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Managing Inter-organizational Dependencies Operation for Discovering Digital Business Model Innovation in Corporate Innovation Ecosystem

Abstract: The Industry 4.0 era has brought forth numerous emerging technologies and business models, creating new opportunities and challenges for manufacturing small and medium-sized enterprises (SMEs) and providing opportunities for innovation. To achieve long-term competitiveness, these enterprises need to pay more attention to operational management innovation through new digital business models (BMI). However, Optimal Distinctiveness Theory suggests that incumbent enterprises face the dual pressure of legitimization and differentiation when integrating cross-border operations in the corporate innovation ecosystem, which can easily lead to the failure of digital BMI. To clarify how inter-organizational dependencies affect digital BMI in a corporate innovation ecosystem, we conducted an empirical study of 210 data from a corporate innovation ecosystem in China. The results show that: a) joint dependence positively affects digital BMI, while asymmetry dependence negatively affects digital business model innovation; b) routine updating mediates the relationship between inter-organizational dependencies and digital BMI; c) cross-border management capabilities moderate the positive effect of routine updating on digital BMI. The study provides theoretical and practical guidelines for the management of inter-organizational dependencies operation between enterprises in the corporate innovation ecosystem.

Keywords: inter-organizational dependencies; corporate innovation ecosystem; digital business models; routine updating; cross-border management capabilities

1 Introduction

The advent of Industry 4.0 has given rise to several emerging technologies, such as Machine Learning, Data Sciences, Cloud Computing, Robotic Systems, Artificial Intelligence (AI), and the Internet of Things (IoT) (Dhiaf et al. 2021; Somohano-Rodriguez et al. 2022). These technologies have created new opportunities for businesses (Enyoghasi and Badurdeen 2021). However, in order to provide better value to customers, manufacturing enterprises must also pay attention to the significant changes in management style, business environment, marketing, labor market, competitive environment, and customer behavior that come with these new technologies. New business models and innovation can help industries maintain long-lasting competitiveness in times of disruption (Frederico 2021). Nonetheless, due to the uncertain external environment and the discontinuous development of technology, innovation is no longer solely the responsibility of individual enterprises, but increasingly depends on complementary corporate innovation ecosystems and networks (Bag et al. 2018; Bellamy et al. 2020). From the perspective of operations and supply chain management, the innovation ecosystem strategy provides a better opportunity for incumbent manufacturing companies to design and implement new business

models. The interdependent and complex relationships within the ecosystem can help enterprises to manage operational aspects more effectively, including partner relationship management, supply chain management, quality management, data analytics and decision support, operational efficiency, and change management, to ensure the quality and sustainability of their products or services (Bhardwaj and Ketokivi 2020). However, due to the diversity of subjects within the corporate innovation ecosystem, the complex dependence network relationships formed by interconnections make the paths and effects of enterprises' innovation activities unpredictable (Adner and Kapoor 2010). Therefore, exploring how incumbent enterprises manage interdependent relationships within the innovation ecosystem is essential for understanding how enterprises leverage their own strengths to achieve better operations management and to clarify the occurrence mechanism of new business models and innovation.

Digital business model innovation, an important type of innovation, is a key factor in enhancing competitive advantage and business performance (Adner 2017). With the implementation of corporate innovation ecosystem strategy, value creation is no longer limited to a linear model within the enterprise, but a mesh model across the enterprise boundary, and how to promote digital BMI within the corporate innovation ecosystem has become a strategic issue that incumbent enterprises must pay attention to (Adner 2017). New technologies such as the Internet of Things and big data analytics can help manufacturing SMEs to better understand their supply chain and production processes, optimize resource allocation and management, and develop new business models and services (Van Wassenhove 2019). In addition, co-innovating with partners can enhance the enterprise's position in the innovation ecosystem, enabling it to acquire more resources and support, and jointly achieve digital BMI and growth (Collins and Browning 2019). However, there is "joint dependence" and "asymmetry dependence" between enterprises in the corporate innovation ecosystem and other enterprises. The dualistic nature of interdependence not only causes friction in collaborative production making strategic tensions in business relationships, but also makes it difficult for enterprises to seek a unique strategic positioning and seriously hinders digital BMI(Fisher et al. 2016). Other perspectives exist in former studies, for example, Zott and Amit (2009) argue that there are positive aspects of interdependence, where enterprises are able to create and share value together through dependencies; others argue that interdependencies facilitate enterprises to change their business models by identifying key players and aligning incentives across the network (Sandstrom and Osborne 2011). In this regard, this research argues that it is necessary to start from the duality of interdependence if we want to clarify the path of digital BMI within the corporate innovation ecosystem. In other words, we need to focus on both joint dependence and asymmetry dependence characteristics of interdependence(de Jong and Benton 2019). Dependence duality is an important exogenous variable and the basis for the study of multiple network relationships of enterprises within the corporate innovation ecosystem, with joint dependence predicting positive and optimistic corporate relationships and asymmetry dependence indicating the opportunistic behavior (Klang

and Hacklin 2013). Therefore, when considering digital BMI within the corporate innovation ecosystem, it is necessary to consider both joint dependence and asymmetry dependence in the corporate dependence.

Although resource dependence is often used to explain digital BMI of enterprises as individual innovation agents (Adner and Kapoor 2010; van der Borgh et al. 2012), there is a paucity of existing research on digital BMI of enterprises in the corporate innovation ecosystem and a lack of research on the possible mediating role of organizational routine updating from the perspective of a dynamic institution-based view. According to the dynamic institution-based view, institutional change is key to determining the governance structure, resource allocation, strategic decisions, and performance level of an organization, which is a continuous dynamic evolutionary process (Deng and Robinson 2021). In addition, routine is not fixed, and routine updating can proactively drive organizations to "mutate" and "upgrade" existing routines to build new innovative capabilities that are compatible with the new environment (LevinthalandMarino 2015). According to optimal distinctiveness theory, organizations need to focus on both legitimacy and differentiation in the corporate innovation ecosystem, where legitimacy allows them to better integrate into the corporate innovation ecosystem and build a wide network of synergistic relationships, while differentiation allows them to lead the development of the corporate innovation ecosystem and gain the ability to cross ecosystem boundaries by occupying a central position (Zhao et al. 2017). Routine updating is also reflected in the self-transformation or endogenous dynamism of enterprises in the corporate innovation ecosystem, showing the dual characteristics of adapting organizational routines to the environment and improving organizational effectiveness, i.e., finding optimal distinctiveness among established routines (Hoekzema 2020). Therefore, based on optimal distinctiveness theory, we suggest that routine updating may play a mediating role in the process of inter-organizational interdependence affecting digital BMI.

