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Opinion

The Coupling Mechanism of the Digital Innovation Ecosystem and Value Co-creation

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Abstract

Value co-creation in the digital innovation ecosystem is of great practical significance for promoting enterprise advantages and high-quality economic development. Digitalization reshapes the logic of value co-creation. Innovation activities are no longer focused only on the internal enterprise but also occur in the ecosystem of interaction and sharing with other heterogeneous and diverse subjects. How can value co-creation be achieved between the digital innovation ecosystems and how can they be coupled between the two? Based on this problem, this paper divides the value co-creation elements of the digital innovation ecosystem into five major elements: digital strategic cognition, digital technology, new digital infrastructure, data resources, and digital innovation capabilities, and explores the coupling mechanism between the digital innovation ecosystem and value co-creation.

Keywords

The digital innovation ecosystem; value co-creation

1. Introduction

Premier Li Keqiang proposed in the 2022 Chinese government report that the innovation-driven development strategy should be implemented in depth. It can be seen that innovation is an important way to drive economic development and enhance the competitiveness of enterprises. However, innovation in the traditional sense is often only active within the organization, so it cannot meet the challenges As society enters the era of innovation 3.0, the boundaries of enterprises are gradually blurred, their openness characteristics are becoming more and more apparent, the innovation model has changed from closed to open [1], and the strategic logic has shifted from competition to symbiosis, enterprises have gradually realized the importance of openness and sharing, and tried to improve their innovation capabilities by jointly building an innovation ecosystem.

The Fifth Plenary Session of the 19th Central Committee of the Communist Party of China did strategic planning for digital development and called for the promotion of digital industrialization and industrial digitalization. With the advent of a new round of scientific and technological revolution, the innovation ecosystem characterized by digitalization is driving industrial change at an unprecedented speed [2]. In the new environment, the virtualization of innovation subjects, the digitization of elements, the process intelligence, and the organization platform all affect the changes in the organizational structure of enterprises, which has led to thinking about how to build a digital innovation ecosystem [3]. Compared with the innovation ecosystem system, the subject heterogeneity in the digital innovation ecosystem is stronger. The resource mobility is more complex [4], which brings about the problems of data resources, innovation subject collaboration, and innovation process control [5], which brings certain challenges to the governance and value co-creation of the digital innovation ecosystem. The value co-creation method under digitalization has been reshaped [3]. However, domestic and foreign research has focused less on the digital innovation ecosystem. The research on this aspect is mainly aimed at the theoretical construction of the digital innovation ecosystem [3], governance mechanisms [5], frameworks [6] and other aspects, and the multi-level heterogeneous resources of the digital innovation ecosystem and the interaction process between different subjects are still unclear [7]. Based on the factors of value co-creation in the digital innovation ecosystem, this paper studies the value co-creation mechanism of synergistic coupling with various subjects and heterogeneous resources of the digital innovation research community, digital innovation development community, digital innovation service community, and digital innovation application community. Research on this issue will contribute to digital innovation practices and expand theories related to the innovation ecosystem. Thus, this paper attempts to study the value co-creation mechanism of how the main body and resources of the digital innovation ecosystem are cooperatively coupled with the elements of value co-creation in the digital innovation ecosystem.

