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# Research on the influence of talent ecosystem on firm innovation performance: Based on the mediating role of collaborative innovation

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This paper extends previous studies on the organizational innovation by analyzing the impact of talent ecosystem on firm innovation performance in innovative enterprises. In addition, the mediating effect of collaborative innovation on the relationship between talent ecosystem and firm innovation performance is analyzed. Grounded in the Resource-Based View (RBV) theory, this paper develops an integrative research model which analyzes those relations using structural equation modeling on a dataset of 176 innovative enterprises. Results suggest that talent competence, organizational environment and regional environment of talent ecosystem have a significant positive impact on collaborative innovation, and organizational environment has a stronger effect on collaborative innovation; talent ecosystem can influence innovation performance to different degrees through the mediating role of collaborative innovation (technology synergy and capability synergy); technology synergy in collaborative innovation positively affects innovation performance, while Technology synergy in collaborative innovation positively affects innovation performance, while capability synergy has no significant effect on innovation performance. The findings of the study provide new ideas for enterprises to improve talent ecosystem and enhance innovation performance.

## KEYWORDS

**talent ecosystem, innovation performance, collaborative innovation, resource-based view, China**

## Introduction

From the current world economic development trend, firm innovation to be a driver of firm GVC participation across countries (Reddy et al., 2021), and this change inevitably puts forward new change requirements for HRM work, research on strategic HRM has increasingly emphasized HR systems as an interrelated set of practices to which employees are exposed to achieve some overarching organizational goal. And the idea of changing new thinking is gradually becoming an important direction for the upgrading and

transformation of human resources management (Rondi et al., 2022). In recent years, the interdisciplinary integration research is increasing day by day. The talent ecosystem introduces the idea of ecology into the research field of management, and constantly urges new management ideas in the in-depth exploration of the interaction mode between various elements and the environment, the competition and cooperation mode between talents and organizations, which has attracted the attention of scholars. As an important subject of innovation, how to use and improve their own talent ecosystem, and how to optimize the collaborative innovation behavior of enterprises from the interaction of individual talent, organizational environment and regional environment in the talent ecosystem, so as to improve the innovation performance, are all realistic problems faced by enterprises. In reality, many enterprises, especially large and medium-sized enterprises, objectively have a talent ecosystem, and the way for enterprises to build and improve their talent ecosystem is mainly to develop and adjust their human resource strategies. In terms of theoretical research, talent ecosystem is a composite ecosystem applied to the field of social science, which can apply ecological ideas to study the organization, environment and mechanism related to talent in social system, and provide new ways and thinking for the management of the relationship between talent, organization and environment.

Park and Burgess (1921) first introduced the concept of human ecology in *Introduction to the Science of Sociology*, pointing out that social science research can study human ecology according to the model of community evolution and turnover in the natural world. Since then, the intersection of ecology and social sciences has increased and become a hot spot for scholars. Deolalika and Hasan (1999) proposed the issues related to human resource ecosystem based on the strategic level of enterprises by analyzing the environmental changes of human resource development before and after the Asian financial crisis. Talent ecosystem can be defined as attracting, motivating and retaining talented workers depending on talent markets with various platforms or developing existing talents' skills and capabilities according to newly emerging skill needs of companies (Karaboga et al., 2020). The enterprise talent ecosystem has the function of value output, and can continuously complete the information-energy flow and material circulation based on human resources. Previous studies have more or less explored the interaction between system talent factors, organizational factors and environmental factors and organizational innovation, for example, Altinoz (2018) pointed out that "talent management has also developed in parallel with the information age and has caused people to become the most valuable capital in creating competitive advantage." Michaelis et al. (2018)'s research provides empirical evidence for a clearer picture of innovation culture, as well as how innovation culture relates to new product performance. Hueske et al. (2015)'s research uses stakeholder

theory to identify external innovation barriers and takes the external environment as a single level of analysis.

It can be seen that talent ecosystem is an important way to enhance the innovation performance of enterprises, and enterprises with good talent ecosystem are more likely to obtain information, reduce innovation cost and enhance innovation performance than those without good talent ecosystem. In the era of knowledge economy, collaborative innovation has gradually become the main way for enterprises to carry out innovation activities. Relying on an individual or an enterprise to carry out innovation alone can no longer meet the requirements of the whole process of innovation activities. Therefore, collaborative innovation can reduce the dependence of an enterprise on an individual and reduce the negative impact of an individual in case of defects (Gloor, 2006) and gradually becomes the main form of enterprise innovation. Collaborative innovation is an innovation activity in which different elements are organically coupled and complement each other, and this process often leads to value growth, which makes collaborative innovation involving multiple individuals and elements a key area of research. Pan and Li (2016) consider the cost functions of product and process innovation are dependent on the knowledge accumulations of product and process innovation. To maximize the value of process and product innovation, supply chain members should conduct collaborative innovation (Lee and Schmidt, 2017). Wang and Hu (2020) argued that innovation can be achieved across enterprise and industry boundaries by sharing knowledge, technology and ideas among innovation agents. Under the collaborative innovation paradigm, collaborative behavior becomes a necessity for innovation activities, and the boundaries of enterprises are no longer closed, and technological and capability collaboration is no longer limited to the internal organization. By conducting internal and external collaboration, firms can reduce uncertainty in the process of technology innovation realization and improve innovation performance. In fact, through resource and information sharing in the talent ecosystem, enterprises promote the realization of collaborative innovation behavior. At the same time, because collaborative innovation in the talent ecosystem is systematic and talent-oriented, it can ensure that the utility of core resources for innovation increases, and when the utility of all elements in the talent ecosystem increases, the innovation performance of enterprises can also be improved. The role of collaborative innovation in the relationship between talent ecosystem as a strategic resource and innovation performance is one of the focuses of this paper.

