Research Article

Evolution of Agricultural Innovation Ecosystem in County Areas: A Life-Cycle Perspective of Cases in Hebei Province

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The concept of agricultural innovation ecosystem in county areas was defined by reviewing the literature on agricultural innovation systems and innovation ecosystems. Combined with the urgent demand for agricultural innovation-driven development, a multidimensional agricultural innovation ecosystem was established in county areas. From the life-cycle perspective, the evolution law of agricultural innovation ecosystems in county areas was analyzed, and the evaluation system was constructed from four aspects: subjects, network, resources, and the environment. Then, the fuzzy technique for order preference by similarity to an ideal solution approach was used to determine the evolution stage of the system. It was found that the agricultural innovation ecosystem in county areas includes three ecological layers of microsubjects, meso-interfaces, and the macroenvironment. The microsubjects exchange material, energy, and information, with the macroenvironment more effectively depending on the carrier function of meso-interfaces. The system shows periodic laws in the process of spiraling evolution, gestation, growth, maturity, and recession, where different stages of the system exhibit different characteristics. Through an empirical analysis of the apple industry of Neiqiu County, Shunping County, and Yi County in Hebei province, the innovation ecosystems formed around the apple industry in the three counties were judged to be in the maturity stage, growth stage, and growth stage, respectively. The evaluation results are consistent with the actual situation, which effectively verified the scientific nature and effectiveness of the theoretical model and the evolutionary evaluation index system.

1. Introduction

It is necessary to implement the rural vitalization strategy, improve the quality of agricultural development, and foster new drivers of rural development. Innovation is the driving force behind rural development. The 14th Five-Year Plan takes innovation as the primary task and places it at the core of the modernization drive, which interprets the meaning of innovation differently. It further emphasizes the priority development of agriculture and rural areas, and puts forward key development directions such as the biological seed industry and digital agriculture. This needs to be achieved by adhering to innovation. It should be noted that although China’s overall scientific research level has reached the international advanced level, there is a large difference in innovation ability between urban and rural areas. Compared with large- and medium-sized cities, the innovation ability of counties as the basis of economic development is still lagging. To compensate for these shortcomings, the General Office of the State Council issued several opinions on innovation-driven development in County areas (State Development Administration [2017] No. 43) on May 11, 2017. These emphasize building innovative counties and innovative towns as the starting point to further promote mass entrepreneurship and innovation, and build a multilevel and diversified pattern of innovation and entrepreneurship in counties. County areas are the key link between urban and rural areas, the main battlefield for implementing the rural revitalization strategy, promoting the integrated development of urban and rural areas, and solving problems related to agriculture, rural areas, and farmers. As society gradually moves from the “innovation system” to “innovation ecosystem” age [1], counties must seize the opportunity. Using science and technology as a guide, and innovation as a
driving force, they should further expand agriculture enterprises, government departments, universities, scientific research institutions, financial institutions and intermediary institutions, intermediaries, and other stakeholders’ close cooperation, to create value, and promote the formation and development of agricultural innovation ecosystem in county areas.

After Freeman [2] proposed the concept of a national innovation system, scholars began to focus on regional studies [3, 4]. Agriculture has significant regional and industrial characteristics. The concept of agricultural innovation was first embodied through the research into regional innovation systems in agriculture. An agricultural innovation system is considered a heterogeneous network consisting of multiple participating members coordinating with each other [5, 6]. Domestic scholars define the connotation of an agricultural innovation system from the perspectives of macro [7], regional [8], goal orientation [9], and element composition [10]. With the promotion of scientific and technological innovation in China, research on the agricultural innovation system is ongoing. Yao et al. [11] analyzed the network characteristics of the agricultural innovation system formed by the participants and proved that the innovation ideas and achievements came from network functions generated by the interconnection of the participants. Zhang [12] and Han [13] studied the agricultural innovation system from the perspectives of stakeholder interaction and social conflict in the same region and period, and found that stakeholder interaction had more positive than negative impacts on the agricultural innovation system, but there were still social conflicts to be solved. In terms of evolution, the agricultural innovation system has experienced three stages: the national agricultural scientific research system, agricultural knowledge information system, and agricultural innovation system [14, 15]. China’s agricultural innovation system presents an evolution trend of “point-chain-group-domain” [16]. In addition, scholars and self-organizations have studied the operation and evolution mechanisms of the agricultural innovation system [17]. With the gradual diversification of market demand and the continuous development of science and technology, the exchanges between the participants and the innovation environment in agricultural innovation systems become increasingly frequent and gradually show the characteristics of “openness,” “dynamic evolution,” and “self-organization,” which lead to the evolution of an innovation paradigm. The research into an innovation ecosystem derives from the concept of a business ecosystem [18]. In 2004, the United States formally proposed an “innovation ecosystem,” and in 2012, it emphasized the building of a new “innovation ecosystem” to meet the challenges facing agriculture, which is sufficient to show the necessity and urgency of studying agricultural innovation ecosystems. “Innovation ecosystem” has rapidly become the focus of domestic and foreign academic research.