2. Literature Review

2.1 Innovation Ecosystem

The existing research on innovation ecosystems mainly focuses on innovation ecosystems' concept, structure, operation, and evolution. In terms of the concept of the innovation ecosystem, Based on the perspective of ecological niche, Iansiti and Levin propose that the innovation ecosystem is composed of enterprises with different locations but interconnected, and is a complex network system covering multi-level nonlinear relationships such as competitive cooperation and coupling and symbiosis [8]. Adner believed that the innovation ecosystem comprises core players, upstream suppliers, downstream complementary parties, and customers, of which the core enterprises play a key role [9]. Regarding structural division research, Judy believed that from the perspective of role positioning, the innovation ecosystem is divided into research communities, development communities, and applied communities [10]. I believe that innovation ecosystems include species, populations, and communities from the perspective of the ecological level [11]. In terms of research on the operation and evolution of the innovation ecosystem, Chae pointed out that there is always a competitive and cooperative relationship within the innovation ecosystem, which has the characteristics of dynamic evolution [6]. The innovation ecosystem emphasizes the common value proposition and carries out innovation activities through open competition and dynamic evolution [12]. With the development of the Fourth Industrial Revolution, the speed of industrial change has accelerated, digitalization has promoted the association and reorganization of resource elements, and the behavioral logic of the innovation ecosystem has changed [13]. With the development of emerging technologies, digital has become a new factor of production, which has a certain impact on the innovation activities organized by enterprises, so scholars will gradually shift their attention to the digital innovation ecosystem.

2.2 The Digital Innovation Ecosystem

The existing research on the digital innovation ecosystem mainly focuses on connotation characteristics, theoretical construction, framework, and governance mechanism. Regarding connotation characteristics, Beltagui and Rosli believed that the digital innovation ecosystem is an organizational system that organizes an interactive ecological cycle. The system subjects are integrated into the ecosystem of competition and cooperation through digital innovation [13]. The main body of the digital innovation ecosystem refers to the innovation subject composed of digital technology and data resources [14]. Scholars like Gu believed that the digital innovation ecosystem is formed by competition and cooperation between relevant entities, coupling, and collaboration, relying on digital technology for innovative production activities [7]. Yang believed that the digital innovation ecosystem integrates the characteristics of the two elements of digital innovation and innovation ecosystem [4]. In terms of theoretical construction, Zhang Chao and other scholars proposed two digital innovation ecosystem manifestations: the innovation-oriented digital ecosystem and digital empowerment innovation ecosystem. They summarized the theoretical framework of the digital innovation ecosystem [3]. At the framework level, Chae examined the dynamic evolution of digital innovation and the general framework of the digital innovation ecosystem [6]. In terms of governance mechanism, Wei and Zhao discussed the governance system of the digital innovation ecosystem based on digital platform construction, digital technology

application, and digital resource synergy from three aspects: relationship, incentive, and control [5], and Yang conducted in-depth research on the governance niche configuration of regional the digital innovation ecosystem resilience improvement [15]. This paper divides the digital innovation ecosystem into digital innovation research communities, development communities, application communities, service communities, and digital innovation environments. It is defined as a complex network system in which digital innovation research, development, application, and service communities connect community subjects of various communities based on digital technology and new digital infrastructure under the role of digital innovation environment, smooth interaction channels, and realize value co-creation.

2.3 Value Co-creation

Value co-creation is to achieve multi-party benefits and maximize overall value through resource complementarity and mutual assistance, which is considered an important means to build a competitive advantage of enterprises and improve the operational efficiency of enterprises to occupy a higher strategic position. With the development of digital technology, value co-creation has shifted to the network and even system level of interaction and resource integration between multi-stakeholders. It no longer stays on the binary interaction between enterprises and customers [16]. The introduction of innovation ecosystems and digital innovation-related theories has led scholars at home and abroad to study the concept of digital innovation ecosystems while believing that the value creation of digital innovation should be from the perspective of ecosystems [17]. However, the interaction process of subjects and resources within the digital innovation ecosystem is still a black box [18], and how to clarify the interaction between the innovation logic of digital remodeling and stakeholders under the metaphor of innovation ecosystem is a more urgent issue in the field of digital innovation [7].

Combined with the above research, it can be found. Research on the digital innovation ecosystem mainly focuses on connotation characteristics, theoretical construction, framework, and governance mechanism. Research on value co-creation has also shifted from binary to multi-ecosystem level. However, there is still relatively little research on value co-creation in the digital innovation ecosystem. The question of how stakeholders and resources interact in the digital innovation ecosystem remains unclear. Therefore, starting from the value co-creation elements of the digital innovation ecosystem, this paper studies the value co-creation mechanism in the digital innovation ecosystem, to clarify the interaction process and relationship between stakeholders in the digital innovation ecosystem.

