sustainability

MDPI

Article

Knowledge Element Relationship and Value Co-Creation in the Innovation Ecosystem

Gening Yang

School of Economics and Management, Nanchang University, Nanchang 330031, China; yanggening@ncu.edu.cn

Abstract: In the era of Innovation 3.0, more and more enterprises are working together to build an innovation ecosystem to achieve value creation. The various participants in the innovation ecosystem promote resource aggregation and integration through cross boundary collaboration, jointly creating the value of the ecosystem. Value co-creation has become the core goal pursued by the participants in the innovation ecosystem. As an innovative participant in the innovation ecosystem, it is particularly necessary for enterprises to explore the formation mechanism of value co-creation from the perspective of enterprise knowledge characteristics. This article analyzes the value co-creation mechanism of innovation ecosystems from the perspective of including internal knowledge bases and external relationships. Based on the dimension of knowledge element relationships, a theoretical model is constructed to investigate the impact of enterprise knowledge element relationships on value co-creation in innovation ecosystems and explore the mediating role of knowledge synergy and the moderating role of innovation ecosystem normativity. The relationships are modeled based on survey data collected from 427 Chinese companies, and multiple regression analysis and bootstrap methods are used to empirically test the hypotheses. The research results show that different dimensions of knowledge element relationships have different impacts on value co-creation. Knowledge element substitution negatively affects value co-creation, while knowledge combination diversity positively affects value co-creation. However, there is an inverted U-shaped relationship between knowledge element complementarity and value co-creation. Knowledge synergy partially mediates the relationship between knowledge element relationships and value co-creation, and innovation ecosystem normativity has a two-stage moderating effect on the path from knowledge element relationships to knowledge synergy to value co-creation. This article enriches the research content of knowledge management in innovation ecosystems, guides enterprises in the innovation ecosystem to reasonably construct their own knowledge systems, and promotes the formation of innovation ecosystem norms, thus promoting the development of value co-creation activities.

Keywords: innovation ecosystem; knowledge element relationship; knowledge synergy; innovation ecosystem normativity; value co-creation

Citation: Yang, G. Knowledge Element Relationship and Value Co-Creation in the Innovation Ecosystem. *Sustainability* **2024**, *16*, 4273. https://doi.org/10.3390/su16104273

Academic Editor: Andrew Thomas

Received: 11 April 2024
Revised: 12 May 2024
Accepted: 16 May 2024
Published: 19 May 2024

1. Introduction

The new paradigm called innovation ecosystem, which is driven by a diverse environment of ecological development, has become a core element in enterprise development strategies [1,2], such as Haier's open innovation platform and IBM's hybrid cloud ecosystem. When Huawei released HarmonyOS 2.0, it stated that only 1% are focused on the successful development of operating systems, and the remaining 99% are focused on ecology. The cross boundary collaboration of participating entities in the innovation ecosystem shapes value creation into a markedly open process, gradually transforming the thinking logic of value output from individual creation to co-creation with other resource owners [3,4]. Most studies have explored the mechanisms, models, and antecedents of value co-creation in innovation ecosystems at the systemic level [4,5], but with minimal exploration of the reasons from the perspective of participating entities. However, the internal characteristics of participants have an impact on their research and development ability, collaborative behavior, and knowledge integration ability, among other aspects. In an innovation ecosystem, value co-creation will constantly change under the influence of participants' internal characteristics. Therefore, seeking the generation mechanism of value co-creation from the perspective of participants can provide an effective reference for building a sustainable and win–win innovation ecosystem and achieving value co-creation.

A knowledge-based theory holds that knowledge is the foundation of value creation [6]. Enterprises, as an innovation participant in the innovation ecosystem [7], achieve value co-creation through knowledge interaction with partners. The success of this process is closely related to the internal knowledge base characteristics of enterprises [8]. Huawei and Haier also deploy their knowledge base in a directional manner in building an innovation ecosystem and influence the knowledge layout of their partners in innovation ecosystem development. In addition, the innovation ecosystem is considered an innovation network primarily connected by collaborative innovation among participants [9]. Knowledge synergy, as the foundation of collaborative innovation [10], can enhance the knowledge level of participants and also improve the overall capacity of the innovation ecosystem [11]. To promote the realization of value co-creation, Huawei regularly holds partner ecological conferences and other activities annually, particularly through the open exchange of knowledge resources, forms knowledge synergy with partners, and realizes the transformation of cooperative relationships from simple economic benefits (e.g., technology and products) to cultural and value recognition. The standardization of the innovation ecosystem, as a situational element, also has a certain impact on the smooth operation of activities in the innovation ecosystem [12] and may play an important role in transforming knowledge resources into value. However, there is currently a lack of clear understanding of the relationship and boundary conditions among knowledge base characteristics, knowledge synergy, and value co-creation. Consequently, this situation leads to low efficiency and insufficient effectiveness in knowledge deployment in the practice process of innovation ecosystems. Therefore, clarifying the relationship between different types of knowledge foundation characteristics, knowledge synergy, and value co-creation in enterprises, as well as whether they are influenced by the standardization of the innovation ecosystem, has become an urgent issue in the research and practice of innovation ecosystem and knowledge management theory.

2. Literature Review

2.1. Innovation Ecosystem and Value Co-Creation

Since Adner [13] officially proposed the concept of innovation ecosystems, it has become a research hotspot in the field of innovation management. Some studies have suggested that the innovation ecosystem is a collection of dynamic entities, innovative activities, innovative products, partnerships, and institutional norms involved in innovation. The innovation ecosystem fully considers the innovation and environmental embeddedness of participating entities, forming a self-organizing network around common value propositions, resource sharing, and interdependence between entities [3,14,15]. Jacobides et al. [16] argued that the innovation ecosystem, unlike traditional innovation paradigms, does not focus on the innovation of individual technologies but on how to create additional value through overall collaborative effort (i.e., products, services, operations, strategies, or business models that are innovative and can bring economic benefits). The innovation ecosystem, as a new competitive unit, adopts a holistic perspective to help participating entities achieve difficult goals solely on their own. Competition between enterprises in the past has gradually evolved into a competition between the innovation ecosystems of enterprises, reflected in the joint effort of participating entities to achieve value co-creation and bring new competitiveness to the system [7,17,18]. Russell et al. [19] believed that an innovation ecosystem is a collaborative network focused on value co-creation.

The existing literature on value co-creation in innovation ecosystems has mainly focused on two aspects. On the one hand, the mechanisms and models of value co-creation in the innovation ecosystem are explored. Kahle et al. [20] conducted research on small and medium-sized enterprises and found that value co-creation in innovation ecosystems relies on the joint participation of multiple stakeholders. They determined that this collaborative model can help overcome resource and technology shortages. Ritala et al. [5] found that the innovation ecosystem satisfies the value acquisition goals of all participating entities through open collaboration to achieve the overall goals of the innovation ecosystem and achieve value co-creation. Yngfalk [21] proposed that the optimal choice for achieving value co-creation in the innovation ecosystem is the interaction combination of operating modes or operating mechanisms, starting from the two main lines of value co-creation models and mechanisms. On the other hand, the antecedents of value co-creation in innovation ecosystems are explored from multiple perspectives. Fontana et al. [22] used the theory of planned behavior as a basis for determining that value orientation, sharing systems, level of trust in leading enterprises, and environmental driving factors can affect value co-creation in the innovation ecosystem. Clarysse et al. [23] indicated that shared vision and shared values among participating entities in an innovation ecosystem can effectively promote value co-creation. Mele et al. [24] combined social network and knowledge combination theories and found that knowledge network embedding can affect value co-creation.

2.2. Knowledge Element Relationship

Knowledge-based theory emphasizes that knowledge is the fundamental resource for value creation [6]. Ritala and Almpanopoulou [25] argued that "innovation" in the innovation ecosystem represents the invention and creation of new knowledge. The value transformation of the innovation ecosystem needs to be achieved with the support of the internal resources of participating entities [26]. Moreover, the collection of knowledge resources owned by enterprises, namely, enterprise knowledge foundation [27], becomes the guarantee for achieving value co-creation. The existing literature has typically divided knowledge foundations into breadth and depth based on structural dimensions, exploring their effects on different outcome variables in different research contexts [28,29]. However, some studies have considered innovation a combination or reorganization of existing knowledge elements [30]. These studies have recognized that the relationships between knowledge elements reflect specific ways in which enterprises utilize knowledge. Understanding knowledge bases from a relational dimension is a superior perspective [31]. Yoon et al. [32] proposed that the knowledge resources of enterprises are composed of knowledge elements and their interrelationships. Moreover, they found that the combination of knowledge elements is related to the development and utilization of new knowledge by enterprises using their knowledge base. Dibiaggio et al. [33] divided the relationship between knowledge elements into knowledge complementarity and knowledge substitutability. They determined that the level of knowledge element complementarity has a promoting effect on the innovation ability of enterprises. However, the level of knowledge element substitution may generally inhibit the innovation ability of enterprises. On this basis, Li et al. [34] further analyzed the curve relationship between knowledge complementarity and knowledge substitutability and technological innovation performance, using them as antecedent variables.

2.3. Knowledge Synergy

Adner [13] indicated that the innovation ecosystem achieves value output by creating collaborative networks that enable participating entities to engage in complementary collaboration. Baldwin et al. [35] explored the driving factors for the operation of innovation ecosystems and found that synergistic effects are an important mechanism for the development of innovation ecosystems. Van Gils and Zwart [36] combined knowledge foundation theory and believed that effective collaboration between enterprises can promote the accumulation of knowledge resources, which is an effective way to achieve value creation. With the advent of the knowledge economy, scholars have combined collaboration with knowledge management and proposed knowledge synergy [10]. Extensive studies have explored the role of knowledge synergy in the relationship between the resource endowment of innovation entities and innovation outcomes. Grimpe and Kaiser [37] conducted research on innovation alliances and determined that knowledge synergy plays a mediating role between alliance knowledge heterogeneity and firm innovation performance. Schilling [38] found that knowledge synergy plays a mediating role between technological diversification and the sustainability of enterprise innovation. Zhang et al. [39] conducted a case study on technology alliances and showed that knowledge flow runs through the entire innovation. Moreover, they determined that knowledge synergy promotes the integration of knowledge resources between enterprises and partners, ultimately achieving technological innovation.