Scholars have different definitions of innovation ecosystem, which can be roughly divided into theoretical perspectives such as system science [19], factor flow [20], innovation network [21], and synergetic [22] and responsible innovation [23]. Innovation ecosystem theory is based on the reference and absorption of relevant theories of the innovation system and innovation network. Considering the interaction and influence between the innovation subject and the external environment, at present, there are still some differences in the research on innovation ecosystem both in academic research and in policy practice [24]. An innovation ecosystem is a system composed of different stakeholders in collaborative evolution, creating value through innovation [25], with characteristics of integrity, hierarchy, dissipation, dynamics, stability, complexity, and regulation [26]. Not all innovation ecosystems have the same structural model. When studying the structure of an innovation ecosystem, most scholars constructed a single-dimensional planar structure model, while a few scholars, such as Zhao and Zeng [27], Su et al. [28] and Zhi [29], analyzed the structure of the innovation ecosystem from multiple perspectives. Zhao et al. constructed an analytical framework of innovation ecosystem from three levels: macro, meso, and micro. They believed that each level is interconnected. The low-level innovation ecosystem can be regarded as a specific innovation habitat, while the high-level innovation ecosystem is the embodiment of rules and order. Su et al. studied the enterprise innovation ecosystem, deconstructed it and constructed a multiplatform collaborative innovation ecosystem composed of core layer, platform layer, and development application layer. Research into innovation ecosystems at home and abroad provides a valuable theoretical and practical basis for future expansion. At present, a few scholars have started to study the agricultural innovation ecosystem. Pigford et al. [30] compared an agricultural innovation system and innovation ecosystem, and expanded the agricultural innovation system using the innovation ecosystem method; Wen [31] studied the level and operation mechanisms of the agricultural innovation ecosystem; based on the innovation ecosystem theory, Yi et al. [32] analyzed the driving factors of agricultural digital transformation and constructed the strategic framework of “production and operation-supporting services-value chain extension”; Zhang et al. [33] explored the evolutionary power and internal mechanism of a mariculture innovation ecosystem from the perspective of core enterprises using the single-case analysis method. Zhang et al. [34], combined with a single case of mariculture, identified the innovation motivation, innovation behavior, and innovation results at different stages to explore the internal evolution mechanism of the innovation ecosystem. Wang et al. [35] broke through the traditional innovation paradigm, expounded the necessity and conditions of ecological evolution of agricultural science and technology innovation system, constructed a theoretical framework of agricultural science and technology innovation ecosystem from four aspects of main body, population, community, and system, and put forward evolutionary goals, paths, and policy suggestions. Still et al. [36] revealed the special characteristics of the innovation ecosystem and the connection of important participants based on visual and quantitative social networks. Chae [37] constructed an analytical framework and, through data and community detection analysis, found that heterogeneity factors and their
communities were constantly evolving in the innovation ecosystem. Autio [38] established a framework from generation to maturity of a multilevel collaborative innovation ecosystem and analyzed the behavioral characteristics of innovation participants in the start-up stage, dynamic stage, and control stage. In order to study the impact of contingencies on the evolution of innovation ecosystem, Poblete et al. [39] introduced temporary structures into the innovation ecosystem to study the ability of key participants to deal with challenges and realize opportunities under different time logics. Domestic scholars focused on the evolution process and evolution cycle of an innovation ecosystem. Ou et al. [40], Wu and Tan [41], and He et al. [42] used an evolutionary game model to deduce the evolution process of the innovation ecosystem. The results show that only through mutualism can the long-term cooperation between innovation subjects in the innovation ecosystem be realized. He et al. [42] analyzed the stability of innovation ecosystem evolution from the perspective of knowledge-sharing incentive, and obtained the influencing factors and corresponding evolutionary paths of knowledge-sharing incentive under different circumstances. Wang and Tang [43] studied the evolution process of regional innovation ecosystem based on the theory of dissipative structure. With the number of dissipative structure increasing year by year, the comprehensive innovation capability of China's regional innovation ecosystem is constantly improving. Sun et al. [44] divided the evolution stage of the innovation ecosystem into a technology protection period, market selection period, and competition diffusion period. In addition, some scholars constructed an index system based on the life-cycle theory to evaluate the cycle evolution stage of the innovation ecosystem [45, 46]. Tan et al. [47] studied the transformation of architects' positions in different evolutionary stages of innovation ecosystem and the impact of changes in their strategic behaviors on the evolution of innovation ecosystem. Wang et al. [48] studied the evolution law of exploration innovation and development innovation and system cycle of regional innovation ecosystem, and found that the two kinds of capabilities change opposite or deviating from each other in different cycle stages. Wang et al. [49] analyzed the influencing factors of resource integration in the initial stage, growth stage, and maturity stage of enterprise innovation evolution cycle and concluded that innovation strategy is the most critical factor of innovation resource integration. With the deepening of research, some scholars began to focus on the periodic evolution characteristics of the innovation ecosystem and, based on the life cycle theory, carried out research from the life-cycle stage discrimination of the innovation ecosystem or the health evaluation of different stages of the life cycle [50].

In sum, the research on agricultural innovation has gradually shifted from the "agricultural innovation system" to "innovation ecological system" theory of sustainable development. At present, most of the research on innovation ecosystems is still in theory, but the application of innovation ecosystems needs further research, and there is a lack of case studies and empirical analysis on industrial innovation ecosystems. In addition, the research is mainly conducted at the provincial and municipal levels, at the mid-level regional and industrial level, and usually involves high-tech industries, strategic emerging industries, cultural and creative industries, and other industries. Research on agricultural innovation ecosystems at the county level is very rare. Based on the ecological theory, this article will construct a theoretical model of the agricultural innovation ecosystem in county areas and study the evolution law of agricultural innovation ecosystems in county areas from the life-cycle perspective, which has important theoretical and practical significance.

As the core element of agricultural innovation development, agricultural innovation system plays a decisive role in rural revitalization and high-quality agricultural development. County is the main battlefield to practice rural revitalization and promote high-quality agricultural development. Therefore, the study of agricultural innovation system from the perspective of county has become the key point to solve the problems of agriculture, rural areas, and farmers in China. County agricultural science and technology innovation involves multisubject participation and multilink crossover, which has gone beyond the traditional single linear innovation mode. It turns to the system innovation mode of interlink interaction and becomes increasingly complicated and dynamic. It is urgent to introduce ecological theory from the innovation paradigm and establish the agricultural innovation management concept based on the innovation ecological view. This can not only promote the ecological transition of agricultural innovation system, but also help to realize the ecological evolution of the county agricultural innovation system. In addition, this will promote county agricultural science and technology innovation open, collaborative, dynamic sustainable development. The concept and principle of stable, durable, and symbiotic natural ecosystem have been adopted by many disciplines and practice fields. How to excavate natural ecosystem to establish sustainable ecosystem mechanism to provide inspiration and reference for innovative management has become a new trend of domestic and foreign scholars. With the new round of innovation paradigm transformation, the traditional innovation system is gradually transformed into innovation ecosystem. As a more advanced innovation paradigm, innovation ecosystem will have important implications for agricultural science and technology innovation and institutional innovation in the new era. As the derivative system and important branch of regional innovation ecosystem and industrial innovation ecosystem, county agricultural innovation ecosystem also has important reference significance to promote rural reform and agricultural development.