The theoretical basis of this research is the dynamic institution-based view and optimal distinctiveness theory. If incumbent enterprises want to evolve with the corporate innovation ecosystem, they need to balance their legitimacy and differentiation in the corporate innovation ecosystem so that they can differentiate themselves optimally within the corporate innovation ecosystem and promote digital BMI by modifying and creating organizational routines that identify the enterprise's identity while deviating moderately from the industry average (Zhao et al. 2017). Based on optimal distinctiveness theory, the present research constructs a theoretical model regarding joint dependence and asymmetry dependence, routine updating, cross-border management capabilities and digital BMI. It reveals the intrinsic mechanism of interdependent duality via routine updating on digital BMI and analyzes the moderation role of cross-border management capabilities between routine updating and digital BMI at the micro level. Not only does it consider the continuous impact of the enterprise's established network of relationships on the organization's operations, but it also enables timely feedback on the external environment,

which can enhance the agility of the enterprise's strategy and ultimately keep the ecosystem stable and evolvable (Benjaafar and Hu 2020). Hope we can reveal the mechanism of inter-organizational dependencies within corporate innovation ecosystem on digital BMI, and provide a theoretical reference for digital BMI of incumbent enterprises under the dual constraints of high dependence and asymmetry dependence.

2 Theoretical Background and Hypothesis

2.1 Inter-organizational dependencies and digital BMI

Since Adner (2006) proposed the concept of corporate innovation ecosystem, it has become an important research topic. As the research progresses, the connotation of corporate innovation ecosystem becomes clearer and many scholars define it as an innovation subject in multiple networks, which is a stable, independent, and interdependent system based on the interaction of common innovation elements such as talent, technology, culture, rules, market, and operation mode (Granstrand and Holgersson 2020). Radziwon and Bogers (2019) argue that the key of corporate innovation ecosystem lies in the symbiotic evolution of heterogeneous members in the system and the synergy between individual and overall goals, which ultimately leads to the creation and capture of innovation value. We can see that interdependence and symbiosis are unique to corporate innovation ecosystems, as it expands inter-organizational relationships from binary to multiple (Adner and Kapoor 2010). At the same time, coordination in ecosystems is complex and the structure of interdependence cannot be decomposed into a collection of independent binary interactions(Frederico 2021). Overall, the dependencies among corporations in innovation ecosystems have an important impact on enterprises' access to critical resources, coping with shocks from environmental changes, reducing transaction costs, and gaining unique competitive advantages (de Jong and Benton 2019).

Although the corporate innovation ecosystem has a complex structure of interdependencies, its formation still relies on the simultaneous exchange activities of single enterprises in the different networks in which they are embedded (Carson and Ghosh 2019). Therefore, understanding the structure of ecosystem evolution from a single enterprise is the micro-foundation for understanding the evolution of the corporate innovation ecosystem. As the dependencies of single enterprises are characterized by duality, this research continues Gulati and Sytch’s (2008) perspective about inter-organizational dependencies that it can be divided into two dimensions: asymmetry dependence and joint dependence, which represent the sum and difference of dependencies between the two sides of a transaction, respectively. Joint dependence mainly refers to the cohesiveness of both subjects in the relationship of cooperation, while asymmetry dependence refers to the differences in resources between the two parties and the coordination of power between them(Guo et al. 2023).

A number of scholars have already studied the influence of asymmetry dependence and joint dependence from various perspectives such as transactional relationships and environmental

dynamics. On the one hand, from the perspective of transactional relationship, scholars have argued that the embedded logic of joint dependence can initiate stronger relationship orientation, higher levels of joint action, and more favorable information exchange. Meanwhile, it can increase trust and commitment between network organizations, and the longer the collaboration, the higher the level of commitment (Huo et al. 2021; Reed 2021). However, asymmetry dependence is a cause of interorganizational uncertainty, which can undermine trust and commitment and lead to conflict, as well as opportunistic behavior between organizations due to power inequity (de Jong and Benton 2019; Kim and Henderson 2015). On the other hand, from the perspective of environmental dynamics, e.g., Burford et al. (2021) find that joint dependence makes enterprises perform better in stable environments, while asymmetry dependence makes enterprises perform better in the face of negative shocks. Furr and Eisenhardt (2021) argue that in high certainty markets, executives have the foresight and time to build strategically valuable interdependence and extend the value of technological resources, whereas in low certainty markets resources may not yet exist or their value (and rarity) is uncertain and interdependence appear to be less closely related to strategic decisions.

In summary, we can find that research on the impact of asymmetry dependence and joint dependence is still limited to single enterprises or two-way relationships, while it is still unclear how the interdependence between participants in different collaborative networks affects the choices of each enterprise, digital BMI, as well as ecosystems (Cennamo and Santaló 2019). In this study, the dimension of inter-organizational dependencies will agree with the studies of Gulati et al. (2005), and we set it in the context of corporate innovation ecosystem and examine the different mechanisms of their influence on digital BMI of enterprises from the perspective of the differences between the two dimensions.

2.2 Inter-organizational dependencies and digital BMI

Digital business model innovation (BMI) refers to the innovation of an organization using internal and external complementary assets to coordinate across organizations on the content, structure, and governance of the transaction process of the enterprise(Amit and Zott 2001). The support of corporate innovation ecosystem allows greater scope for innovation and higher chances of success of business models(Hou and Shi 2021). With the business logic of corporate innovation ecosystem value symbiosis, enterprises cannot only focus on their own interests, but need to build business systems with other enterprises and create unique profit models to achieve joint value creation with partners(Adner and Kapoor 2010). This research argues that joint dependence and asymmetry dependence, as important external relationships in the cooperation process, will affect the digital BMI of enterprises by influencing the innovation of inter-organizational transaction content, transaction structure and transaction governance.