3. Methodology

This paper mainly conducts qualitative research through literature demonstration, characterizes the elements of value co-creation in the digital innovation ecosystem, focuses on the coupling mechanism between the digital innovation ecosystem and value co-creation, and explores the relationship between heterogeneous subjects and resources in the digital innovation ecosystem...

- Five factors of value co-creation are identified from the existing research.
- The roles and effects of five value co-creation factors of the digital innovation ecosystem are analyzed.
- The process of value consensus of each community in the digital innovation ecosystem—connection of value subjects—unimpeded channel—resource

coupling—sustainable value co-creation ability of digital innovation capability.

4. Identification of Value Co-creation Elements in the Digital Innovation Ecosystem

Before elaborating on the coupling mechanism between the digital innovation ecosystem and value co-creation, it is necessary to identify the elements of value co-creation in the digital innovation ecosystem and link the digital innovation ecosystem and value co-creation through the identified elements. Bu believed that the digital innovation ecosystem is based on digital technology using data resources to innovate, thereby promoting the interaction of multiple agents in many application scenarios [19] Value co-creation is a process of multi-subject interaction and resource integration, from which it can be found that both emphasize the two key points of interaction and resources, and interaction requires the support of two value co-creation elements of technology and carrier. At the same time, cognition is a prerequisite for behavior. To realize the interaction of multiple and multi-level agents in the ecosystem, it is first necessary to update the understanding of digital strategy. Chen and Liao pointed out that sustainable digital strategies should simultaneously achieve continuous breakthroughs in the three dimensions of empowerment, cross-border, and connection, and their cognitive framework in the digital era needs to be updated, that is, from the logic of competition to the logic of symbiosis [20]. In addition, enterprises must have digital resources, interactive technologies, and carriers and can effectively integrate and develop diversified resources [21]. Therefore, we can draw inspiration from this; in the digital era, we need to change the cognitive logic, improve digital innovation capabilities, use digital technology to achieve cross-border integration and connection in the ecosystem through value co-creation carriers, and finally realize the coupling between the digital innovation ecosystem and value co-creation.

5. The Value Co-creation Elements of the Digital Innovation Ecosystem

Based on the above identification of the value co-creation elements of the digital innovation ecosystem, this paper proposes the value co-creation elements of the digital innovation ecosystem from five levels: cognition, technology, carrier, resources, and capabilities.

5.1 Digital Strategic Cognition

Cognitive level. Strategic cognition refers to the process by which an organization diagnoses and selects the external environment to form a cognitive structure when planning and decision-making [22]. With the development of the digital age, the organizational boundaries between enterprises are gradually blurred, the strategic cognitive framework has also moved from the competition logic of the industrial age to the symbiotic logic, and the interaction between innovative subjects is more frequent, which we call digital strategic cognition [20].In coupling the digital innovation ecosystem and value co-creation, digital strategic cognition guides the innovation subjects of the digital innovation ecosystem to form consistent value cognition and goals.

5.2 Digital Technology

Technical aspects. The emergence of digital technologies represented by big data, artificial intelligence, cloud computing, 5G, etc., has reduced the shackles of information asymmetry and resource shortage and brought indispensable momentum of the times to the efficient integration and coordinated innovation of resources such as knowledge technology, talents, and funds in the innovation ecosystem, and changed the way and logic of value creation of enterprises and ecosystems [23]. In coupling the digital innovation ecosystem and value co-creation, digital technology connects all subjects of the digital innovation ecosystem to achieve cross-border integration and relationship building.