This article comprehensively applies agricultural innovation theory and ecological theory, takes county agricultural innovation ecosystem and its evolution as the research breakthrough point, and tries to answer the following questions: What is the county agricultural innovation ecosystem? What is the composition and structural level of county agricultural innovation ecosystem? What are the evolution rules and characteristics of agricultural innovation ecosystem at county level? This article constructs an
agricultural innovation ecosystem in county areas and maintains the benign evolution of the system, with a more open perspective. It also removes the disadvantages of single-industry chain integration development, and emphasizes the horizontal and vertical integration of the agricultural industry. Horizontally, a collaborative and symbiotic mechanism should be established for agricultural enterprises, government departments, universities, scientific research institutions, financial institutions, and intermediary institutions, to promote complementary advantages and optimize resource allocation. Longitudinally, the 123-industry depth fusion shall be promoted, and an open, collaborative, sustainable agricultural innovation ecosystem will be formed in county areas to broaden the rural market, link together small farmers and the big market, create an effective demand and supply, speed up the agricultural supply-side structural reform, and promote the development of high-quality agriculture.

The rest of this study is organized as follows. A multidimensional agricultural innovation ecosystem in a conceptual model of county areas is presented in Section 2. Section 3 presents the evolution and evaluation system of agricultural innovation ecosystem in county areas. Methodology and empirical study are presented in Sections 4 and 5. Section 6 presents the results and discussion. The conclusions and implications are presented in Section 7.

2. Conceptual Model of Agricultural Innovation Ecosystem in County Areas

In recent years, research studies on innovation ecosystem have been increasing, mainly focusing on the composition, network structure, and dynamic evolution between innovation subject and innovation environment in innovation ecosystem [41]. Scholars view the innovation ecosystem as a network of interconnected and interacting behaviors of firms, customers, suppliers, complementary innovators, and other regulators. Members face cooperation and competition, following a process of coevolution. Innovation subject and innovation environment are two important factors affecting innovation ecosystem. The innovation subject adapts and transforms the innovation environment, and the innovation environment restrains and promotes the collaborative innovation of the innovation subject [34]. Agricultural innovation ecosystem will also be affected by universities and research institutions, governments, financial institutions, intermediary institutions, and other multiple innovation subjects. However, as the main agricultural operator, the role of farmers in the process of innovation cannot be ignored. County agricultural industry is still scattered, independent farmers as the main production main body. In order to realize the transformation from resource-intensive to technology-intensive agriculture, farmers must be connected, and parks and small towns can play a strong role in demonstration and radiating. The link between the market and farmers can make the scattered farmers realize the sharing of information, technology, talent, capital, and other elements, and provide an important platform for the integration of all kinds of innovation resources in the county [38]. In addition, unlike advanced, sophisticated industries, agriculture itself is a weak industry, and the threshold of entry is low. The regional agriculture, especially the innovative development of county agriculture, is faced with various difficulties. Due to the lack of stable mechanism among agricultural innovation subjects, it is necessary to rely on a stronger innovation platform. Only in this way can interface play a role in promoting and realizing broader and deeper integration of innovation resources. The innovation platform has rich innovation-related resources, including technical resources, information resources, and financial resources, as well as excellent marketing, distribution channels, and legal and other professional services. The platform layer is the connector between the organization through the core layer and the development and application layer [28]. The innovation platform is embedded in the county agricultural innovation ecosystem to form the interface ecology. The innovation subject and the innovation environment will be better integrated, so that the two are no longer distinct. Innovation platform can not only assume the function of innovation subject in the macroenvironment, but also provide a series of capital, technology, culture, and other environments for micro-innovation individuals to promote innovation. Therefore, in view of the dual position and function of innovation platform in county agricultural innovation ecosystem, this article regards it as an embedded ecological layer and constructs a complex and multilevel innovation ecosystem framework from a more open perspective.

2.1. The Definition of Agricultural Innovation Ecosystem in County Areas. The term “innovation ecosystem” refers to an open and complex self-organization system in which innovation subjects gather and form an innovation network within a certain time and space, formed by the flow of material, energy, and information within the external environment [5–7]. The formation and development of an agricultural innovation ecosystem in county areas should be based on resource endowment. At present, there are a general lack of universities and scientific research institutes in counties, a lack of innovative talents, and weak independent innovation in agriculture-related enterprises [22]. Additionally, agricultural innovation in counties mainly depends on universities and scientific research institutes outside the region. Furthermore, different landforms are suitable for different industries, so counties should set innovation goals according to their own resource endowment advantages; goals should not be large and comprehensive, and innovation activities should be carried out near characteristic industries. Under the guidance of government departments, agricultural enterprises, financial institutions, and intermediary institutions within the county interact with universities and scientific research institutions outside the county to form innovation communities with industry-university-research cooperation as the core, near to the characteristic industries. These rely on innovation platform features such as agricultural science and technology park, and characteristic towns, and the innovation environment to
more effectively achieve material, energy, and information flow [28]. Thus, the system of symbiosis, cocreation, co-prosperity, and coevolution is formed. The system is guided by the market demand, and the guidance and regulation of the government. This makes innovation subjects and innovation environment mutually dependent and enforces a harmonious coexistence to obtain the economic benefits, social benefits, and ecological benefits of county agriculture, and realize the sustainable development of agriculture.

2.2. Conceptual Model Construction. The innovation subjects in agricultural innovation ecosystem in county areas have a close relationship of mutual dependence and symbiosis, and jointly create value under the guidance of the concept of value cocreation, to achieve the optimal system. Therefore, the innovation subjects in the system not only compete with each other, but also cooperate with each other, forming a multilevel agricultural innovation ecosystem in county areas. The system is divided into a microsubject ecological layer, meso-interface ecological layer, and macroenvironment ecological layer, as shown in Figure 1.

