multiple sectors. As evidenced by Stonig et al. (2022), in certain cases focal firms need to engage in organisational change to promote ecosystem creation. Results showed that MNOs have been trying to acquire business competencies, however, they struggled a lot and have not succeeded yet. The collected data suggests that the orchestrator role in the 5G ecosystem could potentially be assumed by intermediaries (es. IT integrator) because of their expertise in defining a list of use cases in the vertical target. However, these players do not own the key resources and do not possess specialised technology capabilities. As evidence, interviewees noted that the orchestrators from a technological standpoint are the MNOs, while from the business capabilities are the IT integrators. The MNOs can be referred to the focal firm, the intermediaries, as the co-orchestrators, as they establish and mediate relationships while bridging diverse knowledge, competency, and capability gaps (De Silva et al., 2018).

A tidier setting (Figure 3) emerges with respect to the actual situation, driven by the centralization of orchestration activities in the hands of two players, MNO, the focal firm, and an intermediary company.

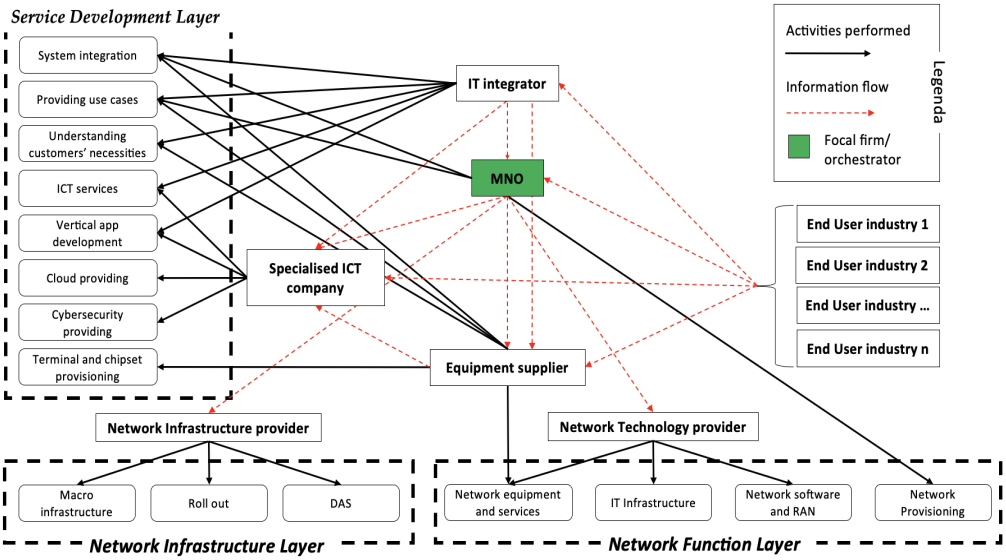

Figure 2: Actual 5G environment framework

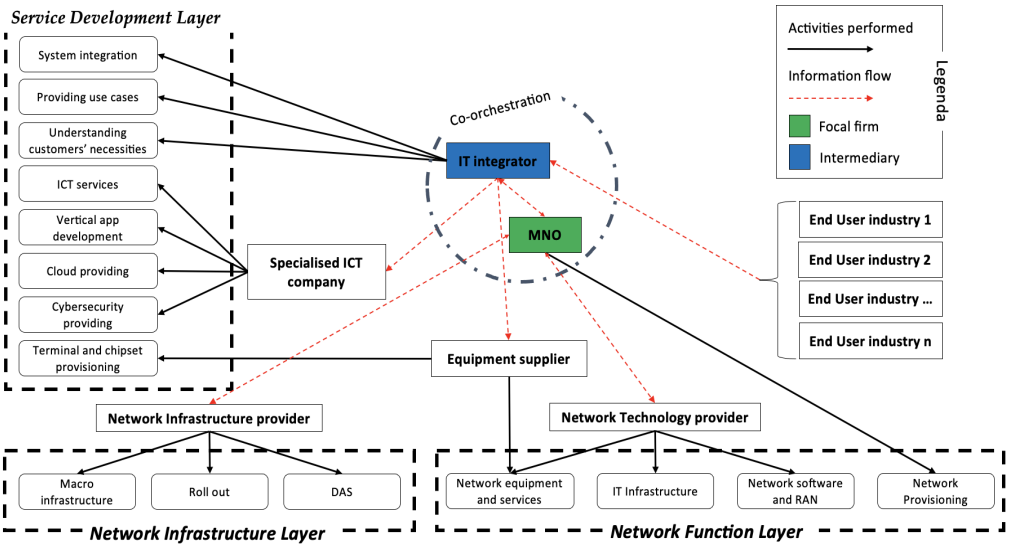

Figure 3: 5G ecosystem framework

5.1 Theoretical Contributions

The theoretical contributions of this research are manifold. First, this investigative empirical study contributes to the 5G managerial literature by providing modelling of the 5G ecosystem, corroborating existing studies (e.g. Teece, 2021; Bauer & Bohlin, 2022). Moreover, it provides the 5G managerial literature with a work that doesn't deal exclusively with the 5G technicalities, but the strategic adoption of such ET. Second, the research contributes also to the ecosystem and ET literature by showing that in an ecosystem based on an ET, due to the wide range of applicability, there is a lack of overlap between those who own the technology and the actual orchestrator since a single firm is not capable of taking on the role of orchestrator alone, but it needs to be supported by an intermediary. The focal firm, indeed, does not have all the capabilities to take the lead and, to promote ecosystem creation, needs either to engage in organisational change (Stonig et al., 2022) or to be supported by an intermediary. This actor, which has responsibility for connecting parties for collaboration (De Silva et al., 2018) and is characterised by cross competencies, can collect information from the customer, understand its needs and create tailored exhaustive solutions. In particular, a dyad of co-orchestrators is needed since overall, they hold the critical asset for the system and the alignment capabilities needed for the ecosystem to emerge. Indeed, for ETs it is important to provide the technology while knowing the multiple industries where it can be applied to foster cross-contamination among them.

Finally, this is also one of the few studies that examine the strategic adoption of an ET from an ecosystem perspective, considering that most publications regarding the structural alignment of a multilateral set of collaborating partners have often focused on discrete technologies (e.g., Kapoor and Lee, 2013; Bohnsack et al., 2024)