2.4. Review

A review of the existing literature indicates certain potential connections among value co-creation in the innovation ecosystem, knowledge element relationship, and knowledge synergy. Value co-creation in the innovation ecosystem has always been the focus of scholars' attention. Existing studies have conducted in-depth research on the operating mechanism and model of value co-creation from multiple perspectives. However, most of them have been based on the overall perspective of the system, and minimal research has been conducted on the influencing factors of value co-creation from the perspective of participating subjects. Accordingly, there is urgency in exploring how the factors of the actual participating subjects affect value co-creation. The knowledge base of an enterprise is the foundation of value creation, and explaining this knowledge base from a relational dimension is a superior perspective. The relevant literature on the knowledge element relationship has mostly been based on an internal perspective within an enterprise. These studies have effectively combined innovation ecosystems with knowledge base theory to explore the role of knowledge element relationship from the perspective of innovation ecosystems, which can relatively enrich the current literature. In the innovation ecosystem, knowledge synergy plays an indispensable role in transforming knowledge resources into value, but the existing literature has focused considerably on alliances or simple inter-enterprise cooperation scenarios. As an innovative ecosystem based on knowledge with collaborative networks, it has essential differences in value pursuit from alliances or simple inter-enterprise cooperation. Hence, the role of knowledge synergy in the innovative ecosystem with symbiotic and dynamic characteristics must be explored. On the basis of the shortcomings of the existing literature, this study attempts to verify the impact of knowledge element relationships on value co-creation in innovation ecosystems from the perspective of knowledge base. Moreover, this research explores the mediating mechanism of knowledge synergy and situational factors in this process to provide theoretical references for enterprises in innovation ecosystems to achieve value co-creation.

3. Theoretical Foundations and Research Hypotheses

3.1. Knowledge Element Relationship and Value Co-Creation

Value co-creation refers to the sharing of innovation resources based on common innovation goals among the various entities in the innovation ecosystem and the continuous creation of value to meet market demands [26]. Knowledge-based theory believes that enterprises are a collection of knowledge elements, and innovation is the combination or reorganization of existing knowledge elements [30]. The interaction between knowledge elements can bring value output. Knowledge element relationship refers to the relationship between knowledge elements in creating new knowledge based on their combined activities [40]. The current study used Colombelli et al. [41] and Dibiaggio et al. [33] as bases to reflect the knowledge element relationship from three aspects: complementarity, substitutability, and knowledge element combination diversity.

Knowledge element complementarity refers to the fact that two knowledge elements have differences and connections and can increase the marginal return of knowledge after combining. Complementarity is manifested in the ability to generate new knowledge through the combination of knowledge elements. When two knowledge elements are combined, they are considered to be complementary if their value or use increases [42]. In the innovation ecosystem, innovation actors overcome the limitations of knowledge resources through open innovation and co-evolution to achieve value co-creation, which is actually knowledge integration and exchange [43]. When knowledge element complementarity increases from low to medium levels, companies have considerably more effective knowledge combination options in their knowledge base, and large-scale knowledge combinations are beneficial for enhancing the value of technology and knowledge [44]. High-quality new knowledge brought by knowledge element complementarity enables companies to have additional unique insights into the knowledge within their field and immediately absorb and understand external knowledge from similar fields of partners, thereby promoting the integration and exchange of knowledge between companies and partners [27]. Therefore, when companies cooperate with partners, value co-creation is also promoted as knowledge element complementarity gradually increases. However, value generation is closely related to the difficulty of generating new knowledge [33] (Dibiaggio et al., 2014). If companies' knowledge element complementarity is substantially high, then they are markedly focused on knowledge in certain related or similar technology fields. Moreover, the path of using knowledge elements is relatively fixed, with limited scope and space for combining knowledge elements. At this point, companies lack experience in dealing with other fields of knowledge elements owned by partners, which increases the difficulty of knowledge interaction between all parties, thereby leading to increased uncertainty in cooperation and even hindering value co-creation [45,46] (Duysters & Lokshin, 2011; He er al, 2023). Therefore, we propose the following hypothesis on the basis of the preceding analysis:

H1a. *Knowledge element complementarity has an inverted U-shaped impact on value co-creation.*

Knowledge element substitutability refers to the fact that different knowledge elements have similar functional attributes, manifested in the degree of similarity in the way that different knowledge elements are combined with other knowledge elements, thereby reflecting the partial overlap of knowledge resources [33,41]. In using knowledge elements, considerably high substitutability of knowledge elements will bring functional redundancy to enterprises, and numerous combined knowledge elements with similar functions will narrow the choice scope of enterprise innovation directions [47]. In addition, knowledge element substitutability relatively reflects the extent of enterprises' limitations in the field of knowledge. The higher the knowledge element substitutability, the more likely enterprises will focus on certain specific knowledge or technology fields, leading to technological lock-in [48] and also causing cognitive inertia in enterprises and R&D personnel [49]. Thus, this situation brings obstacles to value co-creation. Moreover, knowledge element substitutability leads to functional similarity of knowledge elements in enterprises' knowledge bases, causing numerous resources owned by enterprises and partners in the innovation ecosystem to be allocated to knowledge elements with similar attributes. Numerous substitutable knowledge elements occupy limited resources, resulting in enterprises and partners bearing the cost of knowledge diversification without corresponding benefits [27], thereby hindering value co-creation. Hence, we propose the following hypothesis on the basis of the preceding analysis:

H1b. *Knowledge element substitutability has a negative impact on value co-creation.*

The existing literature has indicated that excessive diversity in the knowledge elements of enterprises may lead to insufficient depth of knowledge in specific fields, affecting the accuracy of information acquisition and provision [50]. Unlike the diversity of enterprise knowledge elements, the diversity of the knowledge portfolio reflects the diversity of relationships between knowledge elements in generating new knowledge in enterprises [41]. This case is manifested in the size of the technical field involved in the absorption and utilization of knowledge elements to form new knowledge by enterprises [33]. Innovation ecosystems can achieve value co-creation through creating collaborative networks and collaborating with partners [13]. However, enterprises, in most cases, have difficulty directly translating external knowledge provided by partners in the innovation ecosystem into tangible value, requiring the absorption and utilization of this external knowledge based on internal knowledge [51]. When the diversity of companies' knowledge portfolio is low, its focus on technical fields is relatively narrow. In this case, companies need to exert additional effort and high costs to search for opportunities to combine knowledge elements with partners in the system [52]. Evidently, this situation is not conducive to smooth value co-creation. When the diversity of companies' knowledge portfolio is high, it represents their specialized understanding of knowledge in multiple fields [53], and they have a strong motivation to learn from the knowledge brought by partners in the innovation ecosystem. In addition, an increase in diversity in the knowledge portfolio can reduce the logical barriers between R&D personnel, resulting in companies and partners in the innovation ecosystem easily avoiding conflicts in the direction of knowledge combination [37]. This situation helps companies immediately absorb external knowledge and combine it into new knowledge that can be utilized when facing external knowledge input. Hence, value co-creation with partners is jointly promoted. Accordingly, we propose the following hypothesis on the basis of the preceding analysis:

H1c. *Diversity of knowledge combinations has a positive impact on value co-creation.*

3.2. Mediating Effect of Knowledge Synergy

Knowledge synergy refers to the collaboration of participating parties in an innovation ecosystem to acquire, absorb, integrate, and utilize knowledge resources, which can improve the efficiency of knowledge resource allocation and make the overall benefit greater than the sum of the benefits of each independent component [10]. Knowledge synergy is an important way for enterprises and their partners in the innovation ecosystem to enhance their innovation capabilities and improve their innovation level [54]. Effective knowledge synergy can help enterprises acquire and absorb knowledge that matches their own professional fields from their partners in the innovation ecosystem [37], help enterprises integrate internal and external knowledge resources, and promote value co-creation in the innovation ecosystem [26]. In using knowledge elements to promote knowledge exchange and sharing in the innovation ecosystem, enterprises can achieve additional cognitive "common ground" through knowledge synergy [55], facilitate the formation of common goals or visions among partners, form a consistent innovation direction, and effectively promote value co-creation [8,56]. On the basis of the preceding analysis, this study proposes the following hypothesis:

H2a. *Knowledge synergy has a positive impact on value co-creation.*

The generation of knowledge demand by participating enterprises in the innovation ecosystem is a prerequisite for achieving knowledge synergy in the ecosystem. Knowledge synergy begins when the external knowledge flow of enterprises coincides with their internal knowledge demand [57]. A nonlinear relationship exists between the complementarity of knowledge elements and knowledge synergy in the innovation ecosystem. A low complementarity of enterprise knowledge elements indicates that the effective utilization rate of knowledge elements in their knowledge base is low [33], reflecting a lack of understanding of knowledge in their field and difficulty in identifying knowledge needs [58]. When faced with the inflow of knowledge from partners, enterprises also have difficulty effectively utilizing this knowledge to form synergies. As the complementarity of knowledge elements increases, the distribution of enterprise knowledge elements begins to show a centralized trend, resulting in knowledge demand in certain fields. At this point, enterprises have considerably high potential for collaboration. When enterprises are faced with external knowledge from partners, the former can promote the cross-fertilization of different knowledge elements and effectively promote knowledge synergy [34]. However, this upward trend reaches a certain point and then undergoes dynamic changes. High-level complementarity of knowledge elements means that the connectivity of enterprise knowledge networks is high [59], reflecting the directionality of enterprise knowledge acquisition [60]. This situation makes enterprises markedly "choosy" about acquiring external knowledge. When the external knowledge of partners in the innovation ecosystem cannot coincide with the direction of enterprise knowledge acquisition, the internal knowledge demand and external knowledge flow of enterprises cannot coincide, possibly inhibiting knowledge synergy [59]. On this basis, we propose the following hypothesis:

H2b. *The complementarity of knowledge elements has an inverted U-shaped impact on knowledge synergy.*