However, there are few studies on the interaction between talent ecosystem, innovation behavior and innovation performance at enterprise level, and the following research gaps exist: firstly, there is no systematic research on the structural dimensions of talent ecosystem at enterprise level; secondly, there are few studies on the influence mechanism of different dimensions of talent ecosystem on innovation

performance, and the corresponding theoretical analysis framework has not been established yet, which provides obvious theoretical guidance for the improvement of enterprise innovation performance. Finally, innovation performance, as a direct result of innovation behavior, is the product of the interaction and reconstruction of various groups and elements in the talent ecosystem, and the influence of talent ecosystem on innovation performance may be influenced by collaborative innovation behavior. This paper examines the literature on the elements of talent ecosystem and concludes that although there are differences in the understanding of the elements, the existing studies generally consider talent elements as the core structural elements of talent ecosystem and the ecological environment associated with talent, including organizational environment elements and social environment elements, as the basis of talent ecosystem construction. Thus, this paper divides the talent ecosystem into three dimensions: talent competence, organizational environment, and regional environment. Drawing on scholars' elaboration on the concept of collaborative innovation and considering the internal perspective of enterprise talent ecosystem, this paper attributes collaborative innovation behavior to the synergy between enterprises in both technology and capability. On this basis, we attempt to empirically study the relationship between enterprise talent ecosystem and innovation performance and verify the mediating effect of collaborative innovation in this process, so as to provide a new path for enterprises to gain sustainable competitive advantage and promote innovation performance.

In summary, the main contributions of this paper are as follows: 1) Using the ecosystem as the research perspective, we use empirical analysis to discover the path, intensity and effect of the talent ecosystem and the innovation performance of enterprises, which not only expands the research perspective of modern enterprise human resource management, but also enriches the research scope of ecological theory. 2) Using collaborative innovation as a mediator, we construct the path of "talent ecosystem—collaborative innovation—innovation performance," and sort out the inner mechanism of talent ecosystem affecting innovation performance. 2) Using collaborative innovation as the mediator, we build the path of "talent ecosystem—collaborative innovation—enterprise innovation performance," and sort out the inner mechanism of talent ecosystem affecting enterprise innovation performance, which effectively remedies the lack of research on the relationship between talent ecosystem, collaborative innovation and innovation performance. 3) From the micro-enterprise perspective, we have systematically explained the path of enterprise innovation performance, which is a new interpretation of the path of enterprise innovation performance by using empirical methods to verify the mechanism of the role of talent ecosystem and enterprise innovation performance, which

undoubtedly deepens the theoretical study of organizational innovation.

## Theoretical background and hypotheses

The Resource-based view (RBV) has become a standard to explain why firms in the same industry vary systematically in performance over time (Hoopes et al., 2003). This suggests that the effects of individual, firm-specific resources on performance can be significant (Mahoney and Pandian 1992). The RBV generally tends to define resources broadly and includes assets, infrastructure, skills, and so on. In this regard, it is based on two underlying assertions: resource heterogeneity and resource immobility. Resources possessed by competing firms are heterogeneously distributed and may be a source of competitive advantage when they are valuable, rare, difficult to imitate, and not substitutable by other resources (Barney 1991). Based on resource-based theory, Hult argue that an organization's strategic resources or capabilities first influence the organization's strategic behavior, and strategic behavior further influences organizational performance, strategic behavior is a mediating variable for the influence of an organization's strategic resources or capabilities on its strategic performance (Ketchen et al., 2007).

Collaborative innovation is derived and developed from collaborative theory. In 1969, Haken first proposed the concept of "Synergetics." He pointed out that Synergetics is an effective method to deal with complex systems, which can solve the phenomena or problems composed of many complex systems encountered in social practice (Hermann, 1977). Palford pointed out in their research that collaborative innovation activities are three dynamic ability processes of perception, acquisition and reconfiguration, and its mechanism is that perception enables enterprises to identify innovation opportunities faster. Then collect information to obtain the required innovation knowledge, and finally complete the innovation through resource reconfiguration. And these three parts are interrelated and continuous, which helps enterprises cope with the changing business environment and gain competitive advantage (Alford and Duan, 2018). Supported by the collaborative innovation theory, it helps to put forward solutions suitable for the enterprise's own talent ecosystem itself.

This paper considers talent ecosystem as strategic resources, collaborative innovation as strategic behavior, and innovation performance as the expression of strategic performance. Thus, this paper, from a knowledge-based perspective, studies the relationship between talent ecosystem, collaborative innovation and innovation performance as well as the mediating effect of collaborative innovation on the relationship between talent ecosystem and innovation performance. The theoretical model involves three main

