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How Can Small and Medium-Sized Manufacturing Enterprises Improve Green Innovation Performance through Innovation Ecosystems?

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Abstract: Under the fierce business competition and sustainable development pressure, the pattern of enterprise innovation has gradually changed from independent innovation to cooperative innovation. As a collection of multi-type innovation actors, the innovation ecosystem provides opportunities and platforms for cooperative innovation among government–industry–university–research institutions. While the present studies on innovation ecosystems are mostly from the perspective of the system level, few studies pay attention to the innovation mechanism of small and medium-sized manufacturing enterprises (SMMEs) in the innovation ecosystem. Therefore, this study takes SMMEs embedded in innovation ecosystems as research objects and explores the factors affecting green innovation. We constructed a theoretical model to explain the effect of innovation eco-embeddedness on green innovation performance based on ecosystem theory and network embeddedness theory; we then collected 363 samples of SMMEs in China through surveys and further tested the data empirically. The results show that the innovation eco-embeddedness (IEE) of SMMEs has a positive effect on their green innovation performance (GIP), and their green value co-creation practices (GVCCPs) partially mediate the relationship between IEE and GIP. Moreover, ecological norms (ENs) in the innovation ecosystem not only positively moderate the impact of IEE on GVCCPs but also positively moderate the mediating role of GVCCPs. This study enriches the relevant research on innovation ecosystems from the perspective of non-core enterprises and provides a theoretical basis and practical reference for SMMEs to implement green innovation practices and realize growth through innovation ecosystems.

Keywords: innovation ecosystem; eco-embeddedness; green value co-creation practices; ecological norms; cooperation of government–industry–university–research; green innovation performance

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1. Introduction

In accordance with the requirements of the 2030 Agenda for Sustainable Development (2030 Agenda) and Sustainable Development Goals (SDGs), China has put forward the strategic goal of "carbon emission peaking in 2030 and carbon neutrality before 2060", which puts green innovation at a new, higher level [1,2]. Moreover, with the rapid development of the scientific and technological revolution and industrial transformation, independent innovation is no longer able to cope with the current fierce business competition and sustainable development pressure [3], so manufacturers are attempting to collaborate for innovation with different parties, such as suppliers and research institutions. Among them, the innovation ecosystem built by manufacturers is a means to solve problems in green scientific and technological innovation [3–5]. The innovation ecosystem is a dynamically coordinated system composed of many different actors, such as the government, enterprises, universities, research institutions, and financial institutions [6–8]. Specifically, by aggregating the advantageous resources of all innovation actors embedded in the system, the innovation ecosystem can provide solid resources and a sufficient innovation impetus for green innovation projects involving government–industry–university–research cooperation [9]. For instance, Haier Group built HOPE, an open innovation ecosystem, to cooperate with its upstream suppliers, research institutions, and universities for the purpose of jointly developing new technologies and products [3,10]. In particular, its valve supplier, which is a medium-sized manufacturer, developed a new valve by collaborating with government–industry–university–research institutions through HOPE. And the use of this new valve can reduce power consumption as well as improve the efficiency of air conditioners, thus achieving green innovation in the air-conditioning industry. It can be seen that the innovation ecosystem is a great route for SMMEs to take part in green innovation practices.

At present, lots of research on innovation ecosystems is emerging. For example, Xie and Wang [11] explored the role of innovation ecosystem modes in promoting product innovation based on grounded theory; Ding et al. [12] discussed two platform strategies of innovation ecosystems and revealed the evolutionary mechanisms and process models of these two platform strategies; Wang and Islam [13] explored the management mechanism of external resources in innovation ecosystems from the perspective of resources. Although the role of innovation ecosystems in driving innovation has been widely recognized, there is still uncertainty regarding what factors affect the efficiency of green innovation in SMMEs that are the upstream suppliers and complementary enterprises of core enterprises and that engage in green innovation with government–industry–university–research institutions. Moreover, as an important participant in innovation ecosystems, SMMEs play an indispensable role in the process of the construction of the innovation ecosystem [14]. Therefore, clarifying the factors affecting the GIP of SMMEs is not only useful for SMMEs to obtain better GIP through the innovation ecosystem but also of great significance for the development of innovation ecosystems. In this context, network embeddedness theory holds that when an enterprise attempts to realize innovation by accessing external resources through cooperation, its behavior and performance will be affected by its relationship with other actors and the structure of the entire network [15]. Inspired by this view, we attempt to explore the factors affecting the GIP of SMMEs from the perspective of network embeddedness.

Moreover, how the resources in innovation ecosystems can be transformed into green innovation ability is crucial for SMMEs [9,14]. Green value co-creation practices (GVCCPs) are common processes in which actors achieve common goals [16], so they are important in the process of resource transformation in SMMEs. According to Zaborek and Mazur, value co-creation practices are the processes of resource allocation, communication, and integration carried out by all participants through direct interaction, and the process of resource redistribution is conducive to each participant absorbing and transforming the required resources [17]. Therefore, for SMMEs, participating in GVCCPs with government–industry–university–research institutions creates conditions for them to transform and absorb heterogeneous resources that are conducive to green innovation. Given this, we further explore the impact of the GVCCPs of SMMEs with different embedding characteristics on their GIP in innovation ecosystems.

Additionally, the institutional environment is crucial to avoiding opportunism and ensuring the sustainable and healthy development of innovation ecosystems [18,19]. Referring to Wong and Boon-itt [20] for their description of institutional norms in supply chains and Santos et al. [21] for their study on the coordination mechanism of the innovation ecosystem, this study proposes ecological norms (ENs) to describe the institutional environment of innovation ecosystems and defines ENs as the standards and rules related to the behaviors and practices of innovation actors, mainly including formal rules, coordination and information mechanisms, common knowledge, and certification systems [20,21]. Different from governance by the government, ENs are a means of governance at the system level; that is, ENs are a governance and coordination mechanism jointly formulated and implemented by all innovation actors in the process of self-organization. Furthermore, the mechanism of multi-actor co-governance can not only clarify the responsibilities, rights, and obligations of each actor but also provide an institutional guarantee for interactions between the actors [22,23]. Therefore, for SMMEs, ENs are the basis and institutional guarantee for them to obtain the right to speak and are also important boundary conditions that need to be considered in the process of GVCCPs.

In summary, the innovation ecosystem becomes an effective way for SMMEs to implement green innovation projects with government–industry–university–research institutions, and the behaviors and practices of enterprises will be affected by their structures and ENs in innovation ecosystems. Scholars have conducted extensive studies on the value co-creation, innovation performance, and governance of innovation ecosystems, and these studies usually regard the innovation ecosystem as a whole [24–26], but research on the GVCCP process of a single enterprise and its impact on green innovation is still lacking. In addition, although some scholars [20,21,27] have emphasized the importance of innovation ecosystem governance and coordination, there is a lack of quantitative research. Therefore, based on ecosystem theory and network embeddedness theory, this study takes SMMEs in China as research objects to explore the influence mechanism of IEE on GIP. Furthermore, from the perspective of value co-creation and ecological norms, this study discusses the influence of GVCCPs and ENs on the GIP of SMMEs with different embedding characteristics.

This study is structured as follows. Section 2 introduces the theoretical basis and describes the innovation ecosystem constructed under the scenario of this study. Section 3 establishes the relationship between the variables and constructs the theoretical model based on the theoretical analysis. Section 4 introduces the collection of samples and data and the measurement of variables. Section 5 describes the empirical test. Section 6 discusses the research results, puts forward countermeasures according to the research results, and summarizes the research limitations and prospects.