As shown in Figure 1, the microsubject ecological layer is composed of innovation subjects participating in county agricultural innovation activities, including agriculture-related enterprises, governments, universities and scientific research institutions, financial and intermediary institutions, and the public. Agricultural innovation ecosystem is affected by the interaction of innovation subjects. Through the innovation network formed by the cooperation of all the main bodies, the sustainable innovation ability of the system is constantly improved. These innovation subjects interact with each other to form a good innovation community. Agricultural enterprises, universities, and scientific research institutions constitute the technology R&D community, which is the core community of the county agricultural innovation ecosystem. Government departments and the public constitute strategic demand community. Financial institutions, intermediary institutions, and so on constitute the auxiliary service community. Each community plays a different role and forms a micro-ecological layer with complex network structure. The meso-interface ecological layer is composed of some innovation platform organizations, which provide interfaces and channels for material, energy, information, and technology exchange between innovation subjects and innovation environment, including agricultural science and technology parks, modern agricultural parks, characteristic towns, and agricultural technology innovation alliances. These platform organizations represent the innovation capability of county agricultural innovation system and can connect multiple innovation subjects for cooperative innovation. The macroenvironment ecological layer covers almost all the innovation environments required by county agricultural innovation, including policy environment, resource environment, market environment, technological environment, cultural environment, infrastructure environment, etc., which provides indispensable external conditions for the micromain ecological layer and the meso-interface ecological layer. Innovation environment affects the scope of innovation activities evolution path and innovation performance of county agricultural innovation ecosystem. The macroenvironment promotes or restrains the innovation subjects and innovation platforms in the system, and makes each microsubject ecological layer and meso-interface ecological layer self-adjust and co-evolve under the influence of the innovation environment, so as to achieve the balance and stability of the ecosystem. In the agricultural innovation ecosystem, there is an inseparable relationship between the microsubject layer, the meso-interface layer, and the macroenvironment layer.

2.2.1. Analysis of Microsubject Ecological Layer. The microsubject ecological layer is the base of the agricultural innovation ecosystem in county areas and the main provider of innovation resources. It is composed of the scientific and technological research and development (R&D) community, financial and intermediary institutions, resource environment, and auxiliary service community.

(1) Technology research and development community: Vertically, industry-university-research is the most core position in agricultural innovation ecosystem in county areas, forming the technology, research, and development community in the system. Through industry-university-research cooperation, the synergy problem of agricultural products in the five links of production, processing, storage, transportation, and marketing can be solved, and the synergy mechanism of industrial chain can be formed. The connection channel of primary, secondary, and tertiary industries can be opened, the agricultural industrial chain can be extended, and the integration of primary, secondary, and tertiary industries can be promoted. Horizontally, the innovation results produced through industry-university-research cooperation can improve the social and economic benefits, attract more diverse and broader innovation subjects to join the system, and achieve a win-win situation. Therefore, the technology, research, and development community is a horizontal and vertical network structure. Long-term industry-university-research cooperation in the field of agriculture can enable agriculture enterprises to acquire mature technology, advanced knowledge, and talents from universities and research institutions and improve their independent innovation ability. Universities and scientific research institutions obtain corresponding financial support and platforms and space for scientific research from enterprises, which makes scientific research more suitable for market demand, promotes the transformation and diffusion of innovation, and speeds up the commercialization of innovation achievements.

(2) Strategic and demand populations: The strategy and demand group, which is comprised of government departments and the public, forms the strategic positioning and demand guidance in the agricultural innovation ecosystem in county areas. The government
defines the direction of industry-university-research collaborative innovation for technology, research, and development communities by formulating strategic guidelines; regulates market order by macrocontrol; guides and supports agriculture-related enterprises, universities, and research institutions to engage in agricultural innovation activities by issuing regulations and policies to promote the formulation of technical standards, risk control, and intellectual property rights protection; and supports agricultural enterprises, universities, and departments to actively participate in the development of scientific research projects and the research and development stage of key technologies by financial means. The government can also make recommendations, guide the establishment of industry-university-research platforms, promote cooperation between universities and enterprises, and accelerate the dissemination and diffusion of scientific and technological achievements. The public, including the end consumers and farmers of agricultural products, will feedback their experience of innovative products to agriculture-related enterprises or farmers, and constantly put forward new innovation demands with the changes in the external environment. As the end producers of innovative products, farmers will generate new technological innovation demands according to the changes in consumer demand and promote further cooperation between industry, university, and research institutions.

(3) Auxiliary service community: The operation of agricultural innovation ecosystem in county areas is inseparable from the innovation service function of auxiliary service community, which includes financial institutions, intermediary institutions, and some other organizations. Financial institutions provide indispensable financial support for the agricultural innovation ecosystem in county areas, which is an important energy source and provides financial supply, reduces the damage of natural disasters, and avoids market risks. Intermediary agency is the catalyst of agricultural science and technology innovation and can accelerate the commercialization of agricultural innovation achievements. They gather information, technology, management experts, and intermediary institutions to provide services for agricultural enterprises, reduce the agricultural enterprise and other main innovation body, and directly dock costs. This would ensure a smooth cohesion within the innovation main body and accelerate the agricultural innovation diffusion, transfer, and commercialization, as well as improving the efficiency of the innovation. The
innovation results generated by industry-university-research cooperation are also important sources of business for financial institutions and intermediaries. In addition, some other organizations, such as logistics, e-commerce, venture capital, and other organizations, provide important services in the agricultural innovation ecosystem in county areas.

2.2.2. Analysis of Meso-Interfaces Ecological Layer. The meso-interface ecological layer is the medium and channel for material, energy, information, and technology exchange between innovation subjects and innovation environment. The meso-interfaces ecological layer is an innovation community composed of agricultural science and technology parks, modern agricultural parks, technological innovation alliances, characteristic towns, etc. (hereinafter referred to as parks), which represent the development level of regional industries. At present, the county agricultural industry is mainly operated by scattered and independent farmers, and the degree of organization is low. To realize this transformation and upgrading, farmers must be connected. As the core force of innovation, agriculture-related enterprises are generally small in scale and lack innovation ability, so they do not have enough strength to engage in innovation activities with innovation resources and innovation subjects.

It is necessary for parks and other platform organizations to fulfill the roles of guidance, demonstration, and radiation. This will be achieved by constructing an “agricultural innovation integrated services platform,” gathering the middle and lower reaches of the agricultural enterprise, extending the industrial chain to provide technology, incubation, and other platform services for agriculture-related enterprises, providing manpower, equipment, and financial support for universities and scientific research institutions to promote integration and transformation, and encouraging farmers to actively participate in the application and promotion of new technologies and new models. They rely on the Internet to form the spatial docking inside and outside the county, and establish a strong connection between each other, so as to break the regional boundaries and form the innovation and transformation pattern of the whole industry chain, the whole factor, and the whole process.