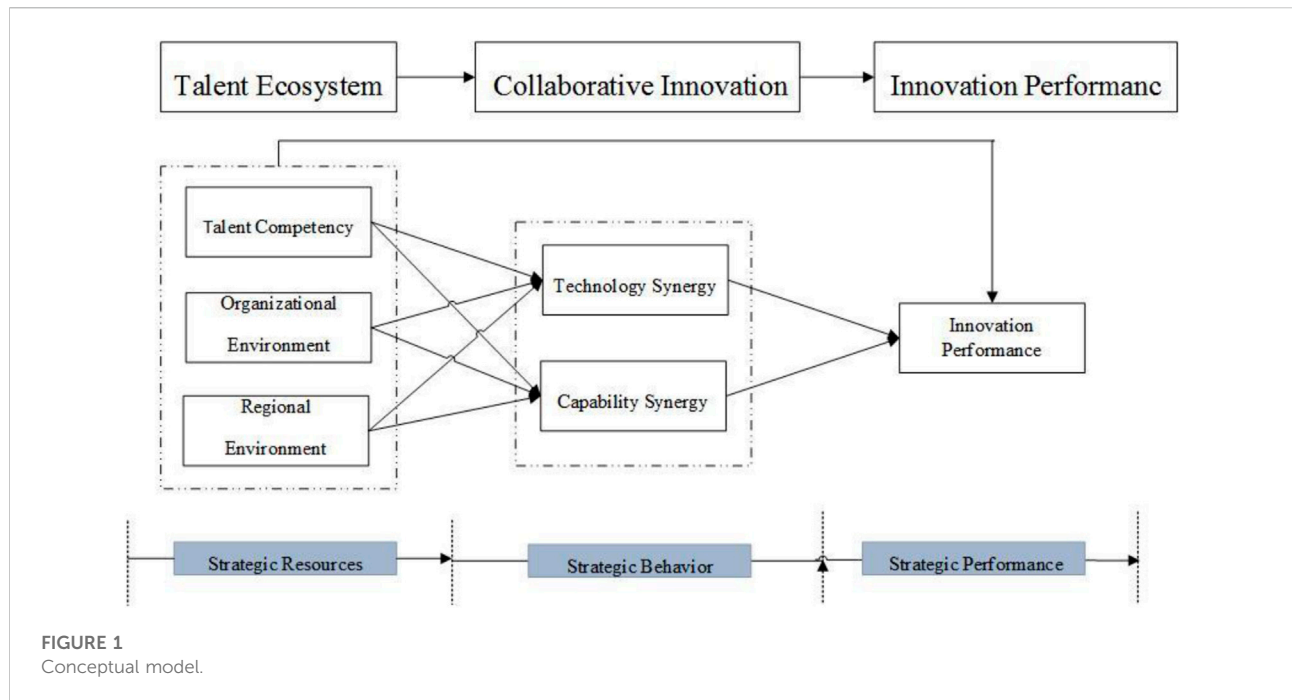


FIGURE 1  
Conceptual model.

variables: First, talent ecosystem (including talent competency, organizational environment and regional environment). The second is collaborative innovation (including technology synergy and capability synergy). The third is innovation performance (including new product launch frequency, new product development cycle, new product market acceptance, new product quality, and new product market development power). The relationship between them is shown in Figure 1.

## Talent ecosystem and collaborative innovation

The value output of the talent ecosystem is a complex process, which depends not only on the improvement of the competency characteristics of the talent population in the talent ecosystem, but also on the improvement of the organizational environment, such as the support of the corporate culture for innovation and the improvement of the management style, and as an important support of the system, the regional environmental factors such as the support of government departments are also closely related to it. In order to adapt to the complex and dynamic development environment, enterprises use the mobility of talent resources to continuously carry out material circulation, and form a relatively stable system of interdependence among talent individuals, talent and organization, talent and environment, so as to promote energy flow and information transmission. The talent competency of talent ecosystem is the combination of knowledge, skills, traits

and other competency characteristics that are closely related to good innovation performance of organizational innovation talents in the process of conducting innovation activities. Technology synergy refers to a firm ability to effectively transform common technologies into capabilities by cooperation (Soto-Acosta and Meroño-Cerdan 2008). In terms of research on the relationship between talent competency and technology synergy, Clarysse et al. (2014) pointed out that knowledge heterogeneity and organizational knowledge capabilities positively affect the path relationship of knowledge synergy in collaborative innovation; Hoffman and HegartyW (1993) pointed out that the competency trait of innovation individual managers' innovativeness helps companies identify innovation opportunities, promote a corporate atmosphere that encourages innovation, improve the process of innovation activities, and achieve mutational innovation. Based on scholars' research, this paper argues that collaborative innovation is the main form of current innovation activities, and that companies realize the interaction of knowledge within the talent ecosystem based on talent competencies during the implementation of innovation behaviors, which in turn promotes the integration of technology sources and achieves technology synergy.

Competency synergy is mainly characterized by the consistency of vision, the degree of cooperation and trust, and the ability to coordinate and collaborate among innovation individuals. A high degree of capability synergy means a better willingness to collaborate and a higher degree of mutual trust, which not only promotes the collaboration process but also

reduces the occurrence of undesirable behaviors (Juana et al., 2018). Generally speaking, partnership runs through the whole collaborative innovation process, and a harmonious collaborative relationship can effectively reduce communication costs, promote capability synergy, and improve the efficiency of collaborative innovation behavior (Gallear et al., 2012). The innovation of knowledge and technology depends on talents (Yang, 2018). Moreover, the ability to innovate, especially in dynamic environments, results from the collective ability of employees to share and combine knowledge (Nahapiet and Ghoshal, 1998). Collaborative innovation behavior relies on talent competence, and the level of competence of individual talents is often closely related to the consistency of goal vision, the degree of trust, and the degree of coordination and cooperation of collaborative subjects, which shows that talent competence can have an important impact on capability collaboration. Based on the above analysis, this paper proposes the following hypotheses.

Ha1: There is a positive relationship between talent competency and technology synergy.

Ha2: There is a positive relationship between talent competency and capability synergy.

The organizational environment in the talent ecosystem is the innovation culture and climate fostered by the organization to support innovative behavior. Organizational environment is referred to as a set of norms, procedures, beliefs and core values that guide and direct its members' thinking and behaviors toward each other as well as the organization's related stakeholders (Cadorin et al., 2017). The organizational environment largely determines the ability of firms to collaborate on innovation. Organizational factors are important drivers for the adoption and implementation of IT innovations (Aboelmaged 2014). In the discussion of the relationship between organizational environment and technology synergy, it has been pointed out that the technological innovation capability of enterprises is not only influenced by resource factors, but also by the environment of interaction between innovation subjects and other factors (Todtling 1992). An innovation-oriented organizational environment not only enables firms to search for complementary or alternative innovation resources in a timely manner, but also gives them a strong advantage in predicting the potential business value of technologies and technological innovation opportunities (Lam et al., 2021), which facilitates technology synergy. As argued by Kayworth, organizational culture is a key factor in facilitating an effective knowledge management process, including knowledge creation, transfer, and application of new and existing knowledge (Kayworth and Leidner, 2004), and it is easier to form technology synergy. In a study related to the relationship between organizational environment and capability synergy, it has been confirmed that organizational culture plays an important role in developing knowledge management. How firms interact with

related stakeholders determines the efficiency of managing external information, which in turn, affects the firms' ability to implement open innovation (Zhu et al., 2019). Aenetz et al. (2011) pointed out that providing a comfortable and positive climate is beneficial for reducing individual stress and enabling innovative talents to engage in innovation activities more efficiently. Thus, this paper argues that the organizational environment plays an important role in capability synergy. Based on the above analysis of the relationship between organizational environment and technology synergy and capability synergy, the following hypotheses are proposed.