5.3 New Digital Infrastructure

Carrier level. Based on the development of the Internet, a new generation of information technologies such as 5G networks and artificial intelligence has iteratively merged to form a new digital infrastructure [24]. The new digital infrastructure realizes the efficient operation and processing of information and data through network technologies such as 5G and cloud computing and smooths the interaction channels for cross-border interaction and sharing in the ecosystem. The new digital infrastructure plays the role of digital support and interactive guarantee in coupling the digital innovation ecosystem and value co-creation.

5.4 Data Resources

Resource level. Data resources are the aggregation of digital information generated under the application of various digital devices and digital infrastructure. In the era of the digital economy, with the widespread popularization of sensors, wearable devices, and smart devices in the whole society, the scale of data has exploded. The collaboration between the enterprise organization and the inside and outside of the system needs to be achieved through the interaction of data elements. Data resources have become a valuable factor in the digital innovation ecosystem. In coupling the digital innovation ecosystem and value co-creation, data resources are the key elements of value co-creation. The multi-flow interaction between general and proprietary data resources is the basic source of value co-creation in the digital innovation ecosystem.

5.5 Digital Innovation Capabilities

Competency level. Digital innovation capabilities are the key elements to enhance the competitive advantage of enterprises, which can be defined as the ability to allocate digital resources to achieve innovation; Liu divided digital innovation capabilities into digital connectivity, data aggregation, intelligent analysis, and digital agility, and combinatorial innovation capabilities at the process and organizational levels [25]. Combined with the above points, this paper divides digital innovation capabilities into digital opportunity capture capabilities, digital environment adaptation capabilities, and digital collaborative innovation capabilities. In coupling the digital innovation ecosystem and value co-creation, digital innovation capability is essential in realizing sustainable value co-creation in the digital innovation ecosystem to realize the value co-creation cycle and value re-creation under the digital innovation ecosystem.

As shown in Figure 1, the process of the five elements of value co-creation in the digital

innovation ecosystem is as follows:

Element 1: Digital strategy Awareness

Cooperating with the digital innovation research and development community to form a consensus on creativity and goals. Value consensus should be formed in the digital innovation application community, and interest consensus should be reached in the digital innovation service community.

Form transboundary symbiosis digital strategic cognition between communities.

Element 2: Digital Technology

Form technology flow, share complementary digital technologies, and build cooperative and sharing relationships with communities of the digital innovation ecosystem to eliminate boundaries.

Element 3: Digital Infrastructure

Digital infrastructure creates unimpeded communication and innovation channels for the value of the digital innovation ecosystem.

Element 4: Data Resources

Data resources are the basic dynamic source support for the creation of ecological value of digital innovation, and collaborative digital technology forms technology flow, material flow, and relationship flow in the digital innovation environment.

Factor 5: Digital innovation capability

Digital innovation capability is an important energy for the sustainable value co-creation of the digital innovation ecosystem, which promotes the virtuous cycle and sustainable value co-creation of the digital innovation ecosystem.

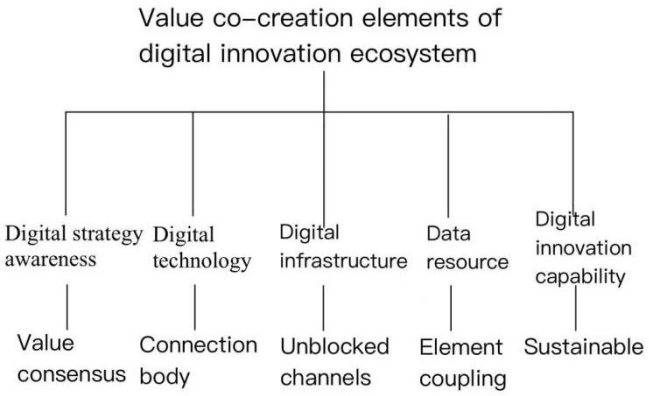

Figure 1 Value co-creation elements of the digital innovation ecosystem.