2.2.3. Analysis of Macroenvironment Ecological Layer. The macroenvironment ecological layer contains includes almost all the policies, materials, talents, scientific knowledge, and infrastructure, and all the cultural factors and value judgments that affect innovation activities. The microsubject ecological layer and meso-interface ecological layer depend on this. It provides an essential habitat for the microsubjects and meso-interfaces. The policy environment mainly refers to the relevant policies and regulations issued by the government, tax incentives, etc. A good policy environment can guide and regulate innovation behavior, reduce transaction costs, and improve the operation efficiency of an agricultural innovation ecosystem in county areas. The resources and environment mainly include all kinds of natural and non-natural resources that support the development of sustainable agricultural innovation, such as seeds, materials, tools, and other material resources necessary for agricultural innovation activities, as well as innovative talents and capital. Environmental resources are necessary for the smooth development of systematic innovation activities. The market environment refers to the sum of many external factors affecting the production and sales of innovative products, including market competition, market supply and demand, market operation, and market trends.

The technical environment refers to the technical level and research and development ability of the region in which the system is located. The continuous improvement of the technical environment can strengthen the hematopoietic function of the system, make the breakthrough innovation achievements in the system emerge continuously, and enhance the competitive advantage of the county agriculture. The cultural environment refers to the values and codes of conduct formed in the long-term development of agricultural innovation ecosystem in county areas. The open and tolerant social and cultural environment can promote mutual trust and interaction among the innovation subjects in the system, and contribute to the sustainable innovation and development of the county agriculture. The infrastructure environment refers to the construction of public facilities by the government to ensure the smooth development of agricultural innovation activities in the county, including transportation, communication, energy, network, and other facilities, as well as the construction of a scientific research platform, education and training, and science and technology promotion. The macroenvironment promotes or restrains each innovation subject, making each innovation subject self-adjust and co-evolve under the influence of innovation environment, to realize the balance and stability of the ecosystem.

An agricultural innovation ecosystem in county areas presents a multidimensional hierarchical relationship under the network relationship effect. The continuous flow of funds, talents, information, and technology between the various levels of the system maintains the system’s dynamic stability over a certain period. The top view of the agricultural innovation ecosystem at the county level is shown in Figure 2.

3. Evolution and Evaluation System of Agricultural Innovation Ecosystem in County Areas

3.1. Evolution Rules. Agricultural innovation ecosystem in county areas will show periodic laws in the process of spiraling evolution. According to the life-cycle theory, the county agricultural innovation ecosystem can be divided into the gestation stage, growth stage, mature stage, and decline stage.

(1) Gestation stage: The gestation stage is the formation stage of the county agricultural innovation ecosystem. The industry is still in the initial stage of development. The number and scale of enterprises in the industry are relatively small, the industrialization
degree is low, and they lack the independent innovation ability to support the industrial development. In counties, the degree of marketization is generally low, and universities and scientific research institutions are mostly concentrated in cities, which lack the basis for market guidance and the scientific research needed to guide agricultural innovation. Therefore, it is necessary to rely on the government to actively and scientifically guide industry-university-research innovation activities. As the interaction between innovation subjects and communities has just been established, the competition and cooperation within the system is not stable enough, the value chain is relatively short, the value network has not been formed, and the operation efficiency of the system is relatively low. This does not lead to the innovation-driven development of county agriculture, and the economic benefits brought by innovation are very low. For financial institutions and intermediaries pursuing business interests, willingness to participate is not high, and a relevant service system has not been established.

(2) Growth stage: The growth stage is the period of rapid development of a county agricultural innovation ecosystem. As industry-university-research cooperation deepens, the system’s innovation ability of the system, the innovation benefit is constantly improved, and an increasing number of innovation subjects are attracted to join the system, so that the types of innovation subjects gradually increase, the size of the population gradually expands, the structure of the innovation community is increasingly complex, and the stability of the system is constantly improved. With the continuous improvement of the market mechanism and the increasing role of the market, the role of the government has weakened, but it still needs to play the role of coordination and distribution. The system is gradually being transformed from a government-driven system to a government-market-driven system. During this stage, the value chain unceasingly extends, and a value network is gradually formed. The relationship between innovation subjects is more stable; the relationship between the innovation community is rapidly enriched and expanded; the number of connections between innovation subjects increases; the frequency of each node interaction increased; the flow of material, energy, and information exchange becomes more effective; the ability to resist risk is gradually enhanced. In addition, with the continuous increase in the economic benefits brought by innovation, financial, intermediary, and other service institutions are more willing to participate in the county agricultural innovation process, so the relevant service system is gradually improved.

(3) Mature stage: The mature stage is the period of the steady development of a county agricultural innovation ecosystem. The system is in a self-sustaining state of dynamic balance; that is, the number of innovation subjects entering and exiting the system maintains a balance. The system has no need to invest a lot of innovation resources; there will be a lot of innovation output. On the basis of industry-university-research innovation cooperation, agricultural enterprises internalize knowledge and

Figure 2: Top view of agricultural innovation ecosystem in county areas.
produce new knowledge to form sustainable independent innovation capabilities. The market mechanism is fully established, so the government plays a more background role, while the market leads in terms of resource allocation. At this stage, the scale of the system reaches its maximum, and the innovation benefit output of the system reaches its maximum and remains relatively stable. The boundary of the system becomes increasingly blurred, and regional boundaries are broken among members, forming a network structure that is suitable for the development of time and space and not easy to change. The organizational mechanism and rules and regulations within the system are relatively perfect. The industry-university-research innovation alliance and related service system are completely established, and win-win cooperation has been realized, which can effectively resist risks. This stage is the turning point of county agricultural innovation-driven development. If the system finds a new breakthrough point in the process of fluctuation, it will enter a new cycle track. Otherwise, it can only continue to develop at the original stable level or even decline due to fierce competition.

(4) Recession stage: Recession stage is the period of the gradual decline of a county agricultural innovation ecosystem. In the recession stage, the environment of the system significantly changes, and the innovation output speed cannot keep up with the pace of environmental change, breaking the original running track of the system. The innovation population is increasingly unable to adapt to changes in the environment, and the degree of dependence is gradually weakened and finally chooses to withdraw. At this stage, the system loses its original competitive advantage, the innovation power is seriously insufficient, the innovation output cannot meet the market demand, and the competitive pressure is increased, which leads to the gradual collapse of the industry-university-research cooperation. The service level of financial institutions, intermediary institutions, and other service institutions accordingly decreases. However, the recession of the system does not mean the complete extinction of the system. When the system fails to meet the needs of technological development and market through timely innovation in response to changes in the environment, it will eventually die out. When innovation subjects can perceive changes in the environment in time, develop an improvement track of community value through active innovation attempts, and realize a coevolution or upgrading based on this, it is possible to extend the system’s life by establishing a new or upgraded innovation ecosystem.