The increase in the substitution level of knowledge elements is manifested in the increase in the number of functionally similar knowledge elements [33], which may have a negative impact on knowledge synergy between enterprises and their partners. On the one hand, the generation of synergistic effects requires smooth knowledge exchange between cooperating parties, and knowledge exchange in the innovation ecosystem requires cognitive proximity, helping the parties to understand and absorb each other's knowledge and facilitating communication in the innovation ecosystem and promoting knowledge synergy [61]. However, the higher the level of substitution of knowledge elements, the easier it is for enterprises to focus on certain specific knowledge areas. This case leads to cognitive distance from other areas of knowledge brought by partners in the innovation ecosystem. The emergence of cognitive distance can result in difficulty for all parties to understand each other, resulting in a lack of common language, limiting smooth knowledge exchange in the innovation ecosystem, and hindering knowledge synergy [62]. In addition, the substitution of knowledge elements leads to a markedly narrow knowledge domain for enterprises, possibly resulting in difficulty for enterprises to identify external knowledge in other areas of the innovation ecosystem brought by partners, which also brings additional coordination and integration costs to knowledge synergy [63]. On the other hand, high levels of substitution of knowledge elements lead to difficulty for enterprises to utilize their large knowledge base, which can easily create a false impression of "rich resources" for them enterprises, leading them to be blindly optimistic and believe that value creation no longer requires the intervention of other parties in the innovation ecosystem [27]. This outcome is not conducive to generating knowledge synergy through interaction with external, non-substitutable knowledge elements. In addition, the substitution of knowledge elements reflects the functional redundancy of enterprise knowledge elements rather than the depth of exploration of a vertical field of knowledge [34]. Even if enterprises face cutting-edge knowledge from partners belonging to their own field, R&D personnel will still have difficulty directly applying such knowledge owing to its obscurity, abstractness, and difficulty in understanding, which is not conducive to generating knowledge synergy [64]. Therefore, we propose the following hypothesis on the basis of the preceding analysis:

H2c. *The substitution of knowledge elements has a significant negative impact on knowledge synergy.*

In the innovation ecosystem, the diversity of participating enterprises' knowledge portfolios can effectively promote knowledge synergy. With an increase in the diversity of knowledge portfolios, an increasing number of successful knowledge combinations are generated, indicating that enterprises have experienced acquiring, understanding, and absorbing numerous knowledge elements, reflecting the excellent absorptive capacity of enterprises for knowledge elements [65]. The absorptive capacity perspective indicates that the existing knowledge accumulation of enterprises affects the recognition, absorption, and integration of external knowledge [66]. That is, the ability of enterprises to understand their own knowledge elements enables them to effectively utilize existing knowledge elements and also externally inflowing knowledge elements, which provides a platform for smooth communication and effective interaction between the main players in the innovation ecosystem. Therefore, when faced with new knowledge from partners, the diversity of the knowledge portfolio increases the number and variety of potential knowledge combinations formed between enterprises and partners, enabling enterprises to effectively transfer and integrate different knowledge and generate synergies [28]. Moreover, high-level knowledge portfolio diversity enables enterprises to have certain predictive capabilities for knowledge elements and their interrelationships. When faced with external knowledge interactions with partners in the innovation ecosystem, they can choose minimally inefficient knowledge combinations and reduce search costs in knowledge synergy [33], thereby promoting such a synergy. Accordingly, we propose the following hypothesis on the basis of the preceding analysis:

H2d. *The diversity of knowledge combinations has a significant positive impact on knowledge synergy.*

The innovation ecosystem is considered an innovation network, with collaborative innovation between participating entities as the main connection [9]. Value co-creation in the innovation ecosystem, as a collaborative integration mechanism, mainly manifests as collaborative interactions between entities based on knowledge resources, namely, knowledge synergy [67]. Knowledge synergy aims to create value and is an effective way for participating companies with different knowledge base characteristics to optimize and integrate knowledge resources [68]. Only when there is a synergistic effect between existing knowledge and acquired knowledge can value co-creation be effectively promoted [55]. When companies have different knowledge element relationships, their needs for external knowledge are also different, which will have differential effects on knowledge synergy and have varying impacts on value co-creation. Therefore, knowledge synergy is an important mediating mechanism between the knowledge base relationships of enterprises and the value co-creation of innovation ecosystems. Accordingly, the following hypothesis is proposed on the basis of the preceding analysis.

H2. *Knowledge synergy has a significant mediating effect between the knowledge element relationship and value co-creation.*

3.3. Moderating Effect of Innovation Ecosystem Standardization

The development of an innovative ecosystem is a process of entropy reduction, and the development from disorder to order gradually brings the system to a state of normalization [69]. The normalization of the innovative ecosystem refers to the degree of standardization of activities and operations in the innovative ecosystem, reflecting the cooperative environment in the innovative ecosystem, which is reflected through formal rules, information, coordination mechanisms, consensus, and certification systems formed within this ecosystem [69,70]. The agreed-upon set formed by participating parties in long-term cooperation contributes to the emergence of the normalization of the innovative ecosystem, and this normalization can guide the behavior and value proposition of participating parties in the activities of such an ecosystem [71].

High-level innovation ecosystem normativity can promote the formation of additional complete regulatory systems and collaboration mechanisms among participating entities, enhance trust among participating entities through effectively suppressing opportunistic behavior, promote knowledge interaction between them, and reduce knowledge exchange barriers [69]. Smooth knowledge exchange within the innovation ecosystem can help companies and partners to markedly understand each other's knowledge information. As the complementarity of knowledge elements changes from low to high, corporate knowledge needs become more directional, forming a stronger synergistic effect. Therefore, innovation ecosystem normativity can enhance the positive relationship between knowledge element complementarity and the left side of the inverted U-shaped curve of knowledge synergy, making the curve rise steeply. In addition, high-level innovation ecosystem normativity can promote the formation of mutually dependent, adaptive, and self-organized coordination systems among participating entities [72]. This situation leads to considerable consensus on knowledge utilization and increases the matching of knowledge elements between them [24]. Moreover, this case can alleviate the inhibitory effect on knowledge synergy owing to reduced knowledge element matching during the transition from medium to high levels of knowledge element complementarity. Therefore, high levels of innovation ecosystem normativity can alleviate the negative relationship between knowledge element complementarity and the right side of the inverted U-shaped curve of knowledge synergy. On this basis, we propose the following hypothesis:

H3a. *Innovation ecosystem norm has a significant moderating effect on the inverted U-shaped relationship between knowledge element complementarity and knowledge synergy.*

On the one hand, improvements in the normativity of the innovation ecosystem can usually enable good interactions between participating entities in formal or informal contractual forms. Long-term positive interactions can promote the formation of similar cognitive foundations among participating entities, thereby facilitating knowledge and information interaction between them and reducing their cognitive distance [69]. Given that the substitution of knowledge elements inhibits knowledge synergy by creating cognitive distance between enterprises and partners [62], high-level innovation ecosystem normativity can alleviate the negative impact of knowledge element substitution on knowledge synergy in this process. On the other hand, high-level innovation ecosystem normativity can usually enable the formation of sound coordination and information transmission mechanisms within the system, helping enterprises to discover heterogeneous knowledge in other fields that can promote their own development [73], making enterprises have knowledge needs. Enterprises can utilize this heterogeneous knowledge through observation, imitation, or purchase. The increase in the substitution of knowledge elements has led to a gradual narrowing of enterprises' knowledge domain, resulting in their difficulty identifying the knowledge of partners in other fields and inhibiting knowledge synergy [63]. In this process, innovation ecosystem normativity can effectively alleviate the adaptation problem in the knowledge domain. In summary, high-level innovation ecosystem normativity can weaken the negative relationship between knowledge element substitution and knowledge synergy. Therefore, we propose the following hypothesis:

H3b. *Innovation ecosystem normativity has a significant moderating effect on the negative relationship between the substitutability of knowledge elements and knowledge synergy.*

By gradually increasing the diversity of knowledge combinations, knowledge synergy is promoted by enhancing the ability of enterprises to absorb and understand partner knowledge [28]. The normative nature of the innovation ecosystem can enhance the ability of enterprises to absorb and understand partner knowledge in this process by improving the exchange and utilization efficiency of knowledge resources in the innovation ecosystem. This case plays a promoting role in the relationship between knowledge combination diversity and knowledge synergy. First, high-level innovation ecosystem normativity can promote the formation of a common understanding among the entire innovation ecosystem. Such an understanding provides a foundation for knowledge learning and interaction between subjects, improves the mutual understanding and interpretation of knowledge among subjects, and enhances the absorption and utilization efficiency of knowledge resources between them [24]. Second, with the improvement in the normativity level of the innovation ecosystem, sound formal rules and regulations can enhance the transparency of the innovation ecosystem, reduce obstacles to information exchange between participating subjects, promote knowledge resource interaction, and enhance enterprises' understanding and absorption of partner knowledge. Therefore, high-level innovation ecosystem normativity can enhance the positive relationship between knowledge combination diversity and knowledge synergy. Accordingly, we propose the following hypothesis on the basis of the preceding analysis:

H3c. *Innovation ecosystem normativity has a significant moderating effect on the positive relationship between knowledge portfolio diversity and knowledge synergy.*

Knowledge synergy promotes value co-creation by promoting the integration of knowledge resources and forming a common understanding through the promotion of knowledge resource integration. This process is influenced by the normativity of the innovation ecosystem. On the one hand, low levels of innovation ecosystem normativity reflect weak institutional environments in the system, possibly leading to communication barriers and a lack of trust among actors, and even opportunistic behaviors (e.g., free-riding) [74]. These aspects are not conducive to the healthy flow and effective integration of knowledge resources and may relatively inhibit the positive impact of knowledge synergy on value co-creation. High levels of innovation ecosystem normativity can provide participating actors with a good cooperation environment, reduce communication barriers between actors, alleviate moral hazards [13], improve the efficiency of knowledge resource allocation, and promote the process from knowledge synergy to value co-creation. On the other hand, innovation ecosystem normativity is the result of long-term cooperation and interaction among system actors. High levels of innovation ecosystem normativity reflect consensus among partners in terms of product, management, and operation, which can promote the formation of a unified cognitive foundation between enterprises and their partners in the system [56]. The diversity of roles played by participating actors in the system has resulted in differences in their understanding of value. Low levels of innovation ecosystem normativity are not conducive to the formation of a common understanding, which is not conducive to enterprises and actors in the system transforming intangible knowledge formed through collaboration into tangible value outputs. High levels of innovation ecosystem normativity can further promote enterprises to form a unified cognitive foundation with partners through knowledge synergy, deepen the common understanding of value among actors, enable actors to form a consistent innovation direction, and promote actors to gradually move from knowledge synergy to value co-creation. Hence, we propose the following hypothesis on the basis of the preceding analysis:

H3d. *Innovation ecosystem normativity has a significant moderating effect on the positive relationship between knowledge synergy and value co-creation.*

In summary, this research further infers that the mediating role of knowledge-based relationships in influencing value co-creation through knowledge synergy is also moderated by the normativity of the innovation ecosystem. This aspect suggests the existence of a moderated mediating model.