2. Theoretical Basis

2.1. Ecosystem Theory and Innovation Ecosystem

The concept of an ecosystem is rooted in the field of biology [28], and in the business field, the ecosystem is seen as a new way to describe the competitive environment [29]. Moore [30] defined the ecosystem as a group of producers and users that surround a core enterprise and improve the performance of the core enterprise through interactions. Merz et al. [31] argued that modularity is the reason for the emergence of ecosystems because of its characteristic that allows a group of different but interdependent organizations to coordinate without completely hierarchical commands. Gueler and Schneider [32] studied the characteristics of the ecosystem and pointed out that all participants in the ecosystem are highly interdependent but do not own each other, and each participant is autonomous and can retain the remaining control. Wei et al. [14] analyzed the reasons for enterprises to join the ecosystem and concluded that the key motivation for enterprises to integrate into the ecosystem was to establish in-depth partnerships and realize complementary collaborative innovation.

With the development of ecosystem theory in the business field, scholars began to explore the application of ecosystem theory in enterprise innovation. Adner [6] was the first one to think about the innovation behavior of enterprises from the perspective of the ecosystem and proposed the concept of an "innovation ecosystem". He proposed that the innovation ecosystem is a network of multiple actors coordinating and interacting with each other around the same value proposition, which consists of the participants, their locations, and their relationships with resource flow [33]. Since then, research on the innovation ecosystem has attracted extensive attention from scholars. Scholars have studied the structure and characteristics of the innovation ecosystem [8,13]. Recently, academia and industry have gradually broadened the perspective from the research on the innovation ecosystem itself to the empowerment of enterprises' green innovation [34,35]. Based on the above research, we constructed an innovation ecosystem for the manufacturing industry, and the components of the innovation ecosystem are shown in Figure 1.

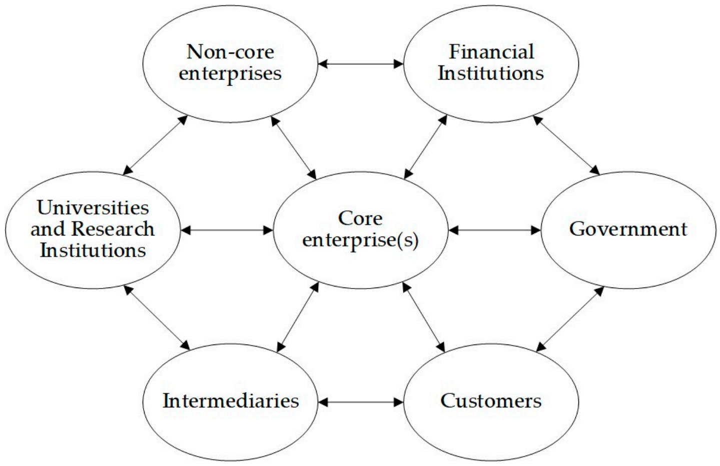


Figure 1. The components of the innovation ecosystem. Source: Own elaboration.

Among them, the core enterprise is the creator of the innovation ecosystem, and it has a leading position and plays a role in promoting the formation, guiding healthy development, and improving the overall ability of the innovation ecosystem [36]. Generally, there is only one core enterprise in an innovation ecosystem, but there are also innovation ecosystems with more than one core enterprise [3].

Non-core enterprises are participants within innovation ecosystems, usually referring to the upstream suppliers and complementary enterprises of the core enterprise, typically small and medium-sized enterprises. In innovation ecosystems, non-core enterprises engage in green innovation around core enterprises [9,14].

The government includes administrative units at all levels. The government provides policy support and tax subsidies to strongly drive green innovation practices [37]; it is both an innovation actor and a service provider within innovation ecosystems [38].

Universities and research institutions are the main participants in green innovation activities. With advantages such as knowledge, technology, and talent, universities and research institutions provide technical and R&D support for the implementation of green innovation activities [13,36].

Financial institutions are banks, securities companies, and insurance companies that provide financial support for green innovation activities. Moreover, financial institutions are important factors in promoting green innovation activities and commercializing R&D achievements in innovation ecosystems [38,39].

Intermediaries are social organizations that provide relevant support services for innovation activities, including notarial intermediaries, agent intermediaries, and information technology service intermediaries. In innovation ecosystems, intermediaries mainly provide services such as technical consultation, value assessment, and patent application in the process of formation to promote the commercialization of scientific and technological achievements [40].

Customers are the users of innovation achievements, and they participate in innovation by transmitting market information and the latest needs to enterprises through user communities and other means. All of this information and all of these needs can provide materials and inspiration for innovation and are the main drivers of innovation activities [8].

2.2. *Network Embeddedness Theory*

Network embeddedness theory was initially used to explain the relationship between economic behavior and social networks. Granovetter [41] pointed out that economic behavior is embedded in social networks or social structures and is simultaneously constrained and promoted by social relationships or network structures. Since then, the research on network embeddedness theory has attracted wide attention from scholars. For instance, Woolcock [42] pointed out that embeddedness refers to connections within communities that create cohesion among individuals, thereby increasing their efficiency in achieving collective goals. Figueiredo [43] believed that embeddedness means that the social connections established between enterprises and other actors in the social environment will affect the competitive performance of enterprises. Wajid et al. [44] argue that embeddedness refers to the social relations between economic and non-economic individuals that lead to unique constraints and incentives on economic behavior.

In conclusion, network embeddedness theory effectively explains the relationship between individuals and the whole. It points out that any economic organization or individual is embedded in a social network that is interwoven by a variety of social relations; in other words, economic behavior is affected by the relationship between various actors and the structure of the whole relationship network, and the degree of this embeddedness has high and low points [9,33]. Gradually, with continuous expansion and enrichment by other scholars, the objects have expanded from social networks to enterprise networks, such as the business ecosystem and innovation ecosystem. Riquelme-Medina et al. [45] analyzed the impact of business ecosystem embeddedness on supply chain competitiveness and defined business ecosystem embeddedness as the degree to which enterprises integrate and become part of the business ecosystem. Zang et al. [9] verified the impact of innovation ecosystem embeddedness on the innovation performance of non-core enterprises in innovation ecosystems.

It can be seen that the application of network embeddedness theory in the field of the business ecosystem and innovation ecosystem can explain the constraining and promotion effects of the ecological network on a single enterprise embedded in innovation ecosystems. Therefore, network embeddedness theory can be used to explain the influence of SMMEs with different embedding characteristics within innovation ecosystems on their behavior and performance.

3. Literature Review and Research Hypotheses

3.1. Innovation Eco-Embeddedness and Green Innovation Performance

Innovation eco-embeddedness (IEE) is developed based on network embeddedness theory. Scholars mostly measure the degree of the embeddedness of enterprises in the ecosystem from two dimensions: structural embeddedness and relational embeddedness [9,41,46]. Further applying it to the innovation ecosystem, for an enterprise embedded in innovation ecosystems, structural embeddedness in innovation ecosystems (IESE) refers to its position in innovation ecosystems and reflects the types and channels of resources that it can access [9]; relational embeddedness in innovation ecosystems (IERE) refers to its degree of trust, interdependence, and information sharing with other innovation actors within innovation ecosystems and reflects the possibility of accessing resources [15]. Green innovation performance (GIP) refers to the performance of enterprises in the processes of green product and process design and production innovation, including their performance in pollution prevention, energy saving, product recycling, harmful substance (waste) discharge, raw material loss, etc. [47] And GIP is the key factor in measuring the effect of the green innovation of enterprises. For SMMEs, being embedded in an innovation ecosystem and accessing relevant innovation resources through structural embeddedness and relational embeddedness can strengthen their green innovation capability. However, the differences in the embedding characteristics of enterprises lead to different types and channels of resources available and possibilities of accessing resources, which, in turn, have different degrees of impact on GIP [48].