Ha3: There is a positive relationship between organizational environment and technology synergy.

Ha4: There is a positive relationship between organizational environment and capability synergy.

The regional environment mainly examines how well the resource, technological, policy, financial, and infrastructural environment of the firm's region supports innovation activities. In terms of research related to the relationship between regional environment and collaborative innovation, Thorgren suggested that government-related policies play an important role in stimulating collaborative innovation behavior of firms (Thorgren et al., 2009). By increasing the scope and frequency of knowledge collaboration among heterogeneous firms, governments can increase the dynamism of knowledge exchange and thus contribute to the growth of firms' innovation performance (Abdollahbeigi and Salehi, 2019). Sun and Cao found that industry innovation policy can mitigate market failures, guide innovation, reset resources, improve the competitive and innovation environments, help build innovation networks, and improve firm innovation capabilities (Sun and Cao 2018). The regional innovation environment can play a supportive role in clustering innovation factors and promoting technological synergy. However, innovation activities are difficult to be achieved by individual enterprises alone, and require the coordination of multiple actors to develop into a good synergy of capabilities. For example, Pulka studied that the government can play a policy-oriented role through political advantages to strengthen the willingness of various subjects to continuously participate in collaborative innovation and promote capability synergy, which helps to reduce the potential risks of collaboration and the probability of opportunistic behavior (Pulka et al., 2021). Building a positive social climate may be crucial to motivate employees to work together through electronic networks and increase e-business use for collaboration and knowledge sharing (Valkokari et al., 2012). Based on the above scholars' studies, this paper argues that regional environment plays an important role in capability synergy. On the basis of technology and capability synergy, regional environment can play a strong role in supporting collaborative innovation behavior. Based on the above analysis, this paper proposes the following hypotheses.

Ha5: There is a positive relationship between regional environment and technology synergy.

Ha6: There is a positive relationship between regional environment and capability synergy.

## Talent ecosystem and innovation performance

Hearn and Pace (2006) first proposed the concept of Value-Creating Ecologies (VCEs), and in their study, they elaborated on the value symbiosis, arguing that the value creation of this symbiosis depends on the industrial ecosystem composed of talents, enterprises, related sectors, and other subjects ecosystem. Innovation performance is one of the important forms of their value performance, therefore, the concept of value creation ecology itself contains the inner logic that organizational ecosystems can influence organizational performance (Baležentis et al., 2021). In terms of research on the relationship between talent competency and innovation performance. A joint survey of Capgemini and LinkedIn indicates that organization-wide digital talent gap has become a big challenge that affects both competitiveness and digital transformation progress negatively (Capgemini Research Institute and LinkedIn 2017). Vyakarnam and Handelberg (2005) state that higher innovation performance is generated thanks to the integration of knowledge, skills, and competencies of different individuals in innovation activities. Based on the above studies, this paper argues that talent competency directly affects innovation performance, and the stronger the talent competency, the better the innovation performance should be.

In terms of research on the relationship between different dimensions of organizational environment and innovation performance, Goodale et al. (2011) verified that top management support, organizational boundaries in organizational environment have a significant positive effect on innovation performance based on research data from 177 different industries in the U.S. Pasamar et al. (2015) argued that organizational culture encourages change is more beneficial to break the limits and also tends to be associated with higher levels of innovation associated with higher levels of innovation. Shen et al. (2022) investigated the impact of technological innovation on promoting ecosystem performance. Drawing on the views of related scholars, this paper argues that organizational environment can influence firms' innovation performance, and the stronger the role of organizational environment in supporting innovation, the better the innovation performance.

The supporting role of regional innovation environment is mainly reflected in the technological development of enterprises relying on various innovation policies and innovation infrastructure to promote the diffusion of new technologies, so as to realize the scale effect of economic growth. In the

context of innovation management research, the external environment is often used as an important antecedent variable in the mechanism of action of firms' innovation activities. Firms in real-life situations are always able to receive various signals from the external environment and, as adaptive organizations, constantly respond to stimuli in an adaptive manner. Resource-based theory suggests that the outcome output of innovation activities is related to the acquisition, replenishment and integration of resources. Referring to the external environment, including both market and technological turbulence, Mina's research highlighted the negative role of technological turbulence in sustainable innovation (Nasiri et al., 2021). Drawing on the views of related scholars, this paper argues that the regional environment can have a significant impact on the innovation performance. The comprehensive analysis leads to the following three hypotheses.

Hb1: There is a positive relationship between talent competency and firm innovation performance.

Hb2: There is a positive relationship between organizational environment and firm innovation performance.

Hb3: There is a positive relationship between regional environment and firm innovation performance.

## Collaborative innovation and innovation performance

Collaborative innovation activities can interact information resources and change the situation of one-way, even closed information channels among collaborative subjects (Wang and Hu 2020). Collaboration can provide enterprises with ways and opportunities to obtain high-quality resources. Only by cooperating with both or more parties to build a good collaborative relationship, can they reduce obstacles in promoting knowledge and information transmission, improve resource utilization efficiency, and then improve innovation performance. How can collaborative innovation behavior of enterprises affect innovation performance? First, the key to collaborative innovation lies in technological synergy. By participating in technically collaborative R&D, enterprises are more likely to collect and store a larger amount of heterogeneous technical knowledge, which can also provide greater support for technological innovation. Technological synergy is the extent to which firms collaborate at the technological level in carrying out innovation activities. The supporting effect of technological synergy on innovation performance is mainly manifested as follows: in the process of carrying out collaborative innovation activities, technological synergy can effectively expand enterprise technical information channel resources, and the wider the scope of cooperation, the more it can broaden the width of technology and knowledge base, and the more it can enrich the variety of enterprise knowledge sources, which in turn can promote the

improvement of enterprise innovation performance (Benitez et al., 2020). Generally speaking, knowledge sources and knowledge stocks within enterprises are relatively stable, and at the same time, technical problems often show homogeneity, so for knowledge-intensive industries, especially high-tech enterprises, extensive cooperation is a proven way for enterprises to expand knowledge increment in the development process, and it is also an effective form for enterprises to acquire complementary knowledge, unique ideas and breakthrough technological innovations. It is beneficial to spawn original innovation activities and create collective value. The collision of knowledge and technologies from different firms increases the level of knowledge flow and subsequently enhances innovation performance (Carliss et al., 2011). Jesús Nieto and Santamaría (2007) found a significant positive relationship between the degree of collaboration among suppliers, customers and research organizations and the degree of product innovation based on research data from Spanish manufacturing firms. A large number of empirical studies have shown that the synergy between firms and external technology sources can enable firms to obtain support in the acquisition of complementary resources and achieve the accumulation of diverse knowledge within the firm, in addition, technology synergy has incomparable advantages in reducing corporate risks and sharing R&D costs, which can ultimately promote innovation performance.