First, as the complementarity of knowledge elements increases from low to medium levels, companies form knowledge synergies with partners through increasing knowledge demand and knowledge resources [34]. This result improves the integration efficiency of internal and external knowledge resources and promotes value co-creation [75]. The normativity of the innovation ecosystem can reduce the risks in this process, improve trust between participating parties, and promote the efficiency of knowledge resource allocation [13]. When the complementarity of knowledge elements increases from medium to high levels, the normativity of the innovation ecosystem can reduce communication barriers between parties and alleviate moral hazards [12], promote knowledge exchange between companies and partners, and form considerable consensus on knowledge utilization [24]. This outcome alleviates the narrowness of knowledge acquisition caused by a substantially high complementarity of knowledge elements, thereby leading to reduced knowledge synergy and inhibiting value co-creation. Accordingly, the following hypothesis is proposed:

H4a. *Innovation ecosystem normativity has a significant moderating effect on the mediating effect of knowledge synergy between knowledge element complementarity and value co-creation.*

Second, improvement in the substitution level of knowledge elements leads to the gradual narrowing of the knowledge field of enterprises and cognitive distance with partners, thereby hindering knowledge synergy, which is not conducive to the integration of knowledge resources and hinders value co-creation [62]. However, high-level innovation ecosystem norms indicate that participating parties have gradually formed a common cognitive foundation through long-term interactions, which is conducive to reducing information exchange barriers between participating parties and can relatively reduce cognitive distance and promote the integration of knowledge resources [71]. Accordingly, the following hypothesis is proposed:

H4b. *Innovation ecosystem normativity has a significant moderating effect on the mediating effect of knowledge synergy between knowledge element substitution and value co-creation.*

Lastly, with the increase in the diversity of knowledge combinations, enterprises can promote knowledge synergy by enhancing their ability to absorb and understand partner knowledge, thereby producing knowledge outcomes and realizing value co-creation [28]. In this process, high-level innovation ecosystem norms can reduce information exchange barriers between participating parties, enhance enterprises' ability to absorb and understand partner knowledge resources [69], and promote the positive interaction and effective integration of knowledge resources. Therefore, we propose the following hypothesis:

H4c. *Innovation ecosystem normativity has a significant moderating effect on the mediating effect of knowledge synergy between knowledge portfolio diversity and value co-creation.*

The research model is shown in Figure 1.

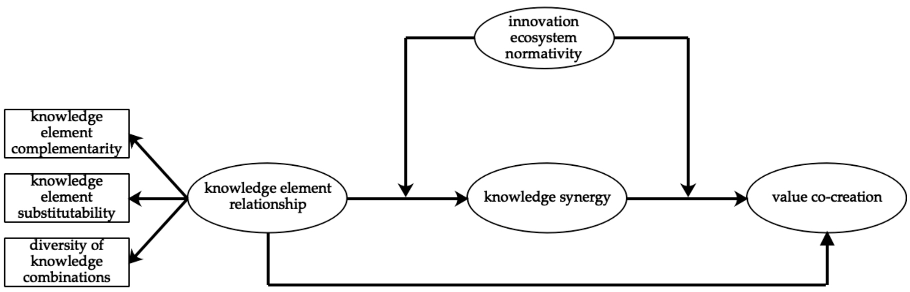

Figure 1. Research model.

4. Methodology

4.1. Sample Selection and Data Collection

This study conducted a questionnaire survey from July to December 2023, targeting high-tech enterprises with high innovation activity. We invited middle and senior managers who understand enterprise strategy and knowledge management to fill out the questionnaire based on the actual situations of the enterprises in the past three years. The questionnaire was mainly distributed in Guangzhou, Hangzhou, Wuhan, Dongguan, and Shenzhen according to the social network of the research team and the current situation of regional development. To ensure the authenticity and validity of the information provided by the respondents, we explained to the respondents the content of the questionnaire and the purpose of the survey when distributing the questionnaire. Moreover, we promised that the survey data would only be used for academic research, ensuring that their personal information would be kept confidential. A pre-research questionnaire was distributed in July 2023 to students working in high-tech enterprises and serving as middle and senior managers in MBA classes. A total of 69 questionnaires were distributed, and 58 were recovered. On the basis of the analysis results and feedback, the unclear and not easily understood contents of the questionnaire items were revised to form a final questionnaire. The formal questionnaire was distributed by combining on-site distribution with an online survey. A total of 648 questionnaires were distributed for the formal survey, and 513 were recovered. To ensure data authenticity, non-high-tech enterprise questionnaires, questionnaires filled out by grassroots employees, questionnaires with considerably short answer times, incomplete and clearly regular questionnaires, and overall contradictory questionnaires were excluded. A total of 86 invalid questionnaires were removed, and 427 valid questionnaires were obtained (valid questionnaire recovery rate of 65.895%). The basic situation of the sample is shown in Table 1.

Table 1. Statistics results for sample attributes.

Variables	Categories	No.	Proportion (%)
Firm size	100 or below	54	12.646
	101–500	102	23.888
	501–1000	68	15.925
	1001–2000	21	4.918
	2001 and above	182	42.623
Firm age	Below 5 years	36	8.431
	5–10 years	150	35.129
	11–15 years	41	9.602
	16–20 years	51	11.944
	21 years and above	149	34.895
Firm ownership	Private	224	52.459
	Non-private	203	47.541

4.2. Measurement

The scales for measuring each variable draw on existing research results, with minor adjustments based on the research context. A Likert 7-point scale is used for measurement, with 1 representing "completely inconsistent" and 7 representing "completely consistent." Referring to Ryoo and Kim's [42] scale for measuring knowledge complementarity, three items were selected for measuring the complementarity of knowledge elements. Referring to Colombelli et al. [41] and Dibiaggio [33] for research content and measurement dimensions of knowledge element substitution and knowledge combination diversity, three items were used to measure knowledge element substitution and knowledge combination diversity, respectively. Referring to the Sanders [56] scale for measuring knowledge synergy, three items were selected for measuring knowledge synergy. Referring to the Pera et al. [69] scale for measuring ecosystem normative mechanisms, four items were used to measure innovation ecosystem normativity. Referring to the Pera et al. [69] scale for measuring value co-creation, four items were used to measure value co-creation. To ensure the rationality and feasibility of the questionnaire design, the content of the variable items was checked before the formal survey. The English scale was adjusted by different researchers using back-translation. All questionnaire items were revised and refined to form an initial questionnaire. Thereafter, a final questionnaire was formed based on expert advice and pre-research. First, two experts in the field of innovation were invited to identify unclear and irrelevant items, modify and improve them, and adjust the order of items based on expert advice. The measurement items for the variables are shown in Table 2. To exclude the interference of other factors on the research results, firm size (FS), firm age (FA), and firm nature (FO) were selected as control variables through summarizing the existing research. FS is measured by dividing the number of existing employees into five levels, with a value of 1 for 100 or below employees, 2 for 101 to 500 employees, 3 for 501 to 1000 employees, 4 for 1001 to 2000 employees, and 5 for 2001 or over employees. FA is measured by dividing the number of years from the date of registration to the date of formal research into five levels, with a value of 1 for below 5 years, 2 for 5 to 10 years, 3 for 11 to 15 years, 4 for 16 to 20 years, and 5 for over 21 years. FO is an ordinal variable using a dummy variable, with values of 0 and 1 for private and non-private enterprises, respectively.

Table 2. Measuring items of variables and test results for reliability and validity.

Variables	Items	Factor Loadings	α	AVE	CR
Knowledge element complementarity (Kec)	Knowledge of enterprise raw material procurement can be used for new product development.	0.923	0.863	0.739	0.918
	Knowledge of enterprise production planning can be used for new product development.	0.877			
	Knowledge of enterprise professional technology can be used for new product development.	0.842			
Knowledge element substitution (Kes)	Professional backgrounds of R&D experts in enterprises are very similar.	0.901	0.890	0.735	0.876
	Enterprise has accumulated a large amount of knowledge in the same field.	0.886			
	Categories of enterprise technology patents are relatively concentrated.	0.794			
Knowledge element combination diversity (Kpd)	Professional technology developed by enterprises includes knowledge from multiple disciplines.	0.899	0.806	0.673	0.842
	Enterprises can appropriately combine the knowledge they have acquired into more new knowledge.	0.751			
	Enterprises can provide a variety of products or services.	0.767			
Knowledge synergy (KS)	Frequency of knowledge flow between enterprises and partners increases.	0.904	0.915	0.728	0.906
	Exchange of implicit or core technologies between enterprises and partners.	0.895			
	Improved efficiency of knowledge sharing between enterprises and partners.	0.876			
Innovation ecosystem normativity (Ien)	Enterprise is located in an innovative ecosystem with relatively sound formal rules.	0.922	0.925	0.780	0.931
	Innovation ecosystem where the enterprise is located has a good information and coordination mechanism.	0.871			
	Members of the innovation ecosystem where the enterprise is located have a consensus on products, technology, operations, and management.	0.907			
	Innovation ecosystem in which the enterprise is located has a commonly recognized certification system.	0.857			
Value co-creation (VC)	Enterprises can cooperate with partners to complete new product design.	0.896	0.940	0.707	0.911
	Enterprises can cooperate with partners to complete new product development.	0.827			
	Cooperation between enterprises and partners can improve the operation process.	0.833			
	Cooperation between enterprises and partners can optimize strategic planning.	0.798			

4.3. Reliability and Validity

This article uses confirmatory factor analysis to conduct reliability testing through internal consistency coefficients. The results are shown in Table 2. The alpha coefficients for each variable are above 0.700, indicating good reliability of the scale. All factor loadings for each item are above 0.700, CR values are above 0.800, and the AVE values are over 0.600, indicating good convergent validity of the scale. The test results for discriminant validity indicate that the square root of the AVE value is greater than the correlation coefficient value of the row and column in which it is located. These results indicate that the variable has good discriminant validity.

4.4. Common Method Bias

This research adopts such measures as anonymous measurement and partial reverse questions to control common method bias procedurally and uses the Harman single factor test to test for common method bias. Unrotated exploratory factor analysis extracts six factors with eigenvalues over 1. The maximum factor variance explains 31.946%, which is below 40%, indicating no significant common method bias.