Specifically, IESE reflects the position of SMMEs within innovation ecosystems, which affects the acquisition of heterogeneous resources. According to network embeddedness theory, the closer the SMMEs to the center of the innovation ecosystem, the richer and more abundant the resources they can access, which is conducive to the identification and acquisition of heterogeneous resources, thus helping to improve the green innovation capability of SMMEs [9,46]. In addition, the position of SMMEs within innovation ecosystems will also affect the establishment of links with other innovation actors; they will have wider links, and it will be easier to establish links with other innovation actors when they are close to the innovation ecosystem [9,15], and the establishment of extensive links can increase the possibility of accessing innovation resources from other innovation actors. Moreover, SMMEs with extensive links have more information advantages that can help them quickly identify opportunities and threats so that they can adjust their green innovation strategies on time [38]. To sum up, IESE not only helps SMMEs to establish extensive links to access green innovation resources but also helps them to improve their green innovation capability and adjust their green innovation strategies.

IERE reflects the relationship of SMMEs with other innovation actors within innovation ecosystems, including trust, interdependence, and information sharing [15]. Specifically, trust is the basis of inter-subjective interaction and cooperation and can provide more opportunities for related actors to access resources and exchange information. When the trust between SMMEs and other innovation actors is high, it is easier for them to access the resources and technologies needed for green innovation from other innovation actors, which is conducive to the implementation of green innovation. What is more, a stable cooperative partnership is conducive to the implementation of inter-subjective activities [16]. Moreover, for SMMEs, interdependence with other actors is conducive to establishing in-depth and stable cooperative partnerships, which can promote the implementation of green cooperative innovation and the integration of industry and education based on government–industry–university–research cooperation projects, as well as improving the utilization rate of resources [14]. In addition, from the perspective of the enterprise strategy, information sharing with other innovation actors can help SMMEs quickly perceive changes in the external environment and understand the technology frontier trends; therefore, they can adjust their green innovation strategies in a timely manner and obtain first-mover advantage [9].

Based on the above analysis, the following hypotheses are proposed.

Hypothesis 1 (H1). *IESE has a significant positive effect on the GIP of SMMEs.*

Hypothesis 2 (H2). *IERE has a significant positive effect on the GIP of SMMEs.*

3.2. Mediating Role of Green Value Co-Creation Practices

Unlike the business ecosystem, which focuses on value capture, the innovation ecosystem emphasizes GVCCPs based on the mechanism of collaborative integration [44]. GVCCPs refer to the common processes of creating common value for relevant innovation actors within innovation ecosystems. With the core of the collaborative interaction of green resources, the GVCCP is a key step for innovation actors to allocate, communicate, and integrate green innovation resources through direct interaction to improve GIP [49,50]. Due to the different embedding characteristics of innovation ecosystems, SMMEs have different attitudes and intentions toward GVCCPs, which results in different degrees of participation in GVCCPs and different conversion efficiencies of resources and ultimately affects GIP [46]; that is, the IEE of SMMEs affects GIP by influencing their GVCCPs.

Specifically, SMMEs with a high degree of IESE have more opportunities to access more kinds of innovation resources, which can enhance their intention to make use of location advantages for their green innovation power [45], and the realization of this process cannot be achieved without their GVCCPs with other innovation actors. In the process of GVCCPs, the abundant innovation resources within innovation ecosystems can be gathered, and SMMEs with a high degree of IESE make use of their location advantages to exchange resources with more innovation actors, integrate and use relevant resources conducive to their green innovation, and create knowledge of green innovation [51]. In addition, these SMMEs with a high degree of IESE can gain a greater right to speak in the process of cooperation by enhancing participation in GVCCPs to enhance their first refusal right in the process of allocating innovation resources.

SMMEs with a high degree of IERE have a high degree of trust, interdependence, and information sharing with other innovation actors [9]. To give full play to their relation effects, these SMMEs tend to establish sustained partnerships with other innovation actors and gather advantageous resources and technologies by participating in GVCCPs to promote resource allocation and sharing [14,52]. Specifically, for SMMEs, a high degree of trust and information sharing with other innovation actors can promote resource sharing and innovation cooperation in the process of GVCCPs, improve the communication frequency with other actors, and provide a guarantee for information interaction, eliminate information asymmetry, and ensure the smooth implementation of joint plans [45,53]. Moreover, inter-subject trust helps to form unified cognition and value proposition, which are conducive to the development of green cooperative innovation [18,26]. In addition, SMMEs can flexibly respond to changes in relationships when their relationship system is relatively mature, thus increasing their initiative in the process of collaboration [16].

Based on the above analysis, the following hypotheses are proposed.

Hypothesis 3 (H3). *GVCCPs have a mediating role in the relationship between the IESE and GIP of SMMEs.*

Hypothesis 4 (H4). *GVCCPs have a mediating role in the relationship between the IERE and GIP of SMMEs.*

GVCCPs are an important way to promote synergistic effects by improving the utilization rate of resources [54]. Specifically, resources within innovation ecosystems are integrated and allocated when innovation actors jointly make green innovation plans and deal with problems that arise during operations. In the process of resource integration, advantageous resources can be gathered [55]. In the process of resource allocation and utilization, dispersed resources are applied to all aspects of green collaborative innovation, which realizes the effective use of resources and meets the needs of green innovation. In addition, the identification and integration of heterogeneous resources can help SMMEs gain inspiration for innovation, and the generation of new technologies and innovative ideas can enhance the green innovation capability of SMMEs, thus improving their GIP [56]. Based on the above analysis, the following hypothesis is proposed.

Hypothesis 5 (H5). *GVCCPs have a significant positive effect on the GIP of SMMEs.*

3.3. Moderating Role of Ecological Norms

Ecological norms (ENs) are the standards and rules that all innovation actors gradually form through long-term collaboration; ENs include formal rules, coordination and information mechanisms, common knowledge, and the certification system. Among them, formal rules mainly refer to the basic rules formed in the system, including entry criteria, behavioral norms, operation requirements, punishment mechanisms, etc., and the existence of formal rules can increase the opportunistic cost of defaulters and inhibit the occurrence of opportunistic behaviors [57,58]. Coordination and information mechanisms are the norms used to coordinate the relationship between innovation actors and promote information sharing within the system, as well as help innovation actors realize the sharing and reasonable allocation of resources [20,45]. Common knowledge refers to knowledge about products, technologies, processes, and management that innovation actors have in common, which contributes to the efficient use of resources [23]. The certification system refers to the standard requirements for system operation and actors' behaviors that are unanimously recognized by all actors, and for each subject, obtaining standard certification is an important source of honorary capital [19]. According to institutional theory, institutions exert a constraining influence on the innovation ecosystem, which forces actors located in the same system and affected by the same institutional factors to converge [20].

Therefore, in innovation ecosystems, ENs are the necessary measures to ensure the healthy development of the innovation ecosystem and good participation of innovation actors.

Specifically, there could be someone who tends to maximize their interests by damaging the interests of other actors, exhibiting opportunistic behavior, which may even lead to the disintegration of the innovation ecosystem when the ENs in the system are not perfect [23]. Under these circumstances, SMMEs with a high degree of IESE will adopt a more conservative cooperative attitude in the face of abundant resources and extensive links around them and will be more cautious in the process of establishing links and exchanging and integrating resources to ensure their interests [21]. As a result, a conservative cooperative attitude and cautious behavior are unconducive to the GVCCPs of SMMEs. On the contrary, perfect ENs can effectively eliminate such concerns and reduce the moral hazard among innovation actors [20], thus driving SMMEs with a high degree of IESE to leverage their location advantage to integrate and utilize the abundant innovation resources in the system by participating in GVCCPs.