First, joint dependence and asymmetry dependence can have an impact on the degree of transactional content innovation. It has been shown that joint dependence increases the depth of

inter-organizational cooperation, simplifies the process of transactions, and expands the scope of transactions(Li et al. 2023). It facilitates the diffusion of productive and innovative resources such as knowledge, ideas, technology, and market information between organizations, easing the scarcity of innovative resources in individual organizations to a certain extent and breaking through resource and environmental constraints. In addition, it enables them to demonstrate better responsiveness and connectivity to market needs than their competitors, thus enabling digital BMI (Kalkanci et al. 2019) . However, when the level of asymmetry dependence is high, the content of the transaction is determined by the power position of the strongest enterprise, leading a low level of information sharing and resources flowing. The stronger party will be more profitable in such conditions, and innovation for the content of the transaction is difficult to occur (Van Wassenhove 2019) .

Secondly, joint dependence and asymmetry dependence can have an impact on the degree of transactional structure innovation. Transaction structures are usually determined by contractual terms that stipulate the interests of each party. Joint dependence allows enterprises to consider the interests of the other party more, balancing the rights, obligations, and risks to satisfy each one. Under the condition, enterprises have more energy and resource base to consider digital BMI (Chen et al. 2022); while under the condition of asymmetry dependence, the trust and communication between enterprises is low. In such situations, the contract terms signed may not only be too stringent to benefit vulnerable enterprises, but also allows the decision on the future direction of development to be made by the strongest party(Bellamy et al. 2020). This situation makes it difficult for SMEs with poor financial resources and technological strength to work with backbone and leading enterprises to innovate on deal structures(Radziwon and Bogers 2019) .

Finally, joint dependence and asymmetry dependence can have an impact on innovation in transactional governance. Transactional governance is a continuous process of balancing conflicts and joint action between different stakeholders, and has been divided into two forms: contractual governance and relationships governance, which are complementary to each other(Teimoury et al. 2010) . With the dual role of contractual and relationship governance, each department is able to negotiate and participate in a cost-effective manner, allowing for better resource allocation and greater flexibility, thus innovation is more likely to occur (Bhardwaj and Ketokivi 2020). However, due to the unequal status of the parties in asymmetry dependence, neither contractual nor relational governance acts as a check on each other, and stronger enterprises tend to exercise control and opportunistic behavior over weaker ones, thus innovation in transactional governance is less likely to occur (OkeandIdiagbon-Oke 2010).

Therefore, we suggest that joint dependence can bring organizations closer together and enable them to change with environment through the sharing of resources and information, thus enabling joint digital BMI. However, in asymmetry dependence, organizations are in an unequal position and power issues prevent the interests of the stronger and weaker parties from being aligned, which in turn undermines the basis of cooperation between the two parties for digital BMI.

Based on this, this study proposes the following hypothesis：

H1a: There is a significant positive effect of joint dependence on digital BMI.

H1b: There is a significant negative effect of asymmetry dependence on digital BMI.

2.3 The mediating effect of routine updating

Routine updating is the "variation", "search" and "selection" of new routines when they are not adapted to the new environment. It enhances the effectiveness and dynamism of an organization's routines and co-evolvement with the ecosystem(Davis and Eisenhardt 2011). There are two main types of routine updating: routine amendment and routine creation. Routine amendment is a modification or refinement of routines that are not adapted to the environment based on the original routine of the genetic section. Routine creation is the mutation of existing routines to create new routines that are coupled and matched to the environment based on iterative experimentation and iteration(Kim and Henderson 2015).

On the one hand, routine amendment and routine creation mediate the relationship between joint dependence and digital BMI. First, a high level of joint dependence indicates a strong complementarity of resources between enterprises, which enables different enterprises to be more closely aligned. It reduces the risks and costs of collaboration, facilitates the flow of technical knowledge and collaborative innovation between enterprises, and brings a diversity of knowledge, ideas, and skills to the organization. This not only increases the organization's knowledge stock, but also extends the boundaries of its cognition, leading to a process of revision and creation of old routines(Davis and Eisenhardt 2011). Second, the participants in the transaction, the ways in which value is co-created, and the mechanisms for capturing and distributing benefits constitute the basic network routines in the corporate innovation ecosystem. The network embeddedness of the corporate innovation ecosystem determines that the essence of digital BMI is the change of existing value network routines. Routine amendment and routine creation are necessary stages in the formation of new network routines(Safavi 2021). They can achieve the rational use of knowledge and heterogeneous resources, update the enterprise's knowledge memory system, enhance the enterprise's foresight of the organization's operation mode, increase the overall stability of the network, and promote the process of digital BMI (Nigam et al. 2016). Finally, the interdependence of organizations is the basis for the establishment and development of a corporate innovation ecosystem. Joint dependence allows enterprises to learn more about customer needs, new market trends and mainstream technologies from partners, while at the same time driving networks to rethink and innovate existing trading models to achieve digital BMI. Routine amendment and routine creation can more effectively transform market opportunities into innovations and make changes to trading methods in a more intuitive way (Yi et al. 2018).

On the one hand, routine amendment and routine creation mediate the relationship between asymmetry dependence and digital BMI. First, asymmetry dependence means that one enterprise has more of the key resources that the other enterprise needs, such as equipment and technology.

In other words, there is a big difference in strength between the two sides, while the dominant enterprise having more autonomy. This imbalance can lead to over-reliance on the original path by both parties, as enterprises are unable to continuously refine and filter their existing knowledge, map existing knowledge and resources, modify redundant and inefficient routines in a timely and effective manner to make routine amendments(Safavi 2021). At the same time, the more profitable the dominant enterprise gets, the more passive it is in searching for new ways of operating, which makes it harder for enterprises to unite and develop with each other or try out new trading routines. That is, routine creation is extremely difficult to occur(Adner and Kapoor 2010). Second, routine amendment is the refinement and elimination of old routines that do not fit the environment and incompatible with co-value creation, in order to help enterprises integrate resources and capabilities, simplify processes and reduce the lack of synergy that previously existed in departments. This process helps to advance the integration of old and new perceptions and norms in the business operating process, so that employees have a highly coherent and common vision and further accelerate the process of digital BMI(Wenzel et al. 2020). Third, the routine changes more drastically and gives the organizational network a completely new code of conduct in routine creation. While ensuring the normal operation of the new business model of the enterprise, routine creation, by adding new and more flexible organizational routines, is able to coordinate all factors, harmonize conflicts and contradictions and reduce operating costs within the organization, which is an important prerequisite for the subsequent optimization, innovation and even reinvention of the business model(Cannas 2021; Safavi 2021). In summary, the negative effects of inter-organizational asymmetry dependence on digital BMI are mainly since asymmetry dependence is not conducive to routine amendment and routine creation, and cannot provide a resource base for innovative transaction models in organizational networks(Cannas 2021).