5. Empirical Results

5.1. Descriptive and Correlation

This study uses SPSS 28.0 to conduct regression analysis to test the research hypotheses. The correlation between variables was tested before analyzing the relationship between variables. The results are shown in Table 3. Note that there is a certain correlation between variables, but all correlation coefficients are below 0.700, and there is no significant multicollinearity problem. In particular, the substitutability of knowledge elements is significantly negatively correlated with value co-creation, and the diversity of knowledge combinations is significantly positively correlated with value co-creation. Hence, H1b and H1c are preliminarily verified. Knowledge synergy is significantly positively correlated with value co-creation. Therefore, H2a is preliminarily verified. The substitutability of knowledge elements is significantly negatively correlated with knowledge synergy, and the diversity of knowledge combinations is significantly positively correlated with knowledge synergy. Thus, H2c and H2d are preliminarily verified. The results lay a foundation for further testing of the hypotheses.

Table 3. Results for the descriptive statistics and correlation coefficients.

Variables	***Kec***	***Kes***	***Kpd***	***KS***	***Ien***	***VC***	***FS***	***FA***	***FO***
Kec	**0.860**								
Kes	−0.046	**0.857**							
Kpd	0.079	−0.386 ***	**0.820**						
KS	0.114	−0.363 ***	0.365 ***	**0.853**					
Ien	−0.098	−0.384 ***	0.293 ***	0.077	**0.883**				
VC	0.056	−0.427 ***	0.458 ***	0.513 ***	0.513 ***	**0.841**			
FS	0.125	0.084	0.175 *	0.046	−0.117	0.056			
FA	−0.133	−0.109	0.172 **	0.123	0.132	0.087	0.169 *		
FO	0.071	0.267 ***	−0.270 ***	−0.149	−0.328 ***	−0.251 ***	0.067	−0.032	
mean	3.522	3.718	4.343	4.417	4.738	4.469	3.462	3.197	0.603
S.D.	1.336	1.437	1.310	1.424	1.609	1.568	1.577	1.583	0.400

Note: n = 427; *** $p < 0.001$, ** $p < 0.010$, * $p < 0.050$; data set in boldface on the diagonal line is the square root of AVE.

5.2. Hypothesis Testing

By using hierarchical regression analysis, control variables, main variables, and interaction terms were added to the model to test the research hypotheses. To reduce the impact of multicollinearity, variables involving square and interaction terms were centered. The VIF values of all regression coefficients were below 10, indicating no multicollinearity between the variables.

(1) Main Effect Test

Table 4 presents the regression results of testing the main effects. Model 1 is the basic model, which only examines the impact of control variables on value co-creation. On the basis of Model 1, Model 2 introduces the first term of knowledge element complementarity. The results show that the regression coefficient of the first term of knowledge element complementarity is not significant, indicating the need for further exploration of possible nonlinear relationships. Model 3 introduces the square term of knowledge element complementarity on the basis of Model 2. The results show that the regression coefficient of the first term of knowledge element complementarity is significantly positive ($\beta = 0.297,\ p < 0.001$). The regression coefficient of the square term of knowledge element complementarity is significantly negative ($\beta = -0.585,\ p < 0.001$). The signs of the coefficients of the first and second terms are opposite, indicating an inverted U-shaped relationship between knowledge element complementarity and value co-creation. Hence, H1a is verified. Model 4 introduces knowledge element substitution on the basis of Model 1. The results show that knowledge element substitution has a significant negative impact on value co-creation ($\beta = -0.413,\ p < 0.001$). Thus, H1b is verified. Model 5 introduces knowledge combination diversity on the basis of Model 1, and the results show that knowledge combination diversity has a significant positive impact on value co-creation ($\beta = 0.404,\ p < 0.001$). Accordingly, H1c is verified.

Table 4. Regression results of the main effects.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Kec		0.088	0.297 ***		
Kec^2			−0.585 ***		
Kes				−0.413 ***	
Kpd					0.404 ***
FS	0.054	0.032	0.022	0.065	−0.028
FA	0.095	0.109	0.026	0.043	0.025
FO	−0.258 ***	−0.261 ***	−0.137 **	−0.149 *	−0.136 *
*VIF*max	1.117	1.096	1.214	1.096	1.154
F	6.138 **	5.469 **	29.481 ***	18.696 ***	16.928 ***
Adj R^2	0.058	0.069	0.382	0.238	0.217

*** $p < 0.001$, ** $p < 0.010$, * $p < 0.050$.

(2) Mediating Effect Test

Table 5 presents the test results of the mediation effects. On the basis of Model 1, Model 6 introduces knowledge synergy, and the results show that knowledge synergy has a significant positive impact on value co-creation ($\beta = 0.472,\ p < 0.001$). Therefore, H2a is verified. Model 10 examines the impact of control variables on knowledge synergy. On the basis of Model 10, Model 11 introduces the first term of knowledge element complementarity. The results show that the regression coefficient of the first term of knowledge element complementarity is not significant ($\beta = 0.119,\ ns$), which requires further exploration of possible nonlinear relationships. Model 12 introduces the square term of knowledge element complementarity based on Model 11. The results show that the regression coefficient of the first term of knowledge element complementarity is significantly positive ($\beta = 0.264,\ p < 0.001$). The regression coefficient of the square term of knowledge element complementarity is significantly negative ($\beta = -0.431,\ p < 0.0011$). The signs of the coefficients of the first and second terms are opposite, indicating an inverted U-shaped relationship between knowledge element complementarity and knowledge synergy. Hence, H2b is verified. Model 13 introduces knowledge element substitution based on Model 10. The results show that knowledge element substitution has a significant negative impact on knowledge synergy ($\beta = -0.357,\ p < 0.001$). Hence, H2c is verified. Model 14 introduces knowledge combination diversity based on Model 10. The results show that knowledge combination diversity has a significant positive impact on knowledge synergy ($\beta = 0.355,\ p < 0.001$). Therefore, H2d is verified.

Table 5. Regression results of the mediating effects.

Variables	*VC*				*KS*				
	Model 6	**Model 7**	**Model 8**	**Model 9**	**Model 10**	**Model 11**	**Model 12**	**Model 13**	**Model 14**
Kec		0.217 ***				0.119	0.264 ***		
Kec^2		−0.475 ***					−0.431 ***		
Kes			−0.306 ***					−0.357 ***	
Kpd				0.286 ***					0.355 ***
KS	0.472 ***	0.284 ***	0.377 ***	0.395 ***					
FS	0.041	0.022	0.056	−0.017	0.026	0.015	−0.011	0.051	−0.043
FA	0.042	−0.018	0.010	0.005	0.108	0.146 *	0.063	0.068	0.062
FO	−0.192 **	0.146 ***	−0.141 **	−0.139 *	−0.118	−0.148 *	−0.074	−0.056	−0.042
*VIF*max	1.129	1.427	1.274	1.293	1.137	1.089	1.207	1.115	1.126
F	24.557 ***	33.981 ***	27.131 ***	26.393 ***	2.973	3.557 *	12.690 ***	10.128 ***	9.834 ***
Adj R^2	0.285	0.436	0.358	0.334	0.015	0.032	0.128	0.122	0.117

*** $p < 0.001$, ** $p < 0.010$, * $p < 0.050$.

Model 7 introduces the linear and quadratic terms of complementary knowledge elements on the basis of Model 6; Model 8 introduces knowledge element substitution on the basis of Model 6; and Model 9 introduces knowledge combination diversity on the basis of Model 6 to test the mediating role of knowledge synergy. The test results show that after adding knowledge synergy, compared with Model 3 in Table 4, the regression coefficient of complementary knowledge elements in a one-time manner changes from 0.297 to 0.217, and the regression coefficient of its square term changes from −0.585 to −0.475. However, the significance level remains unchanged, indicating that knowledge synergy plays a partial mediating role in the relationship between complementary knowledge elements and value co-creation. The regression coefficient of knowledge element substitution changes from −0.413 to −0.306 in Table 4, and the significance level remains unchanged. This result indicates that knowledge synergy plays a partial mediating role in the relationship between knowledge element substitution and value co-creation. The regression coefficient of knowledge combination diversity changes from 0.404 to 0.286 in Table 4, and the significance level remains unchanged. This result indicates that knowledge synergy plays a partial mediating role in the relationship between knowledge combination diversity and value co-creation. Hence, H2 is verified.

(3) Moderating Effect Test

Table 6 presents the test results of the moderating effect. Model 15 introduces the first and second terms of the complementarity of knowledge elements and the interaction term between the complementarity of knowledge elements and the normative nature of the innovation ecosystem based on Model 3 in Table 4. The results show that the interaction term between the second term of the complementarity of knowledge elements and the normative nature of the innovation ecosystem has a significant positive regression coefficient ($\beta = 0.044$, $p < 0.050$). This outcome indicates that the normative nature of the innovation ecosystem has a significant moderating effect on the inverted U-shaped relationship between the complementarity of knowledge elements and knowledge synergy. Thus, H3a is preliminarily verified. Model 16 introduces the interaction term between the normative nature of the innovation ecosystem and the substitutability of knowledge elements based on Model 4 in Table 4. The results show that the interaction term has a significant positive regression coefficient ($\beta = 0.175$, $p < 0.050$), indicating that the normative nature of the innovation ecosystem has a significant moderating effect on the negative relationship between the substitutability of knowledge elements and knowledge synergy. Therefore, H3b is preliminarily verified.

Table 6. Regression results of the moderating effects.