Moreover, perfect ENs mean that there are more comprehensive formal rules in innovation ecosystems, which can create a favorable environment for interaction between innovation actors. Under these circumstances, the rules provide all innovation actors with the right to monitor and report, and those who violate the rules will be punished accordingly [59]. With the guarantee of relevant rules, SMMEs tend to enhance their level of trust, interdependence, and information sharing with other innovation actors to establish good partnerships, access more green innovation resources, and then transform them into green innovation power by participating in GVCCPs. Furthermore, good partnerships help SMMEs to form a consistent value proposition with other innovation actors, including a unified goal and vision, which will provide SMMEs with a foundation for collaboration in green innovation to contribute to the joint development of green innovation plans and joint problem solving with other innovation actors; that is, they promote SMMEs' participation in GVCCPs [26].

In addition, in the process of resource allocation, integration, and utilization by SMMEs participating in GVCCPs with other innovation actors, perfect ENs are helpful in regulating their behavior to increase their possibility of improving GIP in the process of GVCCPs. Specifically, as the participation degree of SMMEs in GVCCPs changes from low to high, on the one hand, relevant norms and standards are helpful for effectively guiding the GVCCPs between SMMEs and other innovation actors, thus contributing to the optimal allocation and effective utilization of green innovation resources within the system and further improving GIP. On the other hand, perfect ENs enhance the transparency of the innovation ecosystem to provide an institutional guarantee for the realization of rights and the improvement of the GIP of SMMEs in the process of GVCCPs [19].

Based on the above analysis, the following hypotheses are proposed.

Hypothesis 6 (H6). *ENs strengthen the positive impact of IESE on GVCCPs.*

Hypothesis 7 (H7). *ENs strengthen the positive impact of IERE on GVCCPs.*

Hypothesis 8 (H8). *ENs strengthen the positive impact of GVCCPs on GIP.*

Based on the above discussion, this study believes that the IEE of SMMEs has an indirect effect on their GIP through GVCCPs, and ENs play a moderating role in this process. Therefore, we further theorize that, in the process of improving GIP through the innovation ecosystem, SMMEs not only need to participate in GVCCPs to realize the transformation and absorption of resources but also need the coordination and supervision of ENs in the process of GVCCPs; that is, ENs can moderate the mediating role of GVCCPs. Specifically, SMMEs with a high degree of IESE will transform and absorb the heterogeneous resources obtained through their location advantage to improve their GIP through active participation in GVCCPs [45], and in this process, changes in the level of ENs will change the willingness of SMMEs to participate in GVCCPs to influence resource utilization. Similarly, SMMEs with a high degree of IERE will give full play to the advantages of the relationship to promote the implementation of cooperation in green innovation and improve GIP by actively participating in GVCCPs [14], and in this process, changes in the level of ENs will change the efficiency of green cooperative innovation [9]. To sum up, changes in the level of ENs will change resource utilization and collaborative efficiency in the process of improving the GIP of SMMEs to influence the indirect effect of GVCCPs. Based on the above analysis, the following hypotheses are proposed.

Hypothesis 9 (H9). *ENs positively moderate the mediating role of GVCCPs between IESE and GIP.*

Hypothesis 10 (H10). *ENs positively moderate the mediating role of GVCCPs between IERE and GIP.*

Based on the above analysis, we developed a theoretical model, as shown in Figure 2.

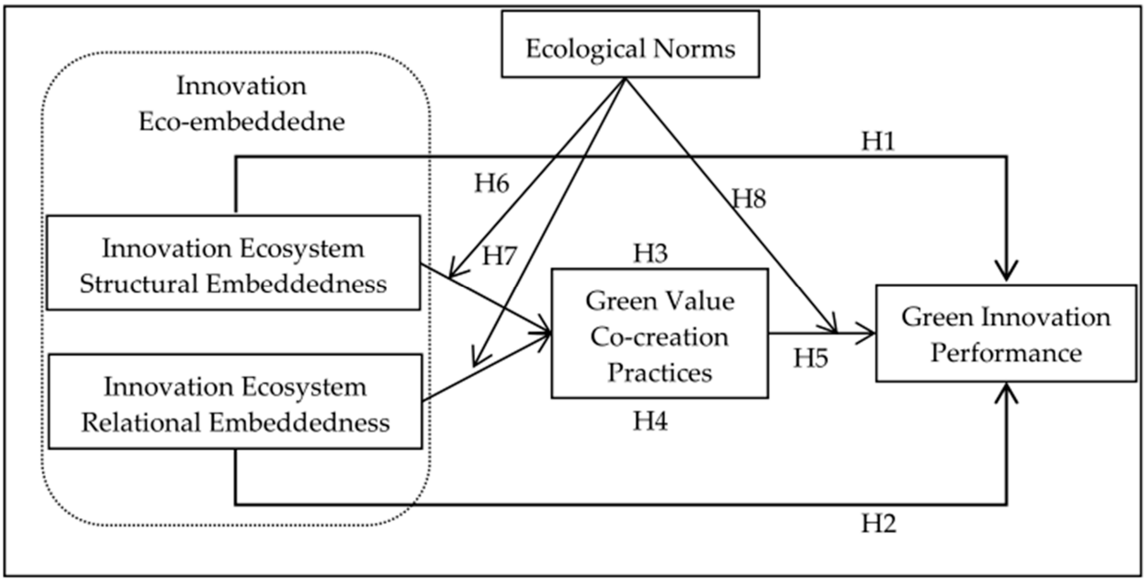


Figure 2. Theoretical model. Source: Own elaboration.

4. Research Design

4.1. Sample and Data Collection

This study takes SMMEs as the research objects. According to the results of the Fourth National Economic Census in China, the legal units of small, medium, and micro-enterprises in China account for 99.8% of all enterprises. Compared with large manufacturing enterprises, SMMEs have limited resources and capabilities, and it is difficult for them to realize green innovation with only internal resources. So, it is of great significance for SMMEs to clarify the path of green innovation through IEE. A pre-survey was conducted before distributing the questionnaire. Firstly, we invited two experts in the field of innovation ecosystems from universities to perform an initial evaluation of the questionnaire we created through relevant literature references and class discussions, after which we modified the questionnaire items according to the experts' suggestions. Then, we issued the questionnaire to students in the MBA course of Operations and Innovation Management and discussed the questionnaire items after they were completed. Finally, we modified the questionnaire again according to feedback from the MBA students and formed the final questionnaire, which is shown in Appendix A.

We issued the questionnaire to selected SMMEs in China that are embedded in innovation ecosystems and implement green innovation around core enterprises. To ensure that the enterprises participating in the survey met the requirements, we included a screening question: "Is your enterprise in innovation ecosystems dominated by focus enterprises (core enterprises) or platform enterprises"? The questionnaire was distributed through MBA classes, industry associations, and other channels through a combination of online and offline methods. A total of 401 questionnaires were collected, and we excluded questionnaires that failed to pass the screening, took too short a time to answer, or were illogical. To further ensure the rigor of the study, we also verified the company information through the official website and other websites. Finally, we obtained 363 valid questionnaires, accounting for 91% of the total questionnaires. The statistics of the sample characteristics are shown in Table 1.

Table 1. Sample characteristic statistics.

Categories	Items	Number of Samples	Percentage (%)
Firm size	Small	138	38.0%
	Medium	225	62.0%
Listed or not	Yes	128	35.3%
	No	235	64.7%
The nature of the firm	State-owned or state-controlled	57	15.7%
	Private	270	74.4%
	Joint venture	15	4.1%
	Overseas-funded	21	5.8%
Firm age	5 years or less	17	4.7%
	6–10 years	66	18.2%
	11–15 years	93	25.6%
	16–20 years	64	17.6%
	More than 20 years	123	33.9%
Years that enterprises have been embedded in innovation ecosystems	1 year or less	17	4.7%
	2–3 years	81	22.3%
	4–5 years	165	45.5%
	More than 5 years	100	27.5%

Source: Own elaboration.

4.2. Variables

The variables involved in this paper include IEE, GVCCP, GIP, and ENs. Before designing the scale, we first combed through relevant research performed at home and abroad and then discussed the measurement of the variables in class. Finally, we formed the measurement scale according to the actual situation of the investigated objects as well as the existing mature scale. A 7-point Likert scale was used for measurement.