5.2 Practical Contributions

Managers and policymakers can benefit from this study in many ways too. To use ET effectively, firms must evolve their business models, focus on their core competencies, and accept their roles in the ecosystem by cooperating with other actors. MNOs should know it is more convenient for them, and preferred by the end user, to cooperate with IT integrators instead of offering end-to-end solutions. Furthermore, IT integrators should understand that it is impossible for them to autonomously orchestrate the ecosystem when they miss the critical resource. From the end user perspective, it emerges that, except for peculiar cases, it is convenient to refer directly to IT integrators, given the potential applications of an enabling technology are uncountable. Moreover, it is highlighted that what is slowing down the optimal commercialisation of 5G is not just technological improvement, but the lack of alignment of the various players from a business strategy perspective.

5.3 Limitations and Future Research Avenues

Given the limited existing literature on the subject, it was chosen to use an exploratory approach employing multiple case studies. Such qualitative research is potentially biased by the interviewer's or interviewee's interpretations, which might distort the final outcomes (Yin, 1984). Future research could analyse quantitatively with longitudinal data how ecosystem emergence occurs with ET. Furthermore, because of the limited data collection, while it has emerged that both actors are necessary to foster the development and adoption of ET, it has not been investigated how the two co-orchestrators can share the created value, introducing new challenges regarding the capture of value from these actors.

Moreover, the research is largely confined to a specific case, and the results may be closely tied to the unique characteristics of the selected context. Accordingly, conducting other research on actual ET could be an interesting avenue for confirming the takeaways of this investigation. Analysing these different technological landscapes might serve as an integrative approach to verify and expand the insights that emerged from this study, thereby enhancing the strength and generalizability of the conclusions.

6. Conclusions

This study examined the development of an ecosystem based on an ET. Driven by a lack of academic research on ecosystem emergence, this study offers a novel analysis of an ET from an ecosystem perspective through an exploratory case study. Qualitative research was conducted using multiple case studies on eight companies within the 5G context. The interactions among these companies were investigated to understand the dynamics of the emerging ecosystem. The key finding is that, in the case of an ecosystem based on an ET, the focal firm does not succeed in becoming the orchestrator alone, because it lacks familiarity with the end user’s business models, processes and specific context comprehension. Therefore, given the large breadth of applicability of an ET, there should be intermediary firms as co-orchestrators.

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