Considering the evolution and development process of a county agricultural innovation ecosystem, different evolution stages present different characteristics. The following is a summary of the evolution characteristics of a county agricultural innovation ecosystem, as shown in Table 1.

3.2. Evaluation Index Selection. Since agricultural innovation ecosystem in county areas is a theoretical analysis framework, which cannot be separated from the practical foundation of the agricultural industry, the innovation subject should carry out innovation activities around the county agricultural characteristic industry, and the system evolution must rely on the characteristic industry. This article takes the apple industry as an example and takes Neiqiu County, Shunping County, and Yi County of Hebei province as sample counties for comparative study, to more objectively summarize the systematic common law and provide a reference for better understanding of the future development trend.

Scholars are paying increasing attention to research on the evolution of innovation ecosystems, but there are few evaluation studies on the evolution and development of the agricultural industry. This article refers to the studies of Yin et al. [51], Miao and Huang [52], Gao et al. [53], and Yin et al. [45], on regional innovation ecosystems and life-cycle evaluations of industrial clusters, to provide a reference for the selection of evaluation indicators for the evolution and development stage of agricultural innovation ecosystem in county areas. This article designs indicators from four aspects—subjects, network, resources, and environment, as shown in Table 2.

(1) Subject aspects: Innovation subjects are the foundation of county agricultural innovation ecosystem and provide innovation resources. Among the selected indicators, the intensity of government support indicates the government’s support to the county agricultural innovation ecosystem through policy formulation, financial support, talent reserve, and other means. The concentration of production scale can reflect the concentration degree of county agricultural characteristic industry development. The service level of industry association is an important intermediary organization, promoting the development of an agricultural characteristic industry in the county, and can promote the flow of knowledge and information in the agricultural innovation ecosystem in the county [54].

(2) Network aspects: Network organization can reflect the relationship between innovation communities in the county agricultural innovation ecosystem. Among the selected indexes, the intensity of industry-university-research cooperation is the core of the county agricultural innovation ecosystem, reflecting the level of innovation ability improvement driven by industry-university-research cooperation innovation. The degree of cooperation between farmers and parks/enterprises can reflect the innovation-driving ability in the region and surrounding areas. The degree of tourism drive can reflect the degree of integration of primary, secondary, and tertiary industries, thus reflecting the comprehensive development capacity of county agriculture.

(3) Resources aspects: Innovative resources are the necessary manpower, and financial and material
resources of the county agricultural innovation ecosystem. The level of agricultural technology personnel allocation can reflect the agricultural science and technology talent reserve at the grassroots level and then affect the quality of agricultural technology promotion. The intensity of technical training input is the intensity with which the government or enterprises employ technical personnel and experts for training, so that farmers can master the technology and knowledge needed to participate in innovation. The adequacy of investment funds is the adequacy of the funds needed to maintain normal system operation.

(4) Environmental aspects: Innovation environments are an indispensable external factor for the operation of county agricultural innovation ecosystem. Among the selected indicators, the degree of technical training input is the intensity with which the government or enterprises employ technical personnel and experts for training, so that farmers can master the technology and knowledge needed to participate in innovation. The extent of the market boom can reflect the market environment of the county’s agricultural innovation ecosystem. The popularity of the Internet can reflect the degree of informatization development and openness of a region. The degree of unobstructed traffic is a necessary condition to increase regional liquidity and openness, which is conducive to improving the open innovation of the system.

4. Methodology

4.1. Principle of Membership Degree. Membership degree is a quantitative evaluation of the degree to which each factor is suitable for the concept. The membership degree can be arbitrarily set at [0,1]. The principle is as follows: assuming the ontological domain $X$, if there are $p$ factors in the domain $X$, the $q$th factor $x_q$ has a corresponding fuzzy subset $A_q$, $A_q (q = 1, 2, \ldots, p)$, and $A_q$ is a set based on the membership function $\mu_{A_q}$. Therefore, $\mu_{A_q}$ is called $A_q$ membership function, and $\mu_{A_q}(x)$ is the $x$ on the membership degree of fuzzy subset of $A_q$. $\mu_{A_q}(x) \in [0,1]$.

4.2. Principles of Closeness. Closeness can represent the degree of approximation between fuzzy sets. Based on the
assumption of membership principle given above, if the fuzzy subset \( \{A_1, A_2, \ldots, A_p\} \) on domain \( X \), the object \( B \) to be recognized is represented as a fuzzy subset of the domain \( X \), and \( B \) is the set reflected by \( \{A_1, A_2, \ldots, A_p\} \) on the set of evaluation grade \( V \). When the fuzzy subset \( B \) is closest to \( A_i \) in the fuzzy subset \( \{A_1, A_2, \ldots, A_p\} \), the corresponding real number \( \sigma(A_i, B) \) is the degree of closeness between fuzzy sets \( A \) and \( B \). The smaller the value of \( \sigma(A_i, B) \) is, the less close \( A \) is to \( B \). When \( 0 \leq \sigma(A_i, B) \), the larger the value of \( \sigma(A_i, B) \) is, the closer the past set \( A \) is to \( B \). The smaller the value of \( \sigma(A_i, B) \) is, the less close \( A \) is to \( B \). In practice, the degree of nearness is often divided into symmetrical closeness and asymmetrical closeness.