4.2.1. Innovation Eco-Embeddedness (IEE)

The measurement of IEE was based on the scale established by Granovetter [41] and Zang et al. [9]. Five measurement items were used to measure IESE and IERE. Among them, IESE reflects the type and quantity of resources that SMMEs can access in innovation ecosystems. In this study, we mainly considered the number of innovation actors connected with them, the number of resources they can access, and the interaction frequency with other innovation actors. IERE reflects the possibility of SMMEs accessing resources within innovation ecosystems. In this study, we mainly considered the availability of resources, trust, interdependence, and information sharing with other innovation actors.

4.2.2. Green Innovation Performance (GIP)

At present, there are two main ways to measure GIP: one is to use objective indicators, such as patents and product innovation, and the other is to use established scales from other scholars to obtain subjective data. Due to the complexity, uncertainty, and diversity of green innovation achievements, this study used established scales from other scholars to measure the GIP of SMMEs. Referring to the research of Chang et al. [60] and Chen et al. [46], and based on the characteristics of SMMEs, the GIP was measured from product and process development and design, production, and manufacturing processes, including innovation results related to energy conservation, pollution prevention, waste recycling, green product design, and enterprise environmental management.

4.2.3. Green Value Co-Creation Practices (GVCCPs)

The measurement of green value co-creation practices (GVCCPs) was based on the scale established by Ranjan and Read [16] and Chang [56]. The participation degree of SMMEs in GVCCPs was measured from two aspects: co-production and value-in-use. Among them, co-production mainly considers whether the surveyed enterprises actively share their ideas and suggestions in the green product development process; value-in-use mainly considers whether the green products and processes of the surveyed enterprise have been improved through the participation of other innovation actors.

4.2.4. Ecological Norms (ENs)

The measurement of ecological norms (ENs) was based on the scale established by Wong and Boon-itt [20], which consists of four measurement items reflecting the degree of institutionalization of the innovation ecosystem. The main consideration is whether the system has sound formal rules, good coordination and information mechanisms, common knowledge, and a jointly recognized certification system.

4.2.5. Control Variables

In this study, firm age (FA), firm size (FS), and years that enterprises have been embedded in innovation ecosystems (EY) are taken as control variables. To a certain extent, the age of an enterprise reflects its ability to access external resources, which may affect its green innovation. The longer an enterprise has been established, the more stable its social relationship resources are, and the easier it is to establish contacts with other enterprises and access related resources. Firm size is the most significant feature of manufacturing enterprises: small-scale enterprises have limited resources and capabilities and are more interested in implementing an ecosystem strategy. The years that an enterprise has been embedded in innovation ecosystems will also affect its degree of IEE, which is mainly reflected in the fact that an enterprise may decide whether to change its embeddedness in innovation ecosystems according to its own earnings and performance changes.

4.3. Reliability and Validity Tests

To test the scale and data quality, we used SPSS 25.0 and AMOS 24.0 for reliability and validity tests. Among them, the reliability of the scale was tested by the coefficient of internal consistency (Cronbach's α) and composite reliability (CR). As for the validity test, the scales adopted in this study all referred to existing mature scales, so confirmatory factor analysis (CFA) was used for the validity test. As shown in Table 2, Cronbach's α was above 0.7 for all items, indicating good internal consistency among the measurement items of each variable, and CR values were all greater than 0.7, indicating the reliable measurement results of the scale. In the validity test, the model fit of the whole scale was verified first. Among them, the Chi-square freedom ratio (CMIN/DF) was 1.658, RMSEA was 0.043, IFI was 0.903, TLI was 0.891, and CFI was 0.901, all of which met the standards suggested by Bentler and indicated that the model had a good fit. Then, the test of model fit was performed on the two dimensions of IEE (second-order variable). The results showed that the Chi-square freedom ratio (CMIN/DF) was 1.544, RMSEA was 0.039, IFI was 0.975, TLI was 0.967, and CFI was 0.975, indicating a good fit. The factor loading coefficients of all items were above 0.4, and the convergent validity (which was measured by AVE) was above 0.5, which indicated that the convergence was good. In addition, to test the commonality among variables, a discriminant validity test was carried out, and the AVE square root of each variable was greater than the correlation coefficient between the variable and other variables, which proved that the independence of each variable was good.

Table 2. Reliability and validity test results.

Variables	Items	Factor Loading	Cronbach'α	AVE	CR
Innovation Ecosystem Structural Embeddedness (IESE)	IESE1 IESE2 IESE3 IESE4 IESE5	0.694 0.546 0.468 0.695 0.642	0.742	0.379	0.749
Innovation Ecosystem Relational Embeddedness (IERE)	IERE1 IERE2 IERE3 IERE4 IERE5	0.678 0.628 0.625 0.485 0.507	0.722	0.347	0.724
Green Value Co-Creation Practices (GVCCPs)	GVCCP1 GVCCP2 GVCCP3 GVCCP4 GVCCP5 GVCCP6 GVCCP7	0.544 0.575 0.506 0.561 0.480 0.549 0.550	0.740	0.290	0.741
Ecological Norms (ENs)	ENs1 ENs2 ENs3 ENs4	0.617 0.703 0.665 0.559	0.729	0.407	0.732
Green Innovation Performance (GIP)	GIP1 GIP2 GIP3 GIP4 GIP5 GIP6 GIP7 GIP8	0.488 0.484 0.440 0.557 0.506 0.542 0.562 0.478	0.734	0.259	0.735

Source: Own elaboration.

4.4. Common Method Bias Test

In this paper, we used Harman's single-factor test to test for common method bias and extracted 5 factors with feature roots greater than 1. The maximum factor variance explanation rate was 24.40% (less than 40%), so there was no serious common method bias in this study.

5. Empirical Analysis and Results

5.1. Descriptive Statistics and Correlation

The results of sample descriptive statistics and correlation analysis are shown in Table 3. From the correlation coefficient matrix, it can be seen that IESE, IERE, GVCCPs, and ENs all had positive correlation coefficients with GIP, which was in line with assumptions and expectations.

Table 3. Descriptive statistics and correlation coefficient matrix.

Variables	Mean	S.D.	IESE	IERE	GVCCP	ENs	GIP	FA	FS	EY
IESE	5.629	0.478	**0.616**							
IERE	5.583	0.475	0.532 **	**0.589**						
GVCCP	5.620	0.471	0.536 **	0.555 **	**0.539**					
ENs	5.047	0.637	0.187 **	0.082	0.358 **	**0.638**				
GIP	5.698	0.493	0.547 **	0.633 **	0.657 **	0.208 **	**0.509**			
FA	3.580	1.253	−0.043	−0.062	0.035	0.075	−0.008	1		
FS	1.620	0.486	0.066	−0.035	0.092	0.098	0.079	0.026	1	
EY	2.960	0.828	0.098	0.067	0.091	0.067	0.087	0.000	0.160 **	1

Note: ** indicates $p < 0.01$; the diagonal elements in bold are the square roots of average variance extracted (AVE).
Source: Own elaboration.

5.2. Main Effect Analysis

The stepwise regression method was used to test the hypotheses. Table 4 shows the results of the main effect test. Model 1 only examined the influence of control variables on GIP. Based on Model 1, Model 2 introduced IESE, and the results showed that IESE had a significant positive impact on GIP (β = 0.541, $p < 0.001$), so H1 was verified. Based on Model 1, Model 3 introduced IERE, and the results showed that IERE had a significant positive impact on GIP (β = 0.635, $p < 0.001$), so H2 was verified.

Table 4. Results of main effect test.