Therefore, the present research argues that two dimensions of inter-organizational dependencies: joint dependence and asymmetry dependence, have opposite effects on digital BMI. And routine amendment and routine creation determine whether the process can occur properly. Based on this, the following hypothesis is formulated:

H2a：Routine amendment mediates the relationship between joint dependence and digital BMI;

H2b：Routine creation mediates the relationship between joint dependence and digital BMI；

H2c：Routine amendment mediates the relationship between asymmetry dependence and digital BMI;

H2d：Routine creation mediates the relationship between asymmetry dependence and digital BMI.

2.4 The moderating effect of cross-border management capabilities

Cross-border management capabilities refer to the diplomatic capabilities of a business, i.e., whether the organization can coordinate the interests of all stakeholders and win their trust and

support (Gulati et al. 2005). Available research shows that the highly dynamic nature of markets, the increasing complexity of products and the rapid pace of technological development make it necessary for enterprises to cross different organizational boundaries in order to establish effective innovation systems. Further, in the process of promoting holistic innovation by enterprises within the corporate innovation ecosystem, enterprises need to access and utilize the resources and capabilities of their partners through ecological networks such as routine amendment and routine creation, integrate external knowledge inflows and commercialize internal knowledge in order to lay the foundation for their own capability development (Nigam et al. 2016). This requires enterprises to overcome boundary issues with other subjects, such as conflicting interests of different subjects in terms of information, communication, knowledge sharing, knowledge creation, exclusivity, privacy, and confidentiality, which require enterprises to have cross-border management capabilities for coordination (Xie and Wang 2020). Therefore, the present research suggests that cross-border management capabilities may have a moderating role between routine amendment and routine creation and digital BMI.

It will cause a lack of understanding and commitment of the organizations to the overall goals of the organizational network when the cross-border management capabilities are low and routine amendment and routine creation between organizations is bound to involve issues of equity or resource balance between the two parties. If an enterprise cannot effectively coordinate the interest with other subjects, it will make the enterprise behavior biased to short-sighted behavior rather than from the long-term interests, so the synergistic cooperation between enterprises cannot achieve the expected goals, and the fit and matching of capabilities and processes within the enterprise cannot be achieved, which in turn is not conducive to the realization of digital BMI (Kalkanci et al. 2019). When cross-border management capabilities are high, enterprises are able to handle inter-organizational problems in a timely manner. It can give high priority to the interests of all parties, effectively coordinate inter-organizational conflicts, and improve the efficiency of cross-border collaboration, so the new knowledge, technology, and information brought by routine amendment and routine creation can be used more efficiently, which enables the enterprise to quickly integrate resources to promote digital BMI (CenamorandFrishammar 2021). That is, the stronger the cross-border management capabilities are, the stronger the contribution of routine amendment and routine creation to digital BMI. Based on this, the following hypothesis is proposed.

H3a: Cross-border management capabilities have a positive moderating effect on the relationship between routine amendment and digital BMI;

H3b: Cross-border management capabilities have a positive moderating effect on the relationship between routine creation and digital BMI.

Optimal Distinctiveness Theory suggests that incumbent firms in a corporate innovation ecosystem need to consider how to manage differentiation and legitimation to achieve optimal innovation performance (Fortin and Oliver 2016). On the one hand, institutional theory suggests that corporations should do their best to maintain strategic similarity with other corporations in order to gain legitimacy and reduce performance penalties for deviating from the public. On the other hand, competitive advantage theory suggests that corporations should seek maximum differentiation to build sustainable competitive advantage and achieve better performance by balancing strategies with different characteristics (Fisher et al. 2016). Optimal distinctiveness theory provides a valuable research perspective to help incumbents in the corporate innovation ecosystem better coordinate the two strategies. Based on the theory of optimal distinctiveness, we believe that routine amendment and routine creation are the expressions of two strategies of legitimization and differentiation. The two enable the enterprises to maintain a large degree of similarity with other enterprises while creating a specific and flexible routine unique to the enterprise by modestly revising and improving the corporate routines and creating. Since routines are a symbol of corporate identity, routine amendment and routine creation allow companies to avoid excessive uniformity or excessive differentiation and help them achieve strategic balance and digital BMI (Li et al. 2023). Meanwhile, strong cross-border management capabilities can effectively coordinate the conflicts in the process of routine amendment and routine creation, thus enabling the incumbent firms to achieve co-evolution with the corporate innovation ecosystem. Therefore, based on the theory of optimal distinctiveness, this study explores the impact of inter-organizational dependencies on digital BMI from the perspective of routine updating and cross-border management capabilities. From the perspective of routine updating and cross-border management capabilities, the research model as shown in **Figure 1**.