Secondly, capability synergy characterizes the degree of trust, coordination and consistency of vision among collaborative subjects in the process of innovation activities. Whether knowledge can be efficiently shared and absorbed in the process of collaborative innovation is usually determined by the degree of capability synergy among innovation subjects. The supporting effect of capability synergy on innovation performance is mainly manifested by the fact that in the innovation process, collaborative subjects discover new opportunities by interacting with others, which leads to the improvement of innovation creation capability (Xu et al., 2018). In particular, when firms search for technologies across borders, their ability to adapt to the dynamic changing environment is also enhanced by achieving capability synergy through coordination and cooperation with different innovators (Wang et al., 2014). Firms are developing more and more collaborative behaviours (shared databases, repositories, discussion forums, workflow.) for the execution of the innovation process (Meroño-Cerdan et al., 2008a). As a consequence, Meroño-Cerdan et al. (2008b) found that most collaborative behaviours are positively related to innovation performance. Meanwhile, deep collaboration among innovation subjects often implies lower knowledge transfer costs, information asymmetry risks and higher trust and cooperation tacit understanding, which makes the transfer, integration and sharing of tacit knowledge more efficient (Serrano and Fischer, 2007). And the closer the collaboration

between subjects and the higher the degree of capability synergy, the higher the degree of understanding of the innovation elements required for R&D and the innovation resources endowed by collaborating partners, the more targeted the enterprises can acquire, assimilate and transform technological knowledge in the synergy, and the more advantageous they can gain in reducing the innovation knowledge search cost and screening cost and promoting the innovation performance. Based on the above arguments, the following two hypotheses are proposed.

Hc1: There is a positive relationship between technology synergy and firm innovation performance.

Hc2: There is a positive relationship between capability synergy and firm innovation performance.

## The intermediary role of collaborative innovation

The essence of collaborative innovation is the collaborative behavior of each innovation subject to reach innovation synergy and achieve value increase based on the interaction of elements. These interactions and diverse collaboration are mainly manifested in the synergy of each innovation subject in terms of technology and capability. In the process of talent ecosystem acting on innovation performance, the collaborative innovation behavior of enterprises can expand the scope of resource search, and enterprises can identify the needed technologies in the larger knowledge system, realize the complementary knowledge in the R&D process, and gradually improve the technical synergy of collaborative teams in the process of continuously realizing the synergy of technology sources, and at the same time continuously feed themselves to form a sustainable innovation capability, so the collaborative innovation in Therefore, collaborative innovation plays a mediating role in the relationship between talent ecosystem and innovation performance. The innovation effectiveness of enterprises depends on the implementation of innovation strategies, and innovation behavior not only determines the level of technological innovation, but also the market share of enterprises (Ritter and Gemünden, 2004). The essence of the intermediary role of the internal collaborative network is the interaction of resources in the collaborative network. Specifically, the integration of innovation factors requires the collaborative network as a medium for transferring flows, while collaborative sharing based on the collaborative network also plays an important role in the firm's ability to enhance innovation creation and commercialization (Stoji, 2021). As a result, the following hypothesis is proposed.

Hd: Collaborative innovation mediates the relationship between talent ecosystem and firm innovation performance.

## Research methodology

### Data collection and sample

The organizations selected for this study are innovative enterprises from China. As countries around the world continue to make efforts in innovation research and development, pilot innovative enterprises have developed into an important part of improving national innovation system. In the new era of innovation development, scholars at home and abroad have also continuously invested in the research and discussion of innovative enterprises in the academic research field. Innovative enterprises are enterprises that possess independent intellectual property rights and well-known brands and rely on technological innovation to gain competitive advantages. Taking innovative enterprises as the research object, based on the pilot list of innovative enterprises approved by the Chinese government, this paper preliminarily screened innovative enterprises in China, selected representative innovative enterprises as the research object, and collected data by mailing questionnaires. Data collection was conducted in two stages: a pilot study and a questionnaire were conducted. Nine SMEs were randomly selected from a database to pretest the questionnaires. Based on these responses and subsequent interviews with participants in the pilot study, minor modifications were made to the questionnaire for the next phase of data collection.

The population considered in this study was the set of all Chinese innovative enterprises. In order to avoid potential errors, each enterprise was filled out by at least two people. 176 enterprises were involved in this research. A total of 370 were identified and contacted for participation. The survey was administered in face-to-face interviews with to the CEO of the companies and the unit of analysis for this study was the company. In total, 352 valid questionnaires were obtained, yielding a response rate of 95.1 percent. The dataset was examined for potential bias in terms of non-response by comparing the characteristics of early and late participants in the sample. These comparisons did not reveal significant differences in terms of general characteristic and model variables, suggesting that non-response did not cause any survey bias.

### Measures

Measurement items were introduced on the basis of a careful literature review. The survey questionnaire was originally designed in English as the key measures used in this study were operationalized using already established instruments published in that language. Scales were measured on a 5-point Likert scale with anchors from strongly disagree (1) to strongly agree (5). We used the back-translation method to ensure the

validity of the translation (Brislin 1980). Existing scales were translated into Chinese and, where necessary, slight wording changes were made to adapt the questions to the context of the study. The research instrument was pretested with several different researchers and managers. Our primary objective was to detect inadequate wording and facilitate the ease of administering the instrument. The results from the pretest showed no particular bias, but some respondents had trouble understanding certain items.