6. The Coupling Mechanism between the Digital Innovation Ecosystem and Value Co-creation

Based on the five elements of value co-creation in the digital innovation ecosystem, this paper expounds on the coupling mechanism between the digital innovation ecosystem and value co-creation from the following aspects.

6.1 Enhance Digital Strategic Cognition - The Formation of Value Consensus

Digital strategic cognition is manifested as a creative consensus in the digital innovation research community, combined with the interaction of university research institutes, digital

innovation research and development enterprises, public scientific research institutions, and other main resources in the innovation research community. The initial creative consensus is formed with the help of digital technology connectivity and digital infrastructure architecture. The subjects within the digital innovation and development community receive the creative ideas of the research community, that is, the value proposition of digital innovation, form a consensus and agree on the goals, and develop digital products and technologies. Based on the concept of common interest, the digital innovation service community forms an intrinsic link of mutual trust and dependence and achieves symbiosis. The digital innovation application community reaches a consensus on the values; users feel the experience value of digital products and services and generate new needs and potential innovation inspiration, and feedback to the development community through the data platform to achieve value feedback. Each community adheres to the strategic cognition of cross-border symbiosis, carries out open innovation activities between multiple fields, levels, and subjects in the digital innovation ecosystem, and finally forms value co-creation in the digital innovation ecosystem.

6.2 Convergence Boundaries with the Help of Digital Technology - Value Co-creation Subject Connection

As a key element of value co-creation in the digital innovation ecosystem [5], digital technology has a certain degree of convergence, which can continuously blur the boundaries of various communities in the ecosystem, promote the sharing and complementarity of heterogeneous resources between communities, and reduce the sense of boundary. The digital innovation research community composed of universities, research institutes, and other populations plays a supporting role in co-creating the value of the entire system, such as intellectual resources and digital technologies. It conveys the value proposition of digital innovation to the digital innovation development community. The Digital Innovation Development Community translates the research community's creative resources and value proposition ideas into concrete practices. Service communities, mainly governments, financial institutions, and intermediaries, are responsible for building service solutions that match digital innovation products and technologies, promoting and transmitting them, and providing policy support to achieve the proliferation of digital innovation value. As the experience side of digital products and services, users and digital enterprises of the digital innovation application community can play a role in valuable feedback and new demand feedback for the digital innovation research community.

6.3 Build Digital Infrastructure to Smooth the Channels of Digital Innovation - The Road of Value Co-creation is Smooth

The construction of digital infrastructure can provide resources and a knowledge base for product development and design of digital innovation research communities, reducing R&D costs and shortening R&D cycles. The Internet of Things and 5G networks provide cross-device, industry, regional, and other interconnections for digital innovation and development communities and the aggregation and sharing of production resources between development entities, and enhance network collaboration and cooperation symbiosis within and outside the community. Based on digital infrastructures such as 5G and the Internet; the digital innovation service community efficiently matches the supply and demand sides, providing feedback channels and supporting services for digital innovation users. The construction of the digital network platform can provide a

channel for consumer experience feedback for the application community while enhancing the innovation ability of the digital innovation research and development community.

6.4 The Open Sharing of Data Resources Realizes the Coupling of Complementary Assets - The Circulation of Value Co-creation Elements

The open sharing of data resources is the key to determining the value of data [26]. Promoting the openness of data resources in the digital innovation ecosystem can effectively reduce the cost of information acquisition and improve resource utilization. There are two ways to couple complementary assets in the digital innovation ecosystem: First, digital platforms gather complementary assets such as knowledge, technology, capabilities, suppliers, service systems, customer relationships, and brand resources required for the operation of various communities, and efficiently match asset demanders through digital technologies such as big data and cloud computing to conduct collaborative exchanges [27]. Second, communities use digital infrastructure and technologies to continuously break through and integrate organizational boundaries, complement each other's strengths, and share resources, thereby improving their value co-creation capabilities. The digital innovation research community transports resources such as knowledge, technology, and capabilities to the development community through the platform, and the development community couples complementary assets into the production of digital innovation products, the digital innovation service community provides resources such as supply channels, service marketing capabilities, and reputation, and the digital innovation application community overflows customer knowledge resources and related resources. These resources are jointly invested in the value creation of the system, forming an interdependent, coupled and symbiotic relationship at the system level, and promoting division of labor cooperation and ecological collaboration.