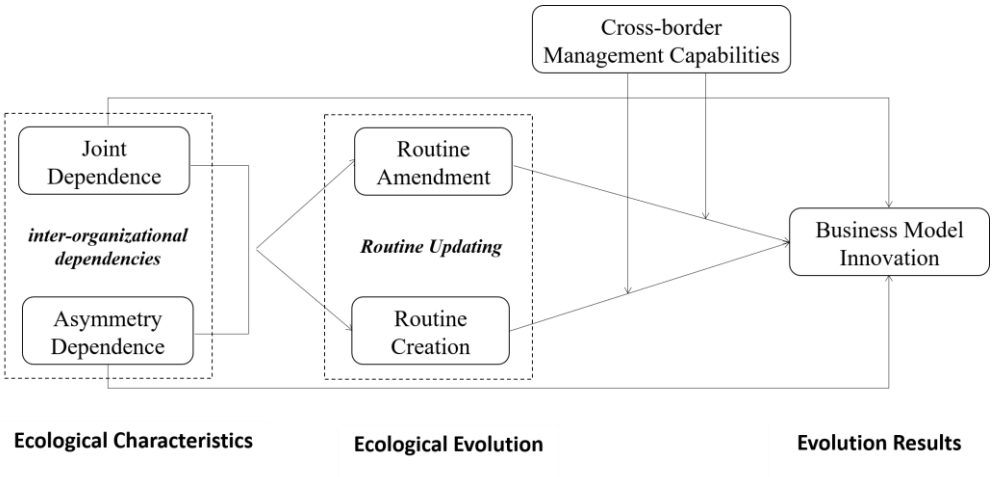

Fig. 1 **Research model**

3. Research design

3.1 Measures

To ensure the reliability and validity of the research measurements, we referred to mature scales and measurements of variables that have been validated, and we have adapted and revised it to the Chinese situation. To ensure the reliability of the questionnaire, we invited three professors and three business managers of the same field to give their opinions on the questionnaire. Based on the feedback, we modified the inappropriate questionnaire items. Finally, 15 enterprises in Guangdong were selected for pre-testing, and the final draft of the questionnaire was formed after revision based on the test results. The questionnaire was based on a five-point Likert scale, in which 1 means "very unsuitable" and 5 means "very suitable", and respondents were asked to score according to the actual situation of the company.

The scale of inter-organization dependence was adapted from Gulati and Sytch (2007). Firstly, the degree of dependence of the relationship subjects on customers and suppliers is measured separately, and then the variables of joint dependence and asymmetric dependence are obtained by adding and subtracting the degree of dependence. Regarding the setting of relevant questions, the items for supplier dependence include five items represented by the following question: "Replacing suppliers would increase costs and cause significant trouble". Customer dependence includes three items represented by the following question: "Existing customers have made significant proprietary investments in your company (reverse-coded)". The measurement of digital BMI was adapted from (Soluk et al. 2021) and included eight items represented by the following question: “In the context of digital technology adoption, our business model offers new combinations of processes, products, services, and information”. The routine updating scale was based on (FeldmanandPentland 2016; Zhen et al. 2021), with eight items measuring routine amendment and routine creation, respectively, representing questions such as "The enterprise would use new knowledge or technologies to improve its process norms if they were available" and "The enterprise encourages employees to choose more effective organizational norms by “trial and error”. The variable of "cross-boundary management capabilities" is mainly based on the research of Gulati and Puranam (2010), and is adapted to the Chinese context with three items, including the representative item: "When disagreements occur, your company generally strives to find a solution that is relatively fair to both parties in the innovation ecosystem." All variables were measured using a 5-point Likert scale.

3.2 Data collection and sample characteristics

A typical corporate innovation ecosystem in China was selected for sample questionnaire collection considering the response rate and time cost. The corporate innovation ecosystem selected for this study takes a large power supply enterprise in the southern region as the central enterprise. The core enterprise has now achieved greater success in jointly exploring the

incubation of 5G innovation applications and products, by collaborating with various enterprises in the 5G smart grid ecosystem in the Pearl River Delta (PRD) region (Reed 2021). Not only the R&D project was identified by the General Office of the Ministry of Industry and Information Technology as a pilot demonstration project for the development of big data industry in 2021, but also the Internet 5E platform developed jointly with other ecological partners was officially launched in the second half of 2021, which is of great practical significance for integrating the energy industry value chain, innovating the energy ecosystem and building a new type of power system. Given that the innovation of transaction models in corporate innovation ecosystem occurs mainly between enterprises, the interdependence between enterprises has a greater impact on their operation and development, and their survival fate is closely linked to the whole corporate innovation ecosystem. Therefore, this research focuses on the impact of interdependence among enterprises in corporate innovation ecosystem (Adner and Kapoor 2010).

With the help of the core enterprises, we conducted a survey of the upstream and downstream enterprises in this corporate innovation ecosystem. In order to improve the recall rate, the questionnaire was distributed in the form of anonymized enterprises and anonymous respondents. The respondent should be a senior or middle-level manager of the company in order to obtain an accurate picture of the interdependencies between enterprises in the corporate innovation ecosystem, the normative processes within the organization and the digital BMI. Our team distributed a questionnaire to the company's managers, with the help of a list of eco-chain partner enterprises provided by the company. The study was conducted from August to December 2021. Ultimately, a total of 298 questionnaires were collected in 500 questionnaires sent out, and excluding invalid questionnaires with missing items and consistent answers, we finally got 210 valid questionnaires with an effective rate of 60%. The specific sample structure is shown in **Table 1**.

Table 1. Statistical information of sample corporations

Variables	Category	Freq	Pct. (%	Variables	Category	Freq	Pct. (%)
Enterprise nature	State-owned	50	23.810	Enterprise size (Number of staff)	<100	35	16.667
	Foreign-invested	12	5.714		101~500	75	35.714
	Private	134	63.810		501~1000	43	20.476
	Other	14	6.667		1001~3000	35	16.667
					>3001	22	10.476
Enterprise age	0~3years	10	4.762	Enterprise assets	<10 million	17	8.095
	4~6 years	10	4.762		10 ~100 million	60	28.571
	7~9 years	20	9.524		100 ~500 million	50	23.810
	10~20 years	96	45.714		0.5 ~2 billion	40	19.048
	>20 years	74	35.238		>2 billion	43	20.476

4 Results

4.1 Reliability and validity

On the one hand, Cronbach's alpha (CA) coefficient and combined reliability (Mastrangelo et al.) was used to test the reliability of the variables. As shown in Table 2, the CA values for all variables in this study were close to or greater than 0.8, and the combined reliability (Mastrangelo et al.) of variables is greater than the recommended level of 0.7, indicating good reliability of the scales in this research.

On the other hand, as shown in Table 2, the load coefficients of all items in this study are greater than 0.6, and the average extracted variance is above 0.5, showing good convergent validity. In addition, as shown in Table 1, the square roots of all variables' AVE (diagonal italics added) are greater than the correlation coefficients, indicating that the model of variables in this study has good discriminant validity. All indicators can be met, showing the good validity of this study.