Variables	*KS*			*VC*
	Model 15	**Model 16**	**Model 17**	**Model 18**
Kec	0.313 ***			
Kec^2	−0.437 ***			
Kes		−0.376 ***		
Kpd			0.386 ***	
KS				0.530 ***
Ien	−0.075	−0.184 *	−0.092	0.552 ***
Kec•*Ien*	0.217 **			
Kec^2•*Ien*	0.044 *			
Kes•*Ien*		0.175 *		
Kpd•*Ien*			−0.078	
KS•*Ien*				0.247 ***
FS	−0.016	0.064	−0.055	0.076
FA	0.072	0.060	0.052	−0.046
FO	−0.094	−0.083	−0.076	0.056
*VIF*max	1.312	1.579	1.322	1.268
F	11.494 ***	8.192 ***	7.583 ***	46.108 ***
Adj R^2	0.258	0.166	0.134	0.517

*** $p < 0.001$, ** $p < 0.010$, * $p < 0.050$.

Model 17 introduces an interaction term between the normativity of the innovation ecosystem and the diversity of knowledge combinations on the basis of Model 5 in Table 4. The results show that the regression coefficient of the interaction term is not significant ($\beta = -0.078$, ns). Hence, H3c is not verified. The possible reason is that when enterprises increase the diversity of knowledge combinations, they correspondingly deepen their knowledge insights in multiple fields and enhance their ability to absorb knowledge from partners in other fields in the innovation ecosystem. Thus, the regulatory effect of the normativity of the innovation ecosystem is diluted through promoting common cognition. Model 18 introduces an interaction term between the normativity of the innovation ecosystem and knowledge synergy on the basis of Model 6 in Table 5. The results show that the regression coefficient of the interaction term is significantly positive ($\beta = 0.247$, $p < 0.001$), indicating that the normativity of the innovation ecosystem positively regulates the relationship between knowledge synergy and value co-creation. Accordingly, H3d is verified.

This study further conducts a simple slope analysis and draws a graph of the moderating effect, as shown in Figure 2. The moderating variable is divided into high and low levels by the mean plus or minus one standard deviation. When the normative level of the innovation ecosystem is high, the curves of knowledge element complementarity and knowledge synergy change, with the steepness on the left side of the inflection point increasing, the right side of the inflection point becoming smooth, and the inflection point moving to the right. The slope of knowledge element substitution on knowledge synergy becomes considerably small, and the slope of knowledge synergy on value co-creation becomes substantially large. Therefore, H3a, H3b, and H3d are further verified.

(4) Moderated Mediating Effect Test

This research uses Process to conduct bootstrap analysis, selects model 58, and sets a standard deviation above and below the mean as the high and low values of the moderating variable to test the results. The results are shown in Table 7. Note that under the path of complementary knowledge elements–knowledge synergy–value co-creation, when the normative level of the innovation ecosystem is low, the 95% confidence interval is [−0.095, 0.057], which includes 0. Moreover, the mediating effect is not significant. When the normative level of the innovation ecosystem is medium or high, the 95% confidence intervals are [0.073, 0.231] and [0.123, 0.567], respectively, which do not include 0. In addition, the mediating effect is significant. Under different levels of normative innovation ecosystems, the mediating effect of knowledge synergy changes, indicating that normative innovation ecosystems moderate the mediating effect of knowledge synergy. Hence, H4a is verified. Under the path of substitutive knowledge elements–knowledge synergy–value co-creation, when the normative level of the innovation ecosystem is low, medium, and high, the 95% confidence intervals are [−0.294, −0.068], [−0.250, −0.135], and [−0.304, 0.028], respectively, which do not include 0. In addition, the mediating effect is significant. When the normative level of the innovation ecosystem is high, the 95% confidence interval is [−0.304, 0.028], which includes 0. Furthermore, the mediating effect is not significant. Under different levels of normative innovation ecosystems, the mediating effect of knowledge synergy changes, indicating that normative innovation ecosystems moderate the mediating effect of knowledge synergy. Therefore, H4b is verified. Under the path of diverse knowledge combinations–knowledge synergy–value co-creation, when the normative level of the innovation ecosystem is low [0.086, 0.302], medium [0.167, 0.294], and high [0.048, 0.383], the 95% confidence intervals do not include 0, and the mediating effect is significant. As the normative level of the innovation ecosystem increases, the mediating effect of knowledge synergy changes and shows an upward trend. This result indicates that normative innovation ecosystems moderate the mediating effect of knowledge synergy. Thus, H4c is verified.

Table 7. Moderated mediation effects.

Paths	Effects		S.E.	Lower	Upper
	−S.D.	−0.012	0.043	−0.095	0.057
Knowledge element complementarity–knowledge synergy–value co-creation	medium	0.126	0.051	0.073	0.231
	+S.D.	0.330	0.144	0.123	0.567
	−S.D.	−0.181	0.036	−0.294	−0.068
Knowledge element substitution–knowledge synergy–value co-creation	medium	−0.193	0.047	−0.250	−0.135
	+S.D.	−0.156	0.082	−0.304	0.028
	−S.D.	0.197	0.062	0.086	0.302
Knowledge element combination diversity–knowledge synergy–value co-creation	medium	0.208	0.058	0.167	0.294
	+S.D.	0.256	0.064	0.048	0.383

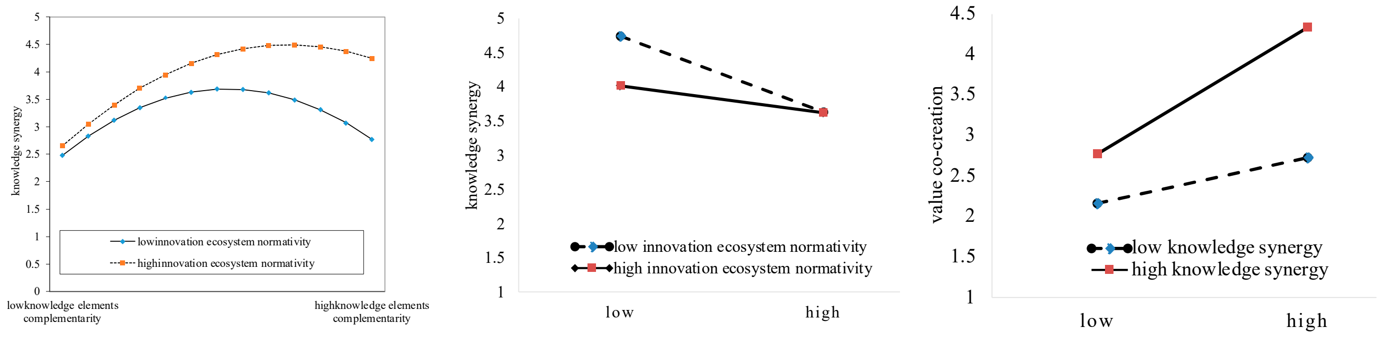

Figure 2. Moderating the effects of innovation ecosystem normativity.

6. Conclusions and Discussion

6.1. Research Conclusion

On the basis of the existing literature on the value co-creation of innovation ecosystems, this study divides the relationship between enterprise knowledge elements into complementary knowledge elements, substituting knowledge elements, and diverse knowledge element combinations from the perspective of the relationship dimension of enterprise knowledge elements. Moreover, this research explores its impact on value co-creation in innovation ecosystems and further analyzes the mediating roles of knowledge synergy and innovation ecosystem norms. The research results show that complementary knowledge elements have an inverted U-shaped impact on value co-creation, substituting knowledge elements have a significant negative impact on value co-creation, and diverse knowledge element combinations have a significant positive impact on value co-creation. Knowledge synergy has a positive impact on value co-creation; complementary knowledge elements have an inverted U-shaped impact on knowledge synergy; substituting knowledge elements have a negative impact on knowledge synergy; and diverse knowledge element combinations have a positive impact on knowledge synergy. Innovation ecosystem norms have a two-stage moderating effect on the path from knowledge element relationships to value co-creation. That is, they moderate the relationships between complementary and substituting knowledge elements and knowledge synergy, and between knowledge synergy and value co-creation. Innovation ecosystem norms also moderate the mediating role of knowledge synergy between knowledge element relationships and value co-creation.

This study found that different types of knowledge element relationships within enterprises have varying impacts on the value co-creation of the innovation ecosystem. This result is consistent with the results of Grigoriou and Rothaermel [8] on the role of internal knowledge attributes within enterprises. The belief is that the effectiveness of cooperation between enterprises and external organizations depends on the former's internal knowledge base characteristics. Different knowledge element relationships lead to differences in the technological exploration and development direction of enterprises. The complementarity, substitution, and diversity of knowledge elements have inverted U-shaped, negative, and positive impacts, respectively, on value co-creation. Enterprises with a high complementarity of knowledge elements have numerous unique insights into their fields, which can promote knowledge integration and exchange within the innovation ecosystem. However, a significantly high-level complementarity of knowledge elements can lead to a fixed path for enterprises to utilize these elements, limiting the scope and space for combining them. The increase in the substitutability level of knowledge elements brings functional redundancy to enterprises, leading to path dependence and hindering the realization of value co-creation. The diversity of knowledge element combinations reflects the diversity of knowledge combinations in generating new knowledge in enterprises, representing their specialized understanding of multiple technical fields, and can help them immediately absorb and utilize external knowledge.

This study also found the mediating role of knowledge synergy in the relationship between knowledge elements and value co-creation, supporting Chen et al. [55]. The collaborative mechanism can play a conductive role in transforming resources into value. The innovation ecosystem is regarded as a collaborative innovation network based on knowledge. Knowledge synergy between participants based on knowledge resources plays an indispensable role in value co-creation. Knowledge synergy aims to create value. By using knowledge elements to promote knowledge exchange and sharing, enterprises in the innovation ecosystem can form a common understanding through knowledge synergy, improve the integration efficiency of internal and external knowledge resources, and optimize the integration of knowledge resources to achieve value co-creation. The gradual improvement in complementarity of knowledge elements enables enterprises to form knowledge synergy with partners through growing knowledge demand. Meanwhile, the complementarity of knowledge elements increasing beyond a certain level easily causes the narrow direction of knowledge acquisition, inhibits knowledge synergy, and has a curved impact on value co-creation. The increase in the level of substitutability of knowledge elements leads to the gradual narrowing of enterprises' knowledge fields and the formation of cognitive distance with partners. This result hinders knowledge synergy, inhibits the integration of knowledge resources, and hinders value co-creation. The increase in the diversity of combinations of knowledge elements is beneficial for enterprises to enhance their ability to absorb and understand their partners' knowledge, promote the output of knowledge achievements through knowledge synergy, and promote value co-creation.

Furthermore, this research found a moderate effect of innovation ecosystem normativity, which is consistent with Plata et al. [12], who believed that normativity plays an indispensable role in the operation of innovation ecosystems. The development of innovation ecosystems is a process from disorder to order. That is, participating parties establish commonly recognized systems and rules through long-term cooperation and interaction, as well as form consensus in management, operation, and regulation. The result is the gradual formation of innovation ecosystem normativity. Innovation ecosystem normativity provides a good environment for realizing value co-creation through relatively complete normative systems and collaborative mechanisms, effectively suppresses opportunistic behavior, enhances trust among participating parties, promotes knowledge interaction among them, reduces barriers to knowledge exchange, and is conducive to improving the absorption and utilization efficiency of knowledge resources in value co-creation. The smooth development of value co-creation activities depends on the support of their underlying normativity. The perfect innovation ecosystem normativity provides a good foundation for knowledge resource interaction and value co-creation, thereby improving the stability and efficiency of cooperation among participating parties.