Variables	GIP		
	Model 1	**Model 2**	**Model 3**
FA	−0.043	0.003	0.013
FS	0.070	0.038	0.096 *
EY	0.089	0.027	0.025
IESE		0.541 ***	
IERE			0.635 ***
VIFmax	1.120	1.133	1.130
R^2	0.014	0.301	0.412
Adjust R^2	0.005	0.293	0.405
F	1.646	38.594 ***	62.645 ***

Note: * indicates $p < 0.05$, *** indicates $p < 0.001$. Source: Own elaboration.

5.3. Mediating Effect Analysis

Table 5 shows the results of the mediating effect test. Model 4 introduced GVCCPs on the basis of Model 1, and the results showed that GVCCPs had a significant positive impact on GIP (β = 0.654, $p< 0.001$), so H5 was verified. Model 5 introduced IESE on the basis of Model 4, and Model 6 introduced IERE on the basis of Model 4 to test the mediating role of GVCCPs. The test results showed that after the GVCCP variable was added, compared with Model 2 and Model 3 in Table 4, the regression coefficient of IESE changed from 0.541 to 0.269, and the significance level did not change, indicating that GVCCPs played a partial mediating role in the relationship between IESE and GIP. H3 was verified. The regression coefficient of IERE changed from 0.635 to 0.392, and the significance level did not change, indicating that GVCCPs played a partial mediating role in the relationship between IERE and GIP, and H4 was verified.

Table 5. Results of mediating effect test.

Variables	GIP			GVCCPs		
	Model 4	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
FA	−0.045	−0.022	−0.010	0.003	0.048	0.052
FS	0.017	0.013	0.051	0.0.080	0.049	0.103 *
EY	0.039	0.019	0.016	0.077	0.016	0.021
IESE		0.269 ***			0.533 ***	
IERE			0.392 ***			0.560 ***
GVCCPs	0.654 ***	0.511 ***	0.434 ***			
VIFmax	1.126	1.421	1.665	1.120	1.133	1.130
R^2	0.435	0.486	0.539	0.014	0.293	0.324
Adjust R^2	0.429	0.479	0.533	0.006	0.285	0.316
F	68.892 ***	67.497 ***	83.517 ***	1.754	37.097 ***	42.855 ***

Note: * indicates $p < 0.05$, *** indicates $p < 0.001$. Source: Own elaboration.

5.4. Moderating Effect Analysis

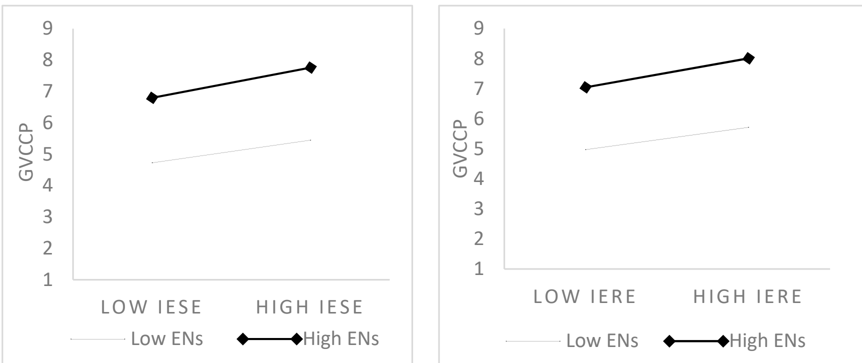
Table 6 shows the results of the moderating effect test. Model 10 and Model 11 successively introduced ENs and the interaction term between IESE and ENs on the basis of Model 8 in Table 5. The results showed that the regression coefficient of the interaction term was significantly positive (β = 0.095, $p < 0.05$), indicating that ENs had a significant positive moderating effect on the positive relationship between IESE and GVCCPs, and H6 was verified. Based on Model 9 in Table 5, Model 12 and Model 13 successively introduced ENs and the interaction term between IERE and ENs. The results showed that the regression coefficient of the interaction term was significantly positive (β = 0.087, $p < 0.05$), indicating that ENs had a significant positive moderating effect on the positive relationship between IERE and GVCCPs, and H7 was verified. Model 14 and Model 15 successively introduced ENs and the interaction term between GVCCPs and ENs on the basis of Model 4 in Table 5. The results showed that the regression coefficient of the interaction term was not significant (β = 0.015, $p > 0.05$), indicating that there was no moderating effect between GVCCPs and GIP, so H8 was rejected.

Table 6. Results of moderating effect test.

Variables	GVCCP				GIP	
	Model 10	**Model 11**	**Model 12**	**Model 13**	**Model 14**	**Model 15**
FA	0.030	0.023	0.033	0.028	−0.043	−0.044
FS	0.029	0.025	0.076	0.071	0.019	0.018
EY	0.012	0.017	0.012	0.008	0.039	0.039
IESE	0.485 ***	0.469 ***				
IERE			0.534 ***	0.520 ***		
GVCCPs					0.665 ***	0.663 ***
ENs	0.262 ***	0.281 ***	0.304 ***	0.328 ***	−0.031	−0.025
IESE*ENs		0.095 *				
IERE*ENs				0.087 *		
GVCCP*ENs						0.015
VIFmax	1.134	1.137	1.131	1.133	1.157	1.377
R^2	0.358	0.367	0.414	0.421	0.436	0.436
Adjust R^2	0.349	0.356	0.406	0.411	0.428	0.426
F	39.844 ***	34.339 ***	50.426 ***	43.084 ***	55.147 ***	45.860 ***

Note: * indicates $p < 0.05$, *** indicates $p < 0.001$. Source: Own elaboration.

In order to further analyze the moderating effect of ENs, a simple slope analysis was performed, and the moderating effects were plotted, as shown in (a) and (b) in Figure 3. Figure 3a shows that under both low and high ENs, the impact of IESE on GVCCPs was positive. The slope of high ENs was larger, indicating that high ENs had a greater impact on the relationship between IESE and GVCCPs, and H4a was further verified. Figure 3b shows that under both low and high ENs, the impact of IERE on GVCCPs was positive. The slope of high ENs was larger, indicating that high ENs had a greater impact on the relationship between IERE and GVCCP, and H4b was further verified.



(**a**) (**b**)

Figure 3. Schematic diagrams of the moderating effect of ENs. (**a**) The moderating effect of ENs on the relationship between IESE and GVCCPs; (**b**) the moderating effect of ENs on the relationship between IERE and GVCCPs. Source: Own elaboration.

5.5. Moderated Mediating Effect Test

The bootstrap method was used to test the mediating effect of moderation, and the test results are shown in Table 7. Under low, medium, and high levels of ENs, the 95% confidence intervals of the mediating effect of GVCCPs on the relationship between IESE and GIP were [0.124, 0.291], [0.186, 0.320], and [0.195, 0.387], excluding 0, indicating a significant mediating effect. With the improvement of the standard level of ENs, the mediating effect of GVCCPs changed and showed an increasing trend, indicating that ENs moderated the mediating effect of GVCCPs, and H9 was supported. Under low, medium, and high levels of ENs, the 95% confidence intervals of the mediating effect of GVCCPs on the relationship between IERE and GIP were [0.130, 0.276], [0.174, 0.306], and [0179, 0.387], respectively, excluding 0, indicating a significant mediating effect. With the improvement of the standard level of ENs, the mediating effect of GVCCPs changed and showed an increasing trend, indicating that ENs moderated the mediating effect of GVCCPs, and H10 was supported.

Table 7. Results of moderated mediating effect test.

Path	Moderator	Effect	SE	95% Confidence Interval	
				LLCI	ULCI
IESE—GVCCP—GIP	Low ENs	0.203	0.043	0.124	0.291
	Medium ENs	0.247	0.034	0.186	0.320
	High ENs	0.293	0.049	0.195	0.387
IERE—GVCCP—GIP	Low ENs	0.197	0.037	0.130	0.276
	Middle ENs	0.236	0.034	0.174	0.306
	High ENs	0.275	0.051	0.179	0.387

Source: Own elaboration.