Table 2. Reliability and validity tests for variables

Construct	Indicators	Factor loading	Cronbach's α	CR	AVE
Digital BMI	DBMI1	0.795	0.925	0.937	0.599
	DBMI2	0.746			
	DBMI3	0.764			
	DBMI4	0.783			
	DBMI5	0.834			
	DBMI6	0.753			
	DBMI7	0.696			
	DBMI8	0.802			
	DBMI9	0.806			
	DBMI10	0.754			
Joint Dependence/Asymmetry dependence	RD1	0.709	0.799	0.907	0.551
	RD2	0.799			
	RD3	0.797			
	RD4	0.771			
	RD5	0.601			
	RD6	0.717			
	RD7	0.769			
	RD8	0.753			
Routine Amendment	RA1	0.875	0.909	0.937	0.788
	RA2	0.885			

	RA3	0.909			
	RA4	0.881			
Routine Creation	RC1	0.863	0.905	0.935	0.781
	RC2	0.879			
	RC3	0.898			
	RC4	0.895			
Cross-border Management Capabilities	SM1	0.905	0.905	0.940	0.840
	SM2	0.915			
	SM3	0.930			

4.2 Homogeneous variance test

Since the sample in this study was drawn from the same subjects, common method variance (CMV) may exist. To control the CMV, we encourage more than one person from the same company to answer together and set reverse questions. The present study used Harman's one-way test to check CMV, and the question items of joint dependence/asymmetry dependence, routine amendment, routine creation, cross-border management capabilities, and digital BMI were subjected to exploratory factor analysis. The results revealed that the eigenvalues of five factors were greater than 1, and the explanatory degree of the first factor was 42.60% (less than 50%), indicating that there is no serious problem of CMV according to Hair et al. (1998). In addition, based on a six-factor structure as suggested by Podsakoff et al (Podsakoff et al. 2003), we constructed a seven-factor structure model by adding the CMV as a latent variable. By comparing the before and after models, it was found that the fit indices did not improve significantly (△RMSEA < 0.01, △TLI < 0.01, △RFI < 0.01, △AGFI < 0.01), although the model with the addition of method factors outperformed the original model, which indicates that the data collection method in this paper did not bring about a serious common method bias.

Furthermore, **Table 3** gives descriptive statistics such as mean, variance and correlation coefficient of the studied variables. Digital BMI has a positive correlation with joint dependence (β = 0.509, p < 0.01) and a negative correlation with asymmetry dependence (β = -0.421, p < 0.01), which initially shows the support for **hypothesis 1a** and **hypothesis 1b**.

Table 3. Descriptive statistical and Pearson's correlation coefficient between the variables

	M	SD	1	2	3	4	5	6	7	8	9
1 Digital BMI	3.891	0.732	**0.774**								
2 Joint Dependence	7.654	1.215	0.509**	**0.742**							
3 Asymmetry dependence	-0.213	0.695	-0.421**	0.152*	**0.742**						
4 Routine Amendment	4.137	0.741	0.704**	0.473**	-0.323**	**0.888**					
5 Routine Creation	3.899	0.849	0.674**	0.430**	-0.348**	0.722**	**0.884**				
6 Cross-border Management Capabilities	3.956	0.894	0.575**	0.412**	-0.197**	0.691**	0.667*	**0.917**			

7 Enterprise nature	2.529	0.924	0.121	-0.079	-0.130	0.103	0.079	0.060	1		
8 Enterprise size	2.690	1.232	0.153*	0.187**	-0.134	0.202**	0.148*	0.090	-0.139*	1	
9 Enterprise age	21.190	16.920	0.059	0.068	-0.029	0.091	0.028	0.009	0.022	0.297**	1

Notes: ** means p<0.01 , * means p<0.05; the diagonal is the square root of AVE (average variance extracted).

4.3 Hierarchical regression analysis

To test the hypotheses presented above, we conducted a multiple linear regression of the variables of interest using cascade regression through SPSS 26.0, controlling enterprise nature, enterprise size, and enterprise age. **Table 4** shows the regression procedure and results, where model 1, 3, and 5 test the effects of the control variables and laid the groundwork for further analysis. Model 6 examined the effect of joint dependence and asymmetry dependence on digital BMI. The analysis of statistical results shows that joint dependence has a significant positive effect on digital BMI(β=0.569 , p<0.000). There is a significant negative effect of asymmetry dependence between digital BMI (β=-0.495, p<0.000) and **H1a** and **H1b** are supported.

Table 4. Hierarchical regression analysis

DV	RA		RC		Digital BMI					
Model	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
JD		0.508***		0.474***		0.569***	0.347***			0.349***
AD		-0.376***		-0.410***		-0.495***	-0.321***			-0.332***
RA							0.289***	0.596***		0.262**
RC							0.160*		0.530***	0.126
SM								0.189**	0.249***	0.094
RA×SM								0.118*		0.203*
RC×SM									0.123*	-0.155
EN	0.133	0.101	0.103	0.065	0.145*	0.099*	0.059	0.050	0.071	0.055
SIZE	0.213**	0.059	0.170*	0.015	0.171*	-0.015	-0.034	0.041	0.064	-0.019
AGE	0.024	0.024	-0.025	-0.024	0.005	0.006	0.003	-0.005	0.029	-0.001
R^2	0.059	0.407	0.033	0.374	0.044	0.538	0.644	0.527	0.505	0.660
F	4.300**	27.987***	2.313	24.341***	3.162*	47.592***	52.247***	37.670***	34.513***	38.664***
$\triangle R^2$		0.348		0.341		0.494	0.600	0.483	0.461	0.616
$\triangle$F		23.687		22.028		44.430	49.085	34.508	31.351	35.502

Notes:

a) ** means p<0.01 , * means p<0.05; the diagonal is the square root of AVE (average variance extracted).

b) Model 2 corresponds to model 1; model 4 corresponds to model 3; model 6, 7, 8, 9, 10 correspond to model 5.

c) "EN": enterprise nature , "SIZE": enterprise size , "AGE": enterprise age , "JD": joint dependence , "AD": asymmetry dependence ,"RA": routine amendment ,"RC": routine creation ,"CM": cross-border management

capabilities.

Model 2 and 4 examine the effect of independent variables on mediators. The results showed that there was a significant positive effect of joint dependence on routine amendment (β=0.508, p<0.000) and routine creation (β=0.474, p<0.000), while asymmetry dependence had a significant negative effect on routine amendment (β=-0.376, p<0.000) and routine creation (β=-0.410, p<0.000). Model 7 tests the effect of mediator on the dependent variable and the results show that both routine amendment(β=0.289, p<0.000) and routine creation(β=0.160, p<0.05) have a significant positive effect on digital BMI.