6.5 Strengthen Digital Innovation Capabilities - Value Co-creation and Sustainability

Digital innovation capabilities are a key factor in the sustainable competitive advantage of enterprises, providing inexhaustible impetus for the sustainable creation of value co-creation in the digital innovation ecosystem. Digital innovation research and development communities, service communities, and application communities share knowledge and technology, are keenly aware of changes in the external environment and innovation points, and improve the ability to capture innovation opportunities. Soft and hard external environmental elements continuously act on each functional community in the form of the ecological flow of technology flow, material flow, and relationship flow. The community and the community are dynamically adjusted to adapt to environmental changes and improve the adaptability of the digital environment through the interaction of complementary resources, technology, knowledge, capabilities, and other elements [28]. At the same time, through the bridges and channels built by digital technology and digital infrastructure, the frequency of communication and interaction between communities is improved, the product development and production cycle are reduced, the real-time feedback of user experience data, and the flow of funds of service communities is more transparent, which promotes the improvement of the digital innovation collaboration ability of the entire ecosystem, and brings key power support for the sustainable creation of digital innovation value.

7. Conclusion

The main conclusions of this paper are as follows:

- The paper puts forward five elements of value co-creation of the digital innovation ecosystem: digital strategic cognition, digital technology, new digital infrastructure, data resources, and digital innovation capability, and believes that the digital innovation ecosystem needs to couple the above five elements to achieve value co-creation among various digital innovation entities.
- The digital innovation ecosystem is a consistent organization based on a common value proposition. Enterprises can go beyond the traditional ideas of innovation leadership and control, develop a digital strategy coordinated with the overall development direction of the digital innovation ecosystem, and enhance the cooperation of complementary digital technologies from the shared digital infrastructure to improve the overall value co-creation level.
- From the perspective of government entities in the digital innovation service community, we can build a social technology collaborative governance system to promote the value co-creation of the digital innovation ecosystem and regulate the behavior of all participants from the aspects of value guidance under the recognition of digital innovation strategy, comprehensive application of digital technology, organizational coordination under the digital innovation ecosystem, and risk control of the digital innovation environment.
- With the gradual maturity of the digital innovation ecosystem, the government can turn to the construction and maintenance of the digital innovation environment, to promote the broad participation of multiple user subjects in the digital innovation ecosystem, grasp the development direction of digital innovation, and strengthen the coping ability and risk control ability of the digital innovation ecosystem governance.

The contribution of the article lies in the following points:

- This paper focuses on the value co-creation elements of the digital innovation ecosystem, proposes a value co-creation coupling mechanism based on the digital innovation ecosystem, and reveals the "black box" of the value co-creation of the digital innovation ecosystem.
- The digital innovation ecosystem supports the co-creation of value and has a guiding role in the development direction of digital innovation. The research conclusions provide policy inspiration for the governance of the innovation ecosystem.

The research deepened the understanding of the value co-creation of the digital innovation ecosystem, echoed the initiative of relevant scholars on "exploring new theoretical perspectives for digital innovation research," and provided a reference for digital innovation research in a complex and dynamic environment.

Author Contributions

Shi Yin and Xiangyang Mu conceptualized and performed the analysis; Xiaoli Xie wrote the manuscript and discussed the analysis; Nan Tao, Xiaoli Xie and Shi Yin edited, restructured, and optimized the manuscript.

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Competing Interests

The authors declare no conflict of interest.

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