6.2. Theoretical Contribution

The existing literature on value co-creation in innovation ecosystems has mostly been limited to exploring the mechanisms, models, and antecedent conditions of value co-creation at the system level [4,9]. The current study starts with the characteristics of participating enterprises and examines the differential effects of different knowledge element relationships on value co-creation in innovation ecosystems. It complements previous research on the antecedents of value co-creation at the level of participating entities and expands the research on knowledge management in the context of innovation ecosystems.

Although the existing literature has recognized that the innovation ecosystem is a knowledge-based multi-agent collaborative network [13], it is still unclear how knowledge synergy plays a role in the innovation ecosystem. The current study proposes the mediating role of knowledge synergy in the value co-creation of the innovation ecosystem. The different dimensions of knowledge element relationships have varying impacts on value co-creation. The mediating effect of knowledge synergy explains the mechanism, opens the "black box" between the two aspects, and reflects the characteristics of collaborative development among participating entities in realizing value co-creation in the innovation ecosystem. The current research likewise provides a theoretical perspective for the realization path of value co-creation.

This study recognizes from existing theoretical results that the innovation ecosystem focuses on the innovation of participating actors and also considers the collaborative environment [3,14]. The interaction between internal characteristics and the external environment of enterprises in the innovation ecosystem scenario affects value co-creation. This research introduces the normative factor of the innovation ecosystem as a situational element and constructs and tests a two-stage moderated mediation model to explore the situational mechanism in the relationship among knowledge elements, knowledge synergy, and value co-creation. The current research considerably explains the indispensable role of innovation ecosystem normativity as a collaborative environment in the entire knowledge resource for value transformation. On the basis of innovation ecosystem characteristics, the integration of innovation ecosystem normativity at the environmental level of the innovation ecosystem with the relationship between knowledge elements at the participating enterprise level in the same framework breaks through the existing literature's focus on micro or macro research perspectives. This approach is helpful to understand the impact mechanism of value co-creation in innovation ecosystems from an integrated perspective and provides new ideas for innovation ecosystem research.

6.3. Managerial Implications

Enterprises in the innovation ecosystem should systematically optimize their own knowledge systems based on their own and their partners' knowledge bases and adopt reasonable strategies to maximize value output. Enterprises should focus on the matching problem of their own knowledge elements and can increase the diversity of knowledge combinations by purposefully deploying knowledge elements. Such a focus will enable them to avoid high similarity of knowledge elements in the knowledge base and promote synergistic effects with partners. Examples are considering the technical background of R&D personnel, purposefully deploying R&D personnel, regularly organizing technical training for R&D personnel, and purposefully guiding R&D personnel in their knowledge specialization direction.

For companies with knowledge element relationships manifested in complementary or substitutive knowledge elements, managers should consider that such partners may not necessarily bring additional co-created value. On the one hand, companies should conduct detailed market research on potential partners in advance, such as investigating the technological patent composition of partners, the main product categories, and the background information of key R&D personnel. On the other hand, companies can promote knowledge exchange among participating entities through regular participation in innovative ecosystem knowledge exchange activities, thereby optimizing each other's knowledge bases.

In the context of rapid knowledge iteration and changing customer needs, the key to realizing value co-creation and building an effective innovative ecosystem is the normative nature of the innovative ecosystem. During the development of an innovative ecosystem, establishing formal rules, regulations, and information coordination mechanisms, as well as forming consensus, are essential to ensuring the smooth realization of value co-creation. Enterprises should cooperate and promote the formation of the normative nature of the innovative ecosystem. When necessary, they can seek cooperation from relevant departments to improve the rules and regulations related to innovative activities and form these norms and standards into written documents with legal effect.

6.4. Limitations and Future

This article employs quantitative analysis to test hypotheses and uncover causal relationships based on questionnaire survey data. Although the scope of conclusions is limited due to sample selection, future research can incorporate qualitative research methods such as case analysis to delve deeper into the significance, experience, and subjective understanding of the results. This study only investigated samples from Shenyang, Dalian, Beijing, and Shanghai. Future studies can consider adding samples from different regions across the country to conduct interregional comparative studies. This study only considers the relationship between knowledge element relationships and value co-creation. Lastly, future research can explore the possible interactions among knowledge element substitution, knowledge element complementarity, and knowledge combination diversity.

Funding: This research was funded by the Jiangxi Province Social Science Fund Project (18GL07) and University-Industry Collaborative Education Program (220601590082739).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Öberg, C.; Alexander, A.T. The openness of open innovation in ecosystems–Integrating innovation and management literature on knowledge linkages. *J. Innov. Knowl.* **2018**, *4*, 211–218. [CrossRef]

2. Jin, Z.; Zeng, S.; Chen, H.; Shi, J. Creating value from diverse knowledge in megaproject innovation ecosystems. *Int. J. Proj. Manag.* **2022**, *40*, 646–657. [CrossRef]
3. Adner, R.; Kapoor, R. Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strateg. Manag. J.* **2010**, *31*, 306–333. [CrossRef]
4. Jyoti, C.; Efpraxia, Z. Understanding and exploring the value co-creation of cloud computing innovation using resource based value theory: An interpretive case study. *J. Bus. Res.* **2023**, *164*, 113970. [CrossRef]
5. Ritala, P.; Agouridas, V.; Assimakopoulos, D.; Gies, O. Value creation and capture mechanisms in innovation ecosystems: A comparative case study. *Int. J. Technol. Manag.* **2013**, *63*, 244–267. [CrossRef]
6. Grant, R.M. Toward a knowledge-based theory of the firm. *Strateg. Manag. J.* **1996**, *17*, 109–122. [CrossRef]
7. Adner, R.; Kapoor, R. Innovation ecosystems and the pace of substitution: Re-examining technology S-curves. *Strateg. Manag. J.* **2016**, *37*, 625–648. [CrossRef]
8. Grigoriou, K.; Rothaermel, F.T. Organizing for knowledge generation: Internal knowledge networks and the contingent effect of external knowledge sourcing. *Strateg. Manag. J.* **2017**, *38*, 395–414. [CrossRef]
9. Joo, J.; Shin, M.M. Building sustainable business ecosystems through customer participation: A lesson from South Korean cases. *Asia Pac. Manag. Rev.* **2017**, *23*, 1–11. [CrossRef]
10. Bashir, M.; Farooq, R. The synergetic effect of knowledge management and business model innovation on firm competence A systematic review. *Int. J. Innov. Sci.* **2018**, *11*, 362–387. [CrossRef]
11. Zárraga, C.; Bonache, J. Assessing the team environment for knowledge sharing: An empirical analysis. *Int. J. Hum. Resour. Manag.* **2003**, *14*, 1227–1245. [CrossRef]
12. Plata, G.; Aparicio, S.; Scott, S. The sum of its parts: Examining the institutional effects on entrepreneurial nodes in extensive innovation ecosystems. *Ind. Mark. Manag.* **2021**, *99*, 136–152. [CrossRef]
13. Adner, R. Match your innovation strategy to your innovation ecosystem. *Harv. Bus. Rev.* **2006**, *84*, 98–107, 148. [PubMed]
14. Granstrand, O.; Holgersson, M. Innovation ecosystems: A conceptual review and a new definition. *Technovation* **2020**, *90*, 102098. [CrossRef]
15. Ojaghi, H.; Mohammadi, M.; Yazdani, H.R. A synthesized framework for the formation of startups' innovation ecosystem: A systematic literature review. *J. Sci. Technol. Policy Manag.* **2019**, *10*, 1063–1097. [CrossRef]
16. Jacobides, M.G.; Cennamo, C.; Gawer, A. Towards a Theory of Ecosystems. *Strateg. Manag. J.* **2018**, *39*, 2255–2276. [CrossRef]
17. Ansari, S.; Garud, R.; Kumaraswamy, A. The disruptor's dilemma: TiVo and the U.S. television ecosystem. *Strateg. Manag. J.* **2016**, *37*, 1829–1853. [CrossRef]
18. Xiong, R.R.; Liu, C.Z.; Choo, K.K.R. Synthesizing knowledge through a data analytics-based systematic literature review protocol. *Inf. Syst. Front.* **2023**, 1–24. [CrossRef]
19. Russell, M.G.; Smorodinskaya, N.V. Leveraging complexity for ecosystemic innovation. *Technol. Forecast. Soc. Change* **2018**, *136*, 114–131. [CrossRef]
20. Kahle, J.H.; Marcon, É.; Ghezzi, A.; Frank, A.G. Smart products value creation in SMEs innovation ecosystems. *Technol. Forecast. Soc. Change* **2020**, *156*, 120024. [CrossRef]
21. Yngfalk, A.F. 'It's not us, it's them!'-Rethinking value co-creation among multiple actors. *J. Mark. Manag.* **2013**, *29*, 1163–1181. [CrossRef]
22. Fontana, R.; Geuna, A.; Matt, M. Factors affecting university-industry R&D projects: The importance of searching, screening and signalling. *Res. Policy* **2006**, *35*, 309–323.
23. Clarysse, B.; Wright, M.; Bruneel, J. Creating value in ecosystems: Crossing the chasm between, knowledge and business ecosystems. *Res. Policy* **2014**, *43*, 1164–1176. [CrossRef]
24. Mele, C.; Spena, T.R.; Kaartemo, V.; Marzullo, M.L. Smart nudging: How cognitive technologies enable choice architectures for value co-creation. *J. Bus. Res.* **2021**, *129*, 949–960. [CrossRef]
25. Ritala, P.; Almpanopoulou, A. In defense of 'eco' in innovation ecosystem. *Technovation* **2017**, *60*, 39–42. [CrossRef]
26. Vaillant, Y.; Lafuente, E.; Vendrell-Herrero, F. Assessment of industrial pre-determinants for territories with active product-service innovation ecosystems. *Technovation* **2023**, *119*, 102658. [CrossRef]
27. Li, Y.J.; Wang, Y.; Salomo, S. An inquiry on dimensions of external technology search and their influence on technological innovations: Evidence from Chinese firms. *RD Manag.* **2014**, *44*, 53–74.
28. Zhou, K.; Li, C. How knowledge affects radical innovation: Knowledge base, market knowledge acquisition, and internal knowledge sharing. *Strateg. Manag. J.* **2012**, *33*, 1090–1102. [CrossRef]
29. Jin, X.; Chen, S.; Wang, J.; Wang, T. A study of the relationship between the knowledge base and the innovation performance under the organizational slack regulating. *Manag. Decis.* **2015**, *53*, 2202–2225. [CrossRef]
30. Fleming, L. Recombinant uncertainty in technological search. *Manag. Sci.* **2001**, *47*, 117–132. [CrossRef]
31. D'este, P. How do firms' knowledge bases affect intra-industry heterogeneity? An analysis of the Spanish pharmaceutical industry. *Res. Policy* **2005**, *34*, 33–45. [CrossRef]
32. Yoon, S.J.; Marhold, K.; Kang, J. Linking the firm′ s knowledge network and subsequent exploratory innovation: A studybased on semiconductor industry patent data. *Innov. Organ. Manag.* **2017**, *19*, 463–482.
33. Dibiaggio, L.; Nasiriyar, M.; Nesta, L. Substitutability and complementarity of technological knowledge and the inventive performance of semiconductor companies. *Res. Policy* **2014**, *43*, 1582–1593. [CrossRef]