Referring to Hayes (2013), we make bootstrapping using the Model 4 of PROCESS in SPSS. The sample size was 5000, and the confidence interval was 95%. The results show a significant mediating effect of routine amendment and routine creation and **hypotheses 2a-2d** are supported. The results are shown in **Table 5**.

Table 5. Breakdown of total, direct and indirect effects

Path	Joint Dependence→Routine Amendment/Routine Creation→Digital BMI				Asymmetry dependence→Routine Amendment/Routine Creation→Digital BMI			
Indicators	Total effect	Direct effect	Indirect effct-1	Indirect effct-2	Total effect	Direct effect	Indirect effct-1	Indirect effct-2
Boot Effect	0.295	0.134	0.097	0.064	-0.434	-0.211	-0.138	-0.085
Boot SE	0.033	0.030	0.025	0.024	0.068	0.050	0.037	0.035
Boot LLCI	0.229	0.074	0.052	0.023	-0.572	-0.310	-0.230	-0.163
Boot ULCI	0.362	0.194	0.149	0.116	-0.305	-0.112	-0.080	-0.024
Relative Effect		45.42%	32.88%	21.70%		48.64%	31.89%	19.47%

Models 8-10 examine the moderating role of cross-border management capabilities. In detail, model 8 and model 9 represent the regression of routine amendment and routine creation on digital BMI after adding cross-border management capabilities. The results showed that both the interaction between routine amendment and digital BMI (β=0.118, p<0.05) and the interaction term between routine creation and digital BMI (β=0.123, p<0.05) were significant. Therefore, **hypotheses 3a and 3b** are supported.

To further examine the interaction of routine amendment and routine creation with cross-border management capabilities, a simple slope analysis was conducted. **Figure 2** and **Figure 3** reveal the moderating effect of cross-border management capabilities. Both low and high values of cross-border management capabilities have significant moderating effects on routine amendment and routine creation and digital BMI. The line for high cross-border management capabilities is significantly steeper compared to the low value, which intuitively indicates the positive interaction of cross-border management capabilities in promoting digital BMI in enterprises.

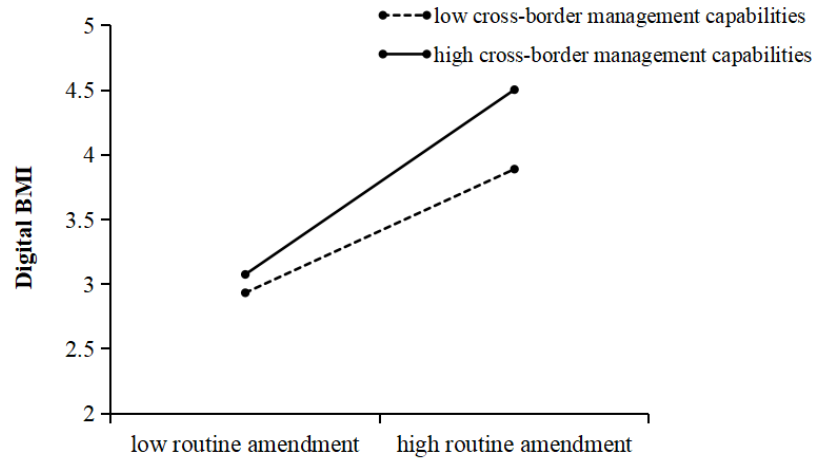

Fig. 2 Moderating effect of cross-border management capabilities on routine amendment and digital BMI

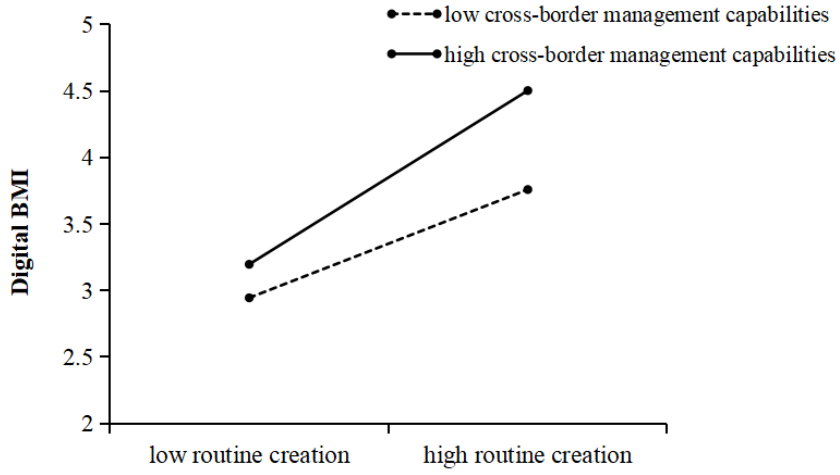

Fig. 3 Moderating effect of cross-border management capabilities on routine creation and digital BMI

5 Discussion and conclusion

5.1 Research summary

The emergence of Industry 4.0 practices and changing market demands in the past few years have led to the emergence of new business models that deliver better value to customers (Dittrich and Seidl 2018; Safavi 2021). One of the main drivers of the innovation system is innovation strategy. For manufacturing SMEs implementing an innovation ecosystem strategy, it is necessary to continuously optimize their production processes and resource management by relying on

managing partnership dependencies with other incumbent enterprises. This can improve efficiency and quality, while also understanding market demand in a timely manner and responding quickly, ultimately achieving digital BMI (Li et al. 2023).

Based on the Optimal Distinctiveness Theory and Dynamic Institution-based View, the mechanism of the joint and asymmetric nature of the incumbent enterprise's dependencies on its digital BMI is examined from the perspective of routine updating, considering the duality of the corporate innovation ecosystem dependencies. The results show that a) joint dependence and asymmetry dependence have opposite effect on digital BMI. There is a significant positive effect of joint dependence on digital BMI and a significant negative effect of asymmetry dependence on digital BMI; b) The mediating role of routine updating between inter-organizational dependencies and digital BMI is significant; c) cross-border management capabilities can moderate the relationship between routine updating and digital BMI, and the positive effect of routine updating on digital BMI is more significant under high cross-border management capabilities.