The symmetric closeness degree is defined as follows: for any fuzzy subset \( A, B \), \( C \), and \( D \) on \( V \),

\[
E_1 = \{ [\mu_A(\mu_k) - \mu_B(\mu_k)] | \mu_k \in V \}.
\]

(1)

\[
E_2 = \{ [\mu_C(\mu_k) - \mu_D(\mu_k)] | \mu_k \in V \}.
\]

(2)

If \( N \) satisfies,

\[
\sum_{k=1}^{n}(\mu_A(\mu_k) + \mu_B(\mu_k)) = \sum_{k=1}^{n}(\mu_A(\mu_k) + \mu_D(\mu_k)).
\]

(3)

If \( E_1 = E_2 \) \( N(A, B) \Rightarrow \) \( N(C, D) \), then \( N \) is the symmetric degree of closeness (if it is continuous, \( \sum \) should be changed to \( \int \) ). The formula of symmetric closeness degree is

\[
N(A, B) = \sum_{k=1}^{n} \min(\mu_A(\theta_k), \mu_B(\theta_k))
\]

\[
\sum_{k=1}^{n} \max(\mu_A(\theta_k), \mu_B(\theta_k))
\]

= \frac{\sum_{k=1}^{n} \min(\mu_A(\theta_k), \mu_B(\theta_k))}{\sum_{k=1}^{n} \max(\mu_A(\theta_k), \mu_B(\theta_k))}
\]

(4)

If \( N \) is not symmetric closeness, it is called asymmetric closeness. The formula is

\[
N(A, B) = 1 - \frac{2}{n(n+1)} \sum_{k=1}^{n} \mu_A(\theta_k) - \mu_B(\theta_k) \times k.
\]

(5)

Among them, \( \theta_k \) represents the decision level of evaluation grade, and \( \mu_A(\theta_k) \) and \( \mu_B(\theta_k) \) represent the membership degree of fuzzy set \( A \) and \( B \) corresponding to \( \theta_k \), respectively.

When \( \theta_1, \theta_2, \ldots, \theta_n \) are regarded as the same level, a symmetrical degree of closeness is usually adopted. When \( \theta_1, \theta_2, \ldots, \theta_n \) are regarded as different levels, an asymmetric degree of closeness is usually used.

### 4.3. Steps of Fuzzy Proximity Evaluation Method

1. Determine the factor set of the evaluated objects. Evaluation only can be carried out when the influencing factors of the evaluated object are clear. By screening the main factors, the factor set of the evaluated object is established. Assuming that the evaluated object has \( N \) main factors, the set of evaluation factors is established, denoted as \( U = \{u_1, u_2, \ldots, u_n\} \).

2. Give the set of evaluation grades or comments. To determine the evaluation grade of evaluation factors, an evaluation grade set or comment set can be formed. Assuming that \( m \) grades can be divided into evaluation factors, the evaluation grade set or comment set can be obtained, denoted as \( V = \{v_1, v_2, \ldots, v_m\} \). In practice, it is generally divided into 3-5 evaluation grades. As comment sets are language sets, such as [excellent, good, qualified, unqualified], and [high, medium, low], it is necessary to use membership degree theory to transform qualitative evaluation into quantitative evaluation in fuzzy comprehensive evaluation, as shown in (1).

According to the membership degree principle, the membership degree \( r_{ij} \) of \( v_j \) \( (i = 1, 2, \ldots, m) \) of any evaluation factor \( u_i \) \( (i = 1, 2, \ldots, n) \) in the evaluation factor set \( U \) can be found, and the fuzzy subset corresponding to each evaluation factor can be obtained. The formula for this is \( \bar{r}_i = (r_{i1}, r_{i2}, \ldots, r_{im})^T \). It should be noted that due to the differences in the degree of membership of each level, the role is not the same. It is necessary to standardize \( r_{ij} \) so that \( \sum_{j=1}^{m} r_{ij} = 1 \), and \( r_{ij} > 0 \).

3. Construct a fuzzy relation matrix. After obtaining the fuzzy subset of each evaluation factor, an \( n \times m \) fuzzy relation matrix \( R \) can be formed:

\[
\bar{R} = \begin{bmatrix}
\bar{r}_{11} & \bar{r}_{12} & \cdots & \bar{r}_{1m} \\
\bar{r}_{21} & \bar{r}_{22} & \cdots & \bar{r}_{2m} \\
\vdots & \vdots & \ddots & \vdots \\
\bar{r}_{n1} & \bar{r}_{n2} & \cdots & \bar{r}_{nm}
\end{bmatrix}
\]

(6)

Among them, \( r_{ij} \) is the membership degree of the \( u_i \) evaluation factor corresponding to the \( v_j \) evaluation grade fuzzy subset.

4. Fuzzy judgment. It is assumed that in the evaluation factor set, \( V = \{v_1, v_2, \ldots, v_m\} \) the characteristic fuzzy subset of subset \( v_j \) of evaluation factor \( j \) is \( S_j = (0, 0, \ldots, 0, 1, 0, \ldots, 0) \). Among them, the \( i \)th component is 1 and the rest components are 0.

Since the evaluation indexes of each dimension do not belong to the same level when designing the evaluation indexes of the evolution and development stage of the agricultural innovation ecosystem in county areas, this article introduces an asymmetric closeness degree to calculate the closeness degree, namely, Type 5.

To calculate the subsymmetric closeness between the fuzzy subsets \( \bar{r}_i (i = 1, 2, \ldots, n) \) and \( \bar{s}_j (j = 1, 2, \ldots, m) \) corresponding to each evaluation factor,

\[
\bar{Z}_i = (Z_{i1}, Z_{i2}, \ldots, Z_{im})^T = (N(\bar{r}_i, \bar{s}_1), N(\bar{r}_i, \bar{s}_2), \ldots, N(\bar{r}_i, \bar{s}_m))^T.
\]

(7)

Then, the proximity matrix of the evaluation factor set \( U \) is

\[
Z = (Z_{ij})_{nm} = (\bar{Z}_1, \bar{Z}_2, \ldots, \bar{Z}_n).
\]

(8)

Based on the technique for order preference by similarity to an ideal solution method, set up the parameter grade “\( V^+ \), “\( V^- \), the corresponding vector “\( \bar{C}_+ \), “\( \bar{C}_- \), to meet
5. Empirical Study

This article takes the apple industry as an example and selects Neiquiu County, Shunping County, and Yi County as sample counties for comparative study, to verify how scientific and effective the theoretical model and evolutionary evaluation index system are in agricultural innovation ecosystems in county areas.

Firstly, according to the evaluation index system of evolution and the development stage of agricultural innovation ecosystem in county areas, the rating index set includes 16 indexes in Table 2, and the evaluation index set of county agricultural innovation ecosystem is denoted as $U = \{u_1, u_2, \ldots, u_{16}\}$.

Secondly, according to the above analysis, the evolution life cycle of the county innovation ecosystem can be divided into four stages: gestation stage, growth stage, maturity stage, and recession stage. Therefore, the evaluation set of the evolution and development stages of the county agricultural innovation ecosystem includes four stages: gestation stages, growth stages, maturity stages, and recession stages. These are denoted as $V = \{v_1, v_2, \ldots, v_4\}$.