Variables were operationalized as multi-item constructs. This paper contains six latent variables: talent competency, organizational environment, regional environment, technology synergy, capability synergy, and innovation performance. The talent competency construct mainly characterizes the degree of talent competency within the enterprise, mainly referring to the scale compiled by Wright (2005) and Spencer and Spencer (1993). The organizational environment concept is mainly characterized as the innovation culture, innovation atmosphere and innovation environment in the organization where the company conducts innovation activities, mainly referring to the scales developed by Castro et al. (2013) and Hurley and Hult (1998). The regional environment level indicators mainly examine the status of resources, technology, policy, finance and infrastructure environment in the region where the firm is located, mainly referring to the research results of Zahra (1993). The measurement of the concept of collaborative innovation mainly refers to the research results of Desouza and Awazu (2006) (Carson and Gilmore, 2000) and Abhari et al. (2017), and the concept includes two dimensions of technology synergy and capability synergy. Among them, the technology synergy dimension is measured by five measures and the capability synergy dimension is measured by three measures. Innovation performance is a multidimensional variable, and this paper draws on the innovation performance measurement indicators of Zhang and Li (2010), and it is measured by five indicators: Launch frequency of new products, development cycle of new products, market acceptance of new products, quality of new products and market development power of new products. The formulation and criteria for answering the questionnaire are defined in the Appendix.

### Data analysis

In this paper, the reliability of the six latent variable scales was measured using Cronbach's alpha coefficient to determine the reliability of each scale. The measurement results showed (Table 1) that the alpha coefficient values of each latent variable were greater than 0.8, indicating a high degree of stability of each scale. Before the factor analysis, the KMO values were used to determine the bias correlation among the variables, and the Bartlett's sphericity test was used to determine the independence of the variables. The validity test results showed



TABLE 1 Test results of reliability and validity.

Variable	Cronbach's $\alpha$	Factor loadings	KMO	Bartlett's sphericity test		Cumulative variance contribution rate%
				Chi-square value	<i>p</i> value	
Talent competence	0.935	>0.6	0.951	1986.190	0.000	69.005
Organizational environment	0.840	>0.5	0.855	669.963	0.000	62.173
Regional environment	0.906	>0.7	0.825	961.770	0.000	78.379
Technology synergy	0.864	>0.5	0.841	829.226	0.000	64.900
Capability synergy	0.843	>0.6	0.718	441.296	0.000	76.236
Innovation performance	0.927	>0.7	0.888	1340.076	0.000	77.462

(Source: own elaboration).

TABLE 2 Correlation analysis.

	M	SD	Talent competence	Organizational environment	Regional environment	Technology synergy	Capability synergy	Innovation performance
Talent competence	3.782	0.836	1					
Organizational environment	3.779	0.817	0.426**	1				
Regional environment	3.236	1.053	0.365**	0.318**	1			
Technology synergy	3.765	0.835	0.554**	0.579**	0.369**	1		
Capability synergy	3.742	0.980	0.548**	0.511**	0.364**	0.828**	1	
Innovation performance	3.381	1.015	0.543**	0.534**	0.453**	0.620**	0.583**	1

Note: \*\* indicates significance level  $p < 0.01$  (Source: own elaboration).

that the KMO values of the six latent variables in the conceptual model were all greater than 0.7, and the significance levels of the approximate chi-square values of the Bartlett's sphericity test were all 0.000 (less than 0.001). Moreover, the cumulative variance contributions of the extracted factors of the six latent variables were higher than 60%, and the factor loadings of each construct were higher than 0.5, so the six latent variables met the requirements of structural validity. In addition, all the scales in this paper were derived from validated mature scales, and the measurement items had good content validity. The comprehensive test results indicated that the validity level of the measurement items was high, and each variable was suitable for factor analysis.

The correlation analysis of each research variable was performed, and the results are shown in Table 2, and there is a significant correlation between each variable. This conclusion initially proves the hypothesis proposed in this paper, and in order to ensure the reliability, the paper then applies the structural equation model for the subsequent analysis.

In this paper, validation factor analysis was conducted on each latent variable using AMOS software, and the results showed that the combined reliability (CR) of the six latent variables in the conceptual model were all greater than 0.8,

and the question-item measures had good internal consistency. In addition, the average variance variances (AVE) of the six latent variables were all greater than 0.5, which reached the ideal value, indicating that the convergent validity was generally good. The goodness-of-fit indicators of the three constructs of talent ecosystem, collaborative innovation, and innovation performance all reach the standard values and have good structural validity, and the factor loadings of each latent variable question item exceed 0.5, and the model test results indicate that the explanatory relevance of the question items to the factors is significant. Combined with the above test results, the inherent quality of the pre-defined models for the three constructs of talent ecosystem, collaborative innovation, and innovation performance is ideal.

## Instrument validation

According to the conceptual model, this paper uses AMOS24.0 to construct the initial structural equation model for calculation. Among them, three exogenous latent variables of talent competency, organizational environment and regional environment are subordinate dimensions of