6. Conclusions and Discussion

6.1. Main Research Conclusions

Based on ecosystem theory and network embeddedness theory, this study constructed a theoretical model for SMMEs to improve GIP through the innovation ecosystem and verified the influencing mechanism of IEE and GVCCPs on GIP through empirical research on SMMEs in China. The study accomplished the translation of research content and course instruction into practice. And we draw the following conclusions.

First of all, IESE and IERE have a positive impact on the GIP of SMMEs. Specifically, the improvement of the IESE of SMMEs expands the channels and types of heterogeneous resource acquisition, providing a resource base for their green innovation and helping to improve their green innovation capability. The improvement of the IERE of SMMEs is conducive to the establishment of stable cooperative partnerships with other innovation actors, thus promoting the implementation of green cooperative innovation among government–industry–university–research institutions, which is further conducive to SMMEs improving GIP. The differentiated impact of IEE on enterprises' GIP obtained in this study conforms to the connotation of network embeddedness theory proposed by Granovetter [41]. In addition, we expanded on the research of innovation eco-embeddedness of Zang et al. [9] from the perspective of green innovation and enriched the research objects in innovation ecosystems based on the research of Jiang et al. [3].

Secondly, GVCCPs play a partial mediating role in the relationship between the IESE and GIP and between the IERE and GIP of SMMEs; that is, SMMEs can indirectly improve GIP through GVCCPs. Specifically, for SMMEs, participating in GVCCPs can help to promote the efficient utilization of resources and improve the synergistic effect, thus affecting their GIP. The exploration of GVCCPs in this study further enriched the concept of green value co-creation proposed by Chang [56] and further refined the mechanism of green value co-creation. It should be noted that in Chang's study, the mediating role of green value co-creation between relational motives and green product innovation performance was not supported, and the scholar further found that, among the interviewed enterprises, the green motives (moral motives, instrumental motives, and relational motivation) of large enterprises were significantly stronger than those of small and medium-sized enterprises. Then, it was put forward that small and medium-sized manufacturing enterprises must cultivate green motives to strengthen their green value co-creation and green product innovation performance. The results of this study strongly support this point of view.

Finally, ENs positively moderate the positive relationships between IESE and GVCCPs and between IERE and GVCCPs. Specifically, in innovation ecosystems, ENs can effectively restrain the relevant behaviors of innovation actors, reduce the occurrence of opportunistic behaviors, and help strengthen the establishment of the relationship between innovation actors. However, the moderating effect of ENs on the GVCCPs and the GIP of SMMEs has not been verified, probably for the following reasons: ① It is affected by the ability of the enterprise itself. It is manifested as the difference and limitation in the resource integration and absorption capacity of SMMEs having an impact on the effect of GVCCPs, which limits the promoting role of ENs. ② The constraining effect of ENs inhibits GVCCPs. It is manifested as the advent of some positive behaviors being inhibited when ENs restrain the relevant behaviors of innovation actors, thus weakening the moderating role of ENs. This study verifies the positive moderating effect of ENs on GVCCPs in SMMEs and further illustrates the significant importance of governance for the development of innovation ecosystems. Interestingly, Wei et al. [14] showed that potential collaborative risks based on a platform had a negative impact on SMEs' behavioral intentions to participate in platform-based innovation ecosystems, which successfully supports our view that ENs are important for the good participation of innovation actors from the side and further proves the rationality of this study. Overall, ENs in innovation ecosystems can reduce the concerns of innovation actors about potential collaborative risks, thus helping to increase the willingness of SMMEs to become embedded in innovation ecosystems and co-create green value with other innovation actors, which further optimizes the structure of the innovation ecosystem by enriching the types of innovation actors in innovation ecosystems.

6.2. Theoretical Contributions

Firstly, this study developed research on the innovation ecosystem from the perspective of network embeddedness theory and the SMME level. Most of the relevant studies regard the innovation ecosystem as a whole to analyze its construction and evolution [13,24,25] or explore the influence of actors' characteristics on their interaction and performance mostly from the aspects of their roles (core enterprise, non-core enterprise) [3,9] and their cooperation mode [61,62], but the structure of SMMEs within innovation ecosystems has not been deeply studied. Based on network embeddedness theory, this study takes SMMEs in China as research objects to explore the internal mechanism of the impact of IEE on their GIP. The study provides a new perspective on green innovation ecosystems.

Secondly, this study explores the factors affecting the green innovation of SMMEs embedded in innovation ecosystems from multiple perspectives. Specifically, from the perspective of value co-creation, this paper explores the influence of GVCCPs on GIP and the mediating role of GVCCPs in the relationship between the IEE and GIP of SMMEs; from the perspective of innovation ecosystem governance, this paper proposes ENs and explores the influence of ENs on the GVCCPs and GIP of SMMEs. As a result, the exploration from multiple perspectives not only enriches the relevant research on value co-creation and the governance of innovation ecosystems but also provides a theoretical basis for follow-up research on green innovation.

Finally, this study supplements the research on the innovation ecosystem from the perspective of quantitative research. Most of the existing studies on the innovation ecosystem are theoretical or qualitative. Based on the survey data from 363 SMMEs in China, this paper empirically verifies the internal mechanism of the green innovation of SMMEs through ecosystems, which provides an empirical basis for subsequent research.

6.3. Managerial Implications

Firstly, because SMMEs are limited in their resources and capabilities, as well as have certain difficulties in achieving independent innovation, embedding in innovation ecosystems to cooperate with government–industry–university–research institutions could be an effective way to achieve green innovation. And we suggest that SMMEs adjust their embedding strategy and adjust their structural embeddedness and relational embeddedness in a timely manner according to the development of the innovation ecosystem in which they are located to maximize their resource acquisition efficiency.

Secondly, GVCCPs are an important way to improve the effective utilization of resources and promote the interplay of synergies, so we suggest that SMMEs make full use of their location and relationship advantages and actively collaborate with government–industry–university–research institutions to realize the integration and utilization of heterogeneous resources and further improve their capability of green innovation.

Finally, ENs are key factors in maintaining the sustainable and healthy operation of the innovation ecosystem. We suggest that all innovation actors pay attention to the formulation and implementation of relevant rules in innovation ecosystems to create a good environment for their interaction and cooperation and improve cooperation guarantees. In addition, ENs in innovation ecosystems need to be continuously improved and supplemented, so we suggest that the creator of the innovation ecosystem modify and improve ENs based on the actual development of the innovation ecosystem, thus preventing unreasonable ecological norms from inhibiting the implementation of cooperative activities in green innovation among innovation actors.

6.4. Limitations and Future Research

As with other studies, this study also has some limitations, which can be further improved from the following aspects in the future. First, this study used a questionnaire to obtain data, which may have introduced subjective bias. In the future, combining the questionnaire with secondary data and longitudinal data for verification can be considered. Second, this study mainly takes SMMEs within innovation ecosystems as the research objects. It may be interesting to consider expanding the research actors, such as by taking financial institutions or scientific research institutions within innovation ecosystems as research objects to conduct relevant research. Third, this study mainly discusses the impact of IEE on the GIP of SMMEs. Future studies can explore the configuration effect affecting the GIP of SMMEs based on the innovation ecosystem.

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Abbreviations

IEE: Innovation eco-embeddedness. IESE: Innovation ecosystem structural embeddedness. IERE: Innovation ecosystem relational embeddedness. GVCCPs: Green value co-creation practices. GIP: Green innovation performance. ENs: Ecological norms.