34. Li, Z.; Wan, T.; Lan, J. Substitution or complementarity: Influence of industry–university–research-institute cooperation governance mechanism on knowledge transfer—An empirical analysis from China. *Sustainability* **2022**, *14*, 7606. [CrossRef]
35. Baldwin, C.Y.; Bogers, M.; Kapoor, R.; West, J. Focusing the ecosystem lens on innovation studies. *Res. Policy* **2024**, *53*, 104949.
36. Van Gils, A.; Zwart, P. Knowledge acquisition and learning in Dutch and Belgian SMEs: The role of strategic alliances. *Eur. Manag. J.* **2004**, *22*, 685–692. [CrossRef]
37. Grimpe, C.; Kaiser, U. Balancing internal and external knowledge acquisition: The gains and pains from R&D outsourcing. *J. Manag. Stud.* **2010**, *47*, 1483–1509.
38. Schilling, M.A. Technology shocks, technological collaboration, and innovation outcomes. *Organ. Sci.* **2015**, *26*, 668–686. [CrossRef]
39. Zhang, W.; Jiang, Y.; Zhang, W. Capabilities for collaborative innovation of technological alliance: A knowledge-based view. *IEEE Trans. Eng. Manag.* **2021**, *68*, 1734–1744. [CrossRef]
40. Resch, C.; Kock, A. The influence of information depth and information breadth on brokers' idea newness in online maker communities. *Res. Policy* **2021**, *50*, 104142. [CrossRef]
41. Colombelli, A.; Krafft, J.; Quatraro, F. Properties of knowledge base and firm survival: Evidence from a sample of French manufacturing firms. *Technol. Forecast. Soc. Change* **2013**, *80*, 1469–1483. [CrossRef]
42. Ryoo, S.Y.; Kim, K.K. The impact of knowledge complementarities on supply chain performance through knowledge exchange. *Expert Syst. Appl.* **2015**, *42*, 3029–3040. [CrossRef]
43. Vargo, S.L.; Lusch, R.F. Institutions and axioms: An extension and update of service-dominant logic. *J. Acad. Mark. Sci.* **2016**, *44*, 5–23. [CrossRef]
44. Wang, H.; Zheng, L.J.; Zhang, J.Z.; Kumar, A.; Srivastava, P.R. Unpacking complementarity in innovation ecosystems: A configurational analysis of knowledge transfer for achieving breakthrough innovation. *Technol. Forecast. Soc. Change* **2024**, *198*, 122974. [CrossRef]
45. Duysters, G.; Lokshin, B. Determinants of alliance portfolio complexity and its effect on innovative performance of companies. *J. Prod. Innov. Manag.* **2011**, *28*, 570–585. [CrossRef]
46. He, Q.; Feng, Y.; Li, Z. Dynamic Complexity Analysis of R&D Levels in the Automotive Industry under the Dual-Credit Policy. *Sustainability* **2023**, *15*, 16520. [CrossRef]
47. Eisenman, M.; Paruchuri, S. Inventor knowledge recombination behaviors in a pharmaceutical merger: The role of intra-firm networks. *Long Range Plan.* **2019**, *52*, 189–201. [CrossRef]
48. Christensen, C.M. The ongoing process of building a theory of disruption. *J. Prod. Innov. Manag.* **2006**, *23*, 39–55. [CrossRef]
49. March, J.G. Exploration and exploitation in organizational learning. *Organ. Sci.* **1991**, *2*, 71–87. [CrossRef]
50. Xu, S. Balancing the two knowledge dimensions in innovation efforts: An empirical examination among pharmaceutical firms. *J. Prod. Innov. Manag.* **2015**, *32*, 610–621. [CrossRef]
51. Tortoriello, M.; Krackhardt, D. Activating cross-boundary knowledge: The role of simmelian ties in the generation of innovations. *Acad. Manag. J.* **2010**, *53*, 167–181. [CrossRef]
52. Guan, J.; Liu, N. Exploitative and exploratory innovations in knowledge network and collaboration network: A patent analysis in the technological field of nano-energy. *Res. Policy* **2016**, *45*, 97–112. [CrossRef]
53. Berchicci, L. Towards an open R&D system: Internal R&D investment, external knowledge acquisition and innovative performance. *Res. Policy* **2013**, *42*, 117–127.
54. Hohberger, J.; Almeida, P.; Parada, P. The direction of firm innovation: The contrasting roles of strategic alliances and individual scientific collaborations. *Res. Policy* **2015**, *44*, 1473–1487. [CrossRef]
55. Chen, M.; Kaul, A.; Wu, B. Adaptation across multiple landscapes: Relatedness, complexity, and the long run effects of coordination in diversified firms. *Strateg. Manag. J.* **2019**, *40*, 1791–1821. [CrossRef]
56. Sanders, N.R. An empirical study of the impact of e-business technologies on organizational collaboration and performance. *J. Oper. Manag.* **2007**, *25*, 1332–1347. [CrossRef]
57. Kao, S.; Wu, C.H. The role of creation mode and social networking mode in knowledge creation performance: Mediation effect of creation process. *Inf. Manag.* **2016**, *53*, 803–816. [CrossRef]
58. Ferreras-Méndez, J.L.; Newell, S.; Fernández-Mesa, A.; Alegre, J. Depth and breadth of external knowledge search and performance: The mediating role of absorptive capacity. *Ind. Mark. Manag.* **2015**, *47*, 86–97. [CrossRef]
59. Terjesen, S.; Patel, P.C. In search of process innovations: The role of search depth, search breadth, and the industry environment. *J. Manag.* **2017**, *43*, 1421–1446. [CrossRef]
60. Nesta, L.; Saviotti, P.P. Coherence of the knowledge base and the firm′ s innovative performance: Evidence from the U.S. pharmaceutical industry. *J. Ind. Econ.* **2005**, *53*, 123–142. [CrossRef]
61. Nooteboom, B.; Van Haverbeke, W.; Duysters, G.; Gilsing, V.; Van den Oord, A. Optimal cognitive distance and absorptive capacity. *Res. Policy* **2007**, *36*, 1016–1034. [CrossRef]
62. Zhao, S.; Wang, J.; Ji, J.; Ekow, A.V. Proximity or alienation? Can knowledge type influence the relationship between proximity and enterprise innovation performance? *Technol. Forecast. Soc. Change* **2024**, *202*, 123314. [CrossRef]
63. Phelps, C.C. A longitudinal study of the influence of alliance network structure and composition on firm exploratory innovation. *Acad. Manag. J.* **2010**, *53*, 890–913. [CrossRef]

64. Du, J.; Leten, B.; Vanhaverbeke, W. Managing open innovation projects with science-based and market-based partners. *Res. Policy* **2014**, *43*, 828–840. [CrossRef]
65. Gifford, E.; Mckelvey, M.; Saemundsson, R. The evolution of knowledge-intensive innovation ecosystems: Co-evolving entrepreneurial activity and innovation policy in the West Swedish maritime system. *Ind. Innov.* **2021**, *28*, 651–676. [CrossRef]
66. Zahra, S.A.; George, G. Absorptive capacity: A review, reconceptualization, and extension. *Acad. Manag. Rev.* **2002**, *27*, 185–203. [CrossRef]
67. Karim, S.; Kaul, A. Structural recombination and innovation: Unlocking intraorganizational knowledge synergy through structural change. *Organ. Sci.* **2015**, *26*, 439–455. [CrossRef]
68. An, X.; Deng, H.; Chao, L.; Bai, W. Knowledge management in supporting collaborative innovation community capacity building. *J. Knowl. Manag.* **2014**, *18*, 574–590. [CrossRef]
69. Pera, R.; Occhiocupo, N.; Clarke, J. Motives and resources for value co-creation in a multi-stakeholder ecosystem: A managerial perspective. *J. Bus. Res.* **2016**, *69*, 4033–4041. [CrossRef]
70. Wong, C.Y.; Boon-itt, S. The influence of institutional norms and environmental uncertainty on supply chain integration in the Thai automotive industry. *Int. J. Prod. Econ.* **2008**, *115*, 400–410. [CrossRef]
71. Shaikh, M.; Levina, N. Selecting an open innovation community as an alliance partner: Looking for healthy communities and ecosystems. *Res. Policy* **2019**, *48*, 103766. [CrossRef]
72. Vargo, S.L.; Lusch, R.F. Service-dominant logic 2025. *Int. J. Res. Mark.* **2017**, *34*, 46–67. [CrossRef]
73. Gawer, A.; Cusumano, M.A. Industry platforms and ecosystem innovation. *J. Prod. Innov. Manag.* **2014**, *31*, 417–433. [CrossRef]
74. Adner, R. Ecosystem as structure: An actionable construct for strategy. *J. Manag.* **2017**, *43*, 39–58. [CrossRef]
75. Capone, F.; Lazzeretti, L.; Innocenti, N. Innovation and diversity: The role of knowledge networks in the inventive capacity of cities. *Small Bus. Econ.* **2021**, *56*, 773–788. [CrossRef]