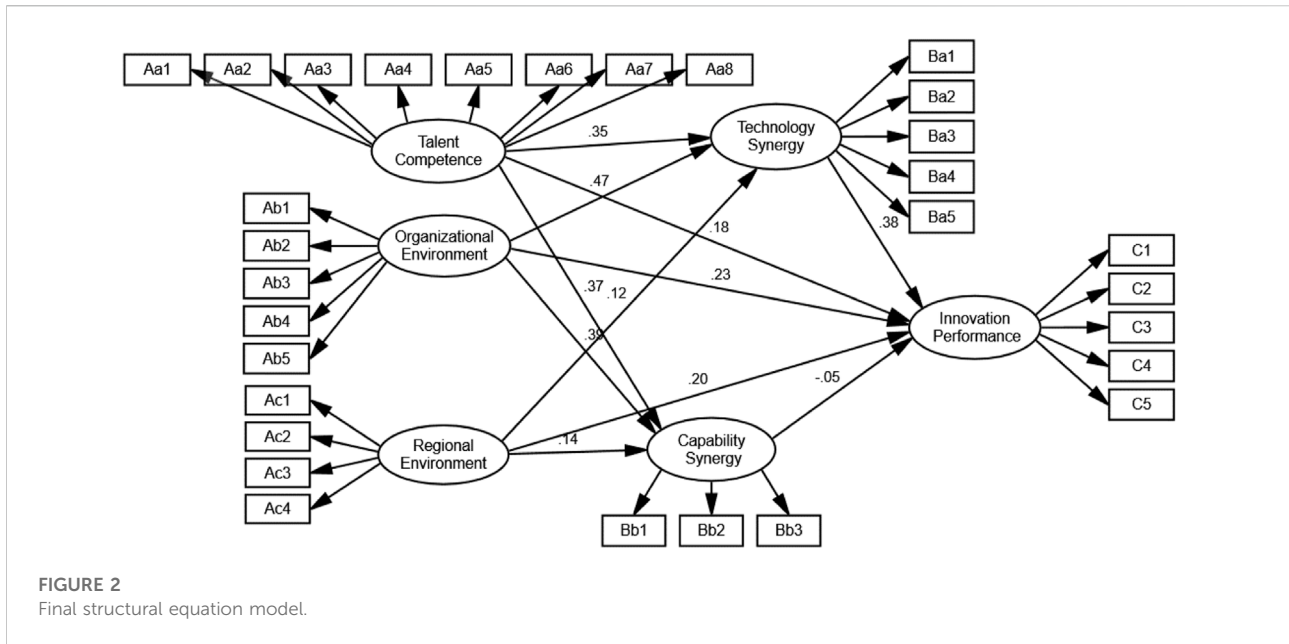


FIGURE 2 Final structural equation model.

TABLE 3 Comparison of simulation fitting results.

Indicator	$\chi^2/df$	RMSEA	GFI	AGFI	NFI	CFI	RFI	TLI	PNFI	PCFI
Fitting criteria	<math>\chi^2/df > 1</math>	<math>< 0.08</math>	>0.8	>0.8	>0.9	>0.9	>0.9	>0.9	>0.5	>0.5
Before correction	2.506	0.065	0.852	0.824	0.877	0.922	0.863	0.913	0.788	0.828
After correction	1.798	0.048	0.886	0.862	0.913	0.959	0.902	0.954	0.808	0.849

(Source: own elaboration).

TABLE 4 Results of structural equation model path coefficients and hypothesis testing.

Hypothesis	Standardized path coefficients	C.R.	p	Result
Ha1 Talent competency → Technology synergy	0.354	6.222	***	√
Ha2 Talent competency → Capability synergy	0.366	6.279	***	√
Ha3 Organizational environment → Technology synergy	0.465	7.344	***	√
Ha4 Organizational environment → Capability synergy	0.388	6.135	***	√
Ha5 Regional environment → Technology synergy	0.122	2.403	0.016	√
Ha6 Regional environment → Capability synergy	0.136	2.578	0.010	√
Hb1 Talent competency → Innovation performance	0.180	3.147	0.002	√
Hb2 Organizational environment → Innovation performance	0.231	3.500	***	√
Hb3 Regional environment → Innovation performance	0.196	4.078	***	√
Hc1 Technology synergy → Innovation performance	0.374	4.711	***	√
Hc2 Capability synergy → Innovation performance	-0.047	-0.881	0.378	×

Note: \*\*indicates significance level  $p < 0.01$  (Source: own elaboration).

talent ecosystem, characterizing the structural features of enterprise talent ecosystem. In addition, three endogenous latent variables of innovation performance, technology

synergy and capability synergy are also set. The initial structural equation model was carried out 10 iterations using the great likelihood estimation, and finally converged

TABLE 5 Results of the test of the mediating effect of collaborative innovation.

	Estimate	S.E.	Bias-corrected bootstrap		Effect	Result
			Lower 95% CI	Upper 95% CI		
Talent competency→	0.123	0.039	0.056	0.214	Indirect effect	Partial mediation
Collaborative innovation→	0.191	0.063	0.065	0.307	Direct effect	
Innovation performance	0.314	0.057	0.204	0.431	Total effect	
Organizational environment→	0.240	0.062	0.134	0.385	Indirect effect	Partial mediation
Collaborative innovation→	0.355	0.124	0.138	0.625	Direct effect	
Innovation performance	0.595	0.106	0.419	0.838	Total effect	
Regional environment→	0.035	0.019	0.004	0.081	Indirect effect	Partial mediation
Collaborative innovation→	0.172	0.046	0.084	0.264	Direct effect	
Innovation performance	0.206	0.045	0.117	0.294	Total effect	

(Source: own elaboration).

to obtain the model fit index, followed by the correction of the initial model by increasing the correlation between error variables, and after the correction, the model fit indexes all reached the ideal values to obtain the final structural equation model (Figure 2).

After the model was revised, AMOS24.0 was run to analyze and calculate again, and the results are shown in Table 3. All the indicators are within the ideal range of the fitted indicators and are optimized compared with the initial model, and the overall fit is good. The hypothesis test results show (Table 4) that the path relationship of capability synergy on enterprise innovation performance is not significant, i.e., Hc2 does not pass the test ( $p > 0.05$ ), and all other path hypotheses are supported, i.e., Ha1, Ha2, Ha3, Ha4, Ha5, Ha6, Hb1, Hb2, Hb3, and Hc1 pass the hypothesis test.

In this paper, we use the Bootstrap test in AMOS to reveal the mediating effect of collaborative innovation between talent ecosystem and innovation performance. We set the sampling number to 2000 and repeat sampling with put-back, and use Bias-corrected Bootstrap to estimate (95% confidence interval). The opposite is not significant. As shown in Table 5, the interval of indirect effect of collaborative innovation between talent ecosystem and innovation performance does not contain 0, thus the indirect effect is significant and the mediating effect exists. To determine whether the mediating effect of co-innovation is partially mediated or fully mediated, the direct and total effects should be further verified. The results of Bootstrap test in this study show that both the direct effect and the total effect interval do not contain 0 (95% confidence interval), so it is partial mediation, i.e., hypothesis Hd is supported. Collaborative innovation plays a partially mediating role in the effect of corporate talent ecosystem on corporate innovation performance.