Appendix A

Questionnaire on green innovation performance of SMMEs through innovation ecosystem embeddedness

Dear Sir/Madam,

Hello! We are researchers from the School of Economics and Management, Chang 'an University. Thank you very much for taking time out of your busy schedule to participate in our survey. The questions in this questionnaire were set based on our learning and discussions in the Operations and Innovation Management course. The purpose of the survey is to explore the factors affecting green innovation in small and medium-sized manufacturing enterprises (SMMEs) embedded in innovation ecosystems, with a view to providing more references for SMMEs to implement green innovation. The survey data is only used for academic research, and there is no right or wrong answer to the question. Please answer according to the actual situation of your company. Thank you very much for your support and participation!

The questionnaire is divided into five parts, the first part is the survey of company's basic situation. The second part is about the innovation eco-embeddedness. The third part is about green innovation performance. The fourth part is about green value co-creation practices. The fifth part is about the ecological norms. The people who answer this questionnaire should have a comprehensive understanding of the innovation ecosystem. We believe that the general manager of the company or senior management of the science and technology research and development department is the most suitable to fill out this questionnaire. If you think you are not the best person to answer certain questions, you can ask the person who knows best to answer them. Also, please include his/her job title and contact information in the questionnaire. If you cannot provide specific data, please make the closest estimate.

Part One: Basic information of the enterprise

1. Company name: ____________________
2. Address (province and city): ____________________
3. Information of the applicant: Name: ________________Department: ______________
   Position (selection): Top management/Middle manager/Grass-roots manager
   Tenure: ____________________(Example: 3 years)
   Phone Number: ____________________Email: ____________
4. Date of establishment: ____________________(Example: 2008)
5. Listed or not: Yes/no
6. Nature of enterprise (choice): State-owned or state-owned holding/Collective ownership/Private enterprise/Joint venture/Foreign enterprise/Other
7. Total number of employees (in persons): $X \geq 1000/300 \leq X < 1000/20 \leq X < 300/X < 20$
8. Operating Income (In Millions of CNY): $Y \geq 400/20 \leq Y < 400/3 \leq Y < 20/Y < 3$
9. Is your organization in an innovation ecosystem dominated by a focal(core) or platform company? Yes/no
10. How long has your organization been part of the innovation ecosystem?
    More than 5 years/3–5 years/1–3 years/less than 1 year

Part Two: Innovation eco-embeddedness

The innovation ecosystem is a dynamic system that consists of the interaction between enterprises and other actors (including core enterprises, non-core enterprises, universities, research institutions, financial institutions, suppliers, intermediaries, customers.) in the process of innSMMEsovation, and the resulting structures and environments, which is also regarded as a network, in which there is one or more core enterprises. There, different ecological participants work together around the core firms to develop new products by sharing technology, knowledge or skills. Innovation ecosystem embeddedness refers to the extent to which a company integrates and becomes part of the innovation ecosystem, including its position in innovation ecosystems, the degree of interdependence, trust, and information sharing with ecosystem members.

Please select your level of agreement with the following statements based on the actual implementation of the innovation ecosystem strategy in your organization (1—strongly disagree, 2—disagree, 3—somewhat disagree, 4—undecided, 5—somewhat agree, 6—agree, 7—strongly agree)

1. We have established relationships with many ecological partners.
   Strongly disagree○○○○○Strongly agree
2. We have access to a wide range of resources through collaboration with our eco-partners.
   Strongly disagree○○○○○Strongly agree
3. We have launched many new green products in cooperation with our eco-partners.
   Strongly disagree○○○○○Strongly agree
4. We cooperate with eco-partners in various modes of green innovation.
   Strongly disagree○○○○○Strongly agree
5. We cooperate with our eco-partners in green innovation relatively frequently.
   Strongly disagree○○○○○Strongly agree
6. We and our eco-partners have similar types of business in the same industry sector.
   Strongly disagree○○○○○Strongly agree
7. The knowledge, technology and resources of the eco-partners are highly available to us.
   Strongly disagree○○○○○Strongly agree
8. The combination of our resources and competencies with the eco-partner helps to improve the company's performance.
   Strongly disagree○○○○○Strongly agree
9. The combination of our resources and competencies with the eco-partner helps to improve the performance of the eco-partner.
   Strongly disagree○○○○○Strongly agree
10. We have established a high level of cooperation and trust with our eco-partners.
   Strongly disagree○○○○○Strongly agree

Part Three: Green innovation performance

Green innovation performance refers to the technological innovation related to energy saving, pollution prevention, waste recycling in all aspects of green products and processes design and production innovation.

Please select your degree of agreement with the following statements (1—strongly disagree, 2—disagree, 3—somewhat disagree, 4—unsure, 5—somewhat agree, 6—agree, 7—strongly agree) according to the actual situation of the enterprise's green innovation performance.

1. We choose materials that do not pollute or that minimize environmental impact when developing or designing products.
   Strongly disagree○○○○○Strongly agree
2. We choose to use materials that consume the least amount of energy and resources when developing or designing products.
   Strongly disagree○○○○○Strongly agree

3. We minimize the use of raw materials when developing or designing products.
Strongly disagree○○○○○Strongly agree
4. We carefully evaluate recyclability, reusability and decomposability of our products when developing and designing products.
Strongly disagree○○○○○Strongly agree
5. We effectively minimize hazardous substances and waste emissions in our production processes.
Strongly disagree○○○○○Strongly agree
6. We efficiently recycle waste and emissions in our production processes so that they can be treated and reused.
Strongly disagree○○○○○Strongly agree
7. We effectively reduce the consumption of water, electricity, coal and oil in the production process.
Strongly disagree○○○○○Strongly agree
8. We effectively minimize the use of raw materials in the production process.
Strongly disagree○○○○○Strongly agree

Part Four: Green Value Co-Creation Practices

Green value co-creation practices refer to a series of interactions between actors in the innovation ecosystem to integrate, assimilate, and reuse innovation resources and technologies. This includes joint planning, joint problem solving, and flexible responses to changes in relationships with ecosystem members.

Please select your level of agreement with the following statements based on your organization's practice of value co-creation with ecosystem partners (1—strongly disagree, 2—disagree, 3—somewhat disagree, 4—undecided, 5—somewhat agree, 6—agree, 7—strongly agree).

1. We share our ideas for other innovation actors about our green products during the development process. Strongly disagree○○○○○Strongly agree
2. We are willing to spare time and effort to share our suggestions with other innovation actors to improve our green products or processes further.
Strongly disagree○○○○○Strongly agree
3. We consider our role to be as crucial as other innovation actors' in the green product development process.
Strongly disagree○○○○○Strongly agree
4. We create different experiences in the green value developing process through collaboration with other innovation actors.
Strongly disagree○○○○○Strongly agree
5. We improve by experimenting in the green value developing process through the participation with other innovation actors.
Strongly disagree○○○○○Strongly agree
6. We create green products unique to the user and the usage condition through the participation with other innovation actors.
Strongly disagree○○○○○Strongly agree
7. We assist other innovation actors to fully participate in the green value developing process.
Strongly disagree○○○○○Strongly agree

Part Five: Ecological norms

Ecological norms refers to the institutional norms and "game rules" that all participants in innovation ecosystems must abide by, which are used to restrict the behavior of ecological members and avoid the occurrence of opportunistic behaviors such as "free riding".

Please select your level of agreement with the following statements (1—strongly disagree, 2—disagree, 3—Somewhat disagree, 4—unsure, 5—Somewhat agree, 6—agree, 7—strongly agree) based on the actual situation of the innovation ecosystem embedded in your company.

1. There are relatively sound formal rules in innovation ecosystems.
   Strongly disagree○○○○○Strongly agree
2. The innovation ecosystem has a good coordination and information mechanism.
   Strongly disagree○○○○○Strongly agree
3. Members of the innovation ecosystem have some common knowledge (including knowledge of products, technologies, processes and management).
   Strongly disagree○○○○○Strongly agree
4. The innovation ecosystem has a commonly recognized certification system (refers to the normative requirements and standards of system operation and behavior).
   Strongly disagree○○○○○Strongly agree

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