5.2 Theoretical implications

First, the present research analyzes the effects of joint dependence and asymmetry dependence on digital BMI within the corporate innovation ecosystem and demonstrates the mechanism of inter-organizational on digital BMI. This not only enriches the research context related to inter-organizational dependencies, but also expands the theoretical study about dependence duality. In earlier studies, the relationship of inter-organizational dependencies was mainly in the context of corporate alliances and supply chain management, and the understanding of inter-organizational dependencies was limited to an inter-organizational linkage (Adner 2017; He et al. 2013). As corporate innovation ecosystem has been highly concerned by the academic and business communities, it is of great theoretical value and practical significance to study the specific influence mechanisms of joint dependence and asymmetry dependence on corporate digital BMI (Adner and Kapoor 2010). However, in studies regarding corporate innovation ecosystem, many scholars consider the interdependence between enterprises as the basic characteristics of the ecosystem, without studying its subsequent impact in detail (Adner and Kapoor 2010), or only from the perspective of SMEs exploring how to achieve decoupling of dependencies (Kim and Henderson 2015). This approach of examining union and asymmetry in dependencies separately hardly explains the perversity of why incumbent enterprises of corporate innovation ecosystem pursue high dependence relationships with other enterprises. Therefore, the present research simultaneously examines how duality in dependency affects enterprise choices, which has implications for future research on the evolution of enterprise management dependency and ecological synergy.

Second, when exploring the relationship between inter-organizational dependencies and digital BMI, the present study starts from the essence of digital BMI and selects routine updating as a mediating variable to reveal how interorganizational joint dependence and asymmetry

dependence affect digital BMI. In other words, we open the "black box" of inter-organizational dependencies on digital BMI from the perspective of the evolution of organizational routines and explain the mediating role of routine updating in different dimensions of inter-organizational dependencies and digital BMI, which provides a theoretical basis for how joint dependence and asymmetry dependence realize digital BMI and deepen present theoretical understanding of the path to realize digital BMI (Nigam et al. 2016). In addition, this study considers enterprises' cross-border management capabilities as a boundary and empirically analyzes its moderating role in the influence of routine amendment and routine creation on digital BMI, which better explains the reasons for the differences in digital BMI caused by different enterprises' routine updating. Previous research on cross-border theory in corporate innovation ecosystems mainly focuses on the "matching" perspective, i.e., how to limit the boundaries between enterprises to better facilitate cooperation between them (Kalkanci et al. 2019). The present study, based on the cross-border management capabilities of enterprises, not only focuses on the matching of cross-border activities, but also on the coordination of conflicts of interests in the process of cross-border activities, which extends the research connotation of cross-border theory and provides conceptual insight and empirical basis for subsequent more in-depth theoretical integration studies.

Finally, this research enriches the research context of the optimal distinctiveness theory in the process of enterprises' digital BMI in the corporate innovation ecosystem. The present study analyzes how enterprises in the corporate innovation ecosystem balance the conflicting forces of coherence (gaining legitimacy) and differentiation (gaining competitive advantage) from the perspective of routine updating according to optimal distinctiveness theory. Regarding how to achieve the best distinctiveness of an enterprise in the corporate innovation ecosystem, this study focuses on corporate routines, which are considered to be the identity labels that distinguish an enterprise from others. Under this condition, it can help enterprises to obtain identities in the corporate innovation ecosystem by routine amendment and routine creation. We combine the dynamic institution-based view with the optimal distinctiveness theory, investigating enterprises' optimal distinctiveness in the implementation of digital BMI and researching how they can get continuous innovation, which enrich the context of the optimal distinctiveness theory.

5.3 Managerial implications

First, enterprises in the corporate innovation ecosystem should pay attention to managing the dependencies with other enterprises. Enterprises need to establish long-term stable relationships with their suppliers, which includes certification, auditing, evaluation, and other processes to ensure timely and quality supply of required raw materials or components. They also need to develop close relationships with their customers to understand their needs, respond to their feedback promptly, and ensure that their products or services meet customer demands. By establishing partnerships with other enterprises or organizations, they can jointly develop new products or services, optimize production processes, and resource allocation, and develop new

business models and services to enhance their position in the innovation ecosystem. Furthermore, enterprises can identify their key suppliers and customers, evaluate their impact on their operations, understand market demands in a timely manner, respond quickly, and establish contingency plans to deal with unexpected situations.

Second, in operation practice, enterprises need to regularly evaluate their standardized processes, and if any practices are found to be hindering internal operational efficiency or enterprise network communication, they should constantly innovate and create new, more efficient methods and systems to maximize organizational operational and resource conversion efficiency. Additionally, in the current era of rapid digital technology development, IT and other supporting technologies (including the Internet of Things, big data analysis, and artificial intelligence) can be utilized to help break down departmental barriers, provide real-time data and insights, and gain a better understanding of production processes for faster decision-making and adjustment. By optimizing operations through simple and direct methods, enterprises can minimize waiting time, reduce coordination work, and avoid repetitive tasks while meeting business and management needs.

Finally, in an environment where cross-border activities are active, enterprises need to engage in more active activities with external organizations. Especially when changing the existing routines of the organization, enterprises need to build and maintain a good network identity in the long run, so that the partners within the corporate innovation ecosystem focus on long-term interests rather than short-term gains. For collaborative projects spanning across departments, industries, and domains, enterprises need to establish effective coordination mechanisms to align the interests of all parties involved and seek mutually beneficial outcomes. In addition, senior managers need to be more sensitive to organizational development and be able to capture their opportunities in contact with other enterprises to enhance the effectiveness of digital BMI.

5.4 Limitations and future research

This study still has some theoretical and empirical limitations. First, the sample in this study is small due to the availability of sample information, future studies may consider increasing the sample. Second, the present study examines the digital BMI in the corporate innovation ecosystem from the perspective of routine updating and cross-border management capabilities of a single enterprise. However, the cross-sectional data cannot reflect the dynamic process of corporate routine updating, and future research could consider a follow-up survey in the form of data collection over a longer period to test and extend the theoretical model established by the study. Finally, this study explored the moderating effect of cross-border management capabilities in routine updating and digital BMI, but cross-border management capabilities will be better expressed in larger organizational networks. Future research might focus on the size of the organizational network and examine the boundary role of corporate cross-border management capabilities better in larger value networks.

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