## Result

Based on the resource-based theory, this paper establishes the conceptual model of “talent ecosystem-collaborative innovation-firm innovation performance” and selects 352 samples for empirical testing.

- (1) Talent competency, organizational environment and regional environment of talent ecosystem have positive effects on technological synergy and capability synergy in collaborative innovation, but the strength of the effects are not consistent. Specifically, organizational environment has a stronger effect on technology synergy and capability synergy, followed by talent competency. A good organizational innovation environment is very important for enterprises to implement collaborative innovation behaviors, and the benign operation of enterprise talent ecosystem largely benefits from a good internal environment of the organization. It can be seen that the creativity of enterprise talents is inseparable from their internal innovation environment. Enterprises should provide a good innovation atmosphere for talents in collaborative innovation, cultivate a corporate culture conducive to innovation, build a platform for communication, and strengthen individual cooperation; at the same time, they should respect the main role of talents in collaborative innovation behavior, continuously explore the value of talents from all aspects of their competency, adjust the structure of talents, and realize the great improvement of their competency and the effective guarantee of organizational environment, so as to promote the implementation of collaborative innovation behavior.
- (2) Talent competency, organizational environment and regional environment indirectly contribute to the innovation performance of enterprises through collaborative innovation (both technology synergy and

capability synergy), collaborative innovation plays a part in mediating the relationship between talent ecosystem and innovation performance. In addition, among the three paths of talent ecosystem acting on innovation performance, organizational environment has the greatest influence on innovation performance through the intermediary of collaborative innovation. The empirical test results show that enterprises should focus on the improvement of organizational environment in the process of building and improving talent ecosystem. Enterprises should cultivate a good organizational environment with the spirit of innovation and continuously strengthen the supporting role of organizational environment in the process of implementing collaborative innovation strategy, and at the same time, they should make good use of the catalytic role of regional environment to realize the gathering and flow of talents, knowledge, information and other elements, interact more high-quality resources to realize collaborative innovation, and then provide support for the improvement of innovation performance.

- (3) In the path relationship between collaborative innovation and innovation performance, technological synergy positively affects innovation performance, while capability synergy does not show a significant effect on enterprise innovation performance. The results of this hypothesis test indicate that technology synergy dominates in innovation performance improvement. Firms are able to use the exchange of energy in the talent ecosystem to acquire high-quality knowledge and resources, and then absorb and integrate them to achieve collaborative innovation at the technological level, and sustain their efforts in innovative products or services to create higher innovation performance. Hypothesis Hc2 does not pass the test, which means that capability synergy has no significant effect on the innovation performance. The capability synergy of collaborative innovation is a more complex synergistic activity, which is long-term and complex from the determination of synergistic goals to the deployment of resources, collaboration, benefit sharing, risk management, and the final achievement of innovation results, and the synergistic effect of  $1 + 1 > 2$  can be achieved only after a certain period of collaboration between all elements and subjects in the enterprise talent ecosystem. This also indicates to a certain extent that capability synergy is a long-term process and there is a certain time lag in the improvement of innovation performance among the innovation subjects of talent ecosystem.

## Conclusion

This paper develops an integrative research model which analyzes those relations using SEM on a dataset of innovative enterprises. Results suggest that talent competence, organizational environment and regional environment of talent ecosystem have a significant positive impact on collaborative innovation, and

organizational environment has a stronger effect on collaborative innovation; talent ecosystem can influence innovation performance to different degrees through the mediating role of collaborative innovation (technology synergy and capability synergy); technology synergy in collaborative innovation positively affects innovation performance, while Technology synergy in collaborative innovation positively affects innovation performance, while capability synergy has no significant effect on innovation performance. The management enlightenment based on enterprise innovation are as follows: (1) Enterprises should improve the competence level of innovation talents, improve the knowledge structure, innovation ability and personal traits of innovation groups from the knowledge dimension, skill dimension and quality dimension of talents, seek to maximize the talent potential and talent value in the enterprise talent ecosystem, and continuously activate the source of value creation. (2) Enterprises should improve the organizational innovation environment, give full consideration to the long-term nature of collaborative innovation, focus innovation development on smooth communication channels while minimizing the state of conservative and stagnant behavior due to fear of criticism, and make continuous efforts in creating an innovation ecological atmosphere to promote the interaction of innovation elements; in addition, enterprises should establish a more flexible organizational structure to continuously break through the shackles that bind creativity. The shackles of creativity should be broken. (3) Enterprises should improve the level of adaptability of the external environment, continuously cultivate the sensitivity to seek innovation opportunities from the regional environment, and improve the ability to utilize and integrate regional innovation resources. At the same time, the government should constantly improve the regional innovation environment, provide systematic and effective policy support from the regional industrial development layout, financial support, cultural atmosphere, infrastructure and other aspects, promote the establishment of multi-party collaborative innovation mechanism, break the adverse situation of market segmentation and industrial monopoly, provide efficient support for the mutual penetration and integration of different regions and industries, and help the upgrading of enterprise innovation.

Based on the current research on the relationship between talent ecosystem, collaborative innovation and innovation performance and the shortcomings of this paper, the following perspectives are proposed for future research: First, due to various limitations, the sample representativeness of the questionnaire survey is limited, and subsequent research can try to extract objective data from the public information of some enterprises or local governments for empirical analysis. Secondly, the role of enterprise talent ecosystem and collaborative innovation in innovation performance is a long-term process, and the empirical value of the research findings may be further enhanced if the data are obtained by long-term tracking. Thirdly, this paper proposes the important mediating variable of collaborative innovation in the study of the relationship between talent ecosystem and innovation

performance, but it is unknown whether there are other mediating or moderating variables that play a role in this process based on different research perspectives, and the related research boundary needs to be broadened.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

Ethics review and approval/written informed consent was not required as per local legislation and institutional requirements.

## Author contributions

WG, writing–original draft preparation, formal analysis; CL, writing–original draft preparation, methodology. All authors have read and agreed to the published version of the manuscript.

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## Conflict of interest

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