Thirdly, to make the final judgment, it is necessary to combine the evaluation index with the system evolution stage and construct the fuzzy relation matrix of the system evolution stage.

### 5.1. Questionnaire Design

In this article, the required data were collected by issuing questionnaires, using a Likert five-level scale. The scale was set as "lowest," "lower," "general," "higher," and "highest," with corresponding scores of 1, 2, 3, 4, and 5, respectively, denoted as $A = \{A_1, A_2, A_3, A_4, A_5\}$.

The research group conducted a field survey of Shunping County, Neiquiu County, and Jingxing County from October to November 2019. Due to the outbreak, no field survey could be carried out. The author made up for this by means of a random telephone interview in March 2020 to obtain primary data. As farmers are the main participants in the agricultural industry in the county, farmers are the main objects of the investigation in this article, supplemented by the investigation of relevant staff of government agencies, heads of parks/enterprises, and personnel from universities or scientific research institutions. The situation of the investigated objects is shown in Table 3.

Reliability and validity tests were conducted on the questionnaire. Cronbach $\alpha$ coefficient, Kaiser–Meyer–Olkin (KMO) sampling appropriateness test, and Bartlett sphere

| Basic information | Neiquiu County | Shunping County | Yi County |
|-------------------|---------------|-----------------|-----------|
| Number            | Proportion    | Number          | Proportion |
| Gender            |               |                 |           |
| Male              | 42            | 36              | 41        |
| Female            | 33            | 39              | 34        |
| Age               |               |                 |           |
| Under 25          | 3             | 6               | 9         |
| 25–35             | 15            | 8               | 10        |
| 36–45             | 17            | 16              | 22        |
| 45–60             | 28            | 34              | 27        |
| Above 60          | 7             | 11              | 7         |
| Education         |               |                 |           |
| Junior high and below | 42        | 40              | 41        |
| High school       | 18            | 19              | 19        |
| College and university | 6         | 8               | 6         |
| Postgraduate and above | 9          | 8               | 9         |

Table 3: The situation of the investigated objects.
required. In practical studies, a Cronach \( \alpha > 0.7 \) is generally required. In practical studies, a Cronach \( \alpha \) coefficient higher than 0.6 is also acceptable. When Cronach \( \alpha \leq 0.6 \), this indicates low reliability of the data scale. SPSS 20.0 was used to test the reliability of the subtables of the data scale in the three counties. The results showed that the overall Cronach \( \alpha \) coefficients of Neiqiu County, Shunping County, and Yi County were 0.836, 0.851, and 0.842, respectively, and the overall Cronach \( \alpha \) coefficient of the three counties were all higher than 0.8. This indicates that the questionnaire has good reliability and high data consistency. KMO test coefficient was between 0 and 1. In general, KMO > 0.7 indicates high correlation and partial correlation between variables, while a KMO below 0.5 indicates poor reliability of the questionnaire. When the significance probability of Bartlett sphericity test is \( P < 0.05 \), the correlation between variables is high. The results showed that the overall KMO value of Neiqiu County was 0.824, and the overall Bartlett test result was 0.000. The KMO value of Shunping County was 0.836, and the Bartlett test result was 0.000. The overall KMO value of Yi County survey was 0.804, and the overall Bartlett test result was 0.000, indicating that the questionnaire’s structural validity was good. According to the statistics of the questionnaire, Tables 4–6 are obtained.

### 5.2. Constructing Fuzzy Relation Matrix.

The fuzzy relation matrix \( H \) is given by:

\[
H = \begin{bmatrix}
0.0400 & 0.0000 & 0.1200 & 0.0267 & 0.0267 & 0.0267 & 0.0533 \\
0.1467 & 0.0400 & 0.2667 & 0.0667 & 0.1200 & 0.0933 & 0.2133 \\
0.2800 & 0.1333 & 0.3867 & 0.1867 & 0.1867 & 0.1333 & 0.2400 \\
0.3600 & 0.4400 & 0.1733 & 0.3600 & 0.4133 & 0.4400 & 0.4667 \\
0.1733 & 0.3867 & 0.0533 & 0.3467 & 0.2533 & 0.3067 & 0.0267 \\
0.0533 & 0.0400 & 0.0267 & 0.0267 & 0.0267 & 0.0133 & 0.0000 \\
0.0667 & 0.0933 & 0.2133 & 0.0533 & 0.0667 & 0.267 & 0.0267 \\
0.1467 & 0.4267 & 0.1733 & 0.1200 & 0.1333 & 0.3067 & 0.4533 \\
0.4533 & 0.3733 & 0.5067 & 0.3867 & 0.4400 & 0.4533 & 0.0000 \\
0.2800 & 0.0667 & 0.2400 & 0.4000 & 0.3867 & 0.2133 & 0.0000 \\
\end{bmatrix}
\]
In this article, Neiqu County is taken as an example to show the calculation process. According to Table 4, the set \( V = \{v_1, v_2, \ldots, v_4\} = \{\text{gestation stage}, \text{growth stage}, \text{maturity stage}, \text{recession stage}\} \) of the agricultural innovation ecosystem in county areas, the basic fuzzy relation matrix \( H = U \times V \) can be obtained.

To construct the final fuzzy relation, the index characteristics of the evaluation index of the evolution and development stage of the agricultural innovation ecosystem in county areas should be determined at different development stages. Based on the above theoretical research on the evolution characteristics of the agricultural innovation ecosystem in the county areas, and after many exchanges with mentors and experts, the evaluation index characteristics of the evolution and development stage of the agricultural innovation ecosystem at the county level were determined, as shown in Table 7.

On the basis of Table 4, we can obtain the language variable of the evaluation index of the evolution and development stage of the agricultural innovation ecosystem at the county level, \( V = \{v_1, v_2, \ldots, v_4\} = \{\text{gestation stage}, \text{growth stage}, \text{maturity stage}, \text{recession stage}\} \), and after many exchanges with mentors and experts, the evaluation index characteristics of the evolution and development stage of the agricultural innovation ecosystem at the county level were determined, as shown in Table 7.

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Table 6: Evaluation table of evolution stage of apple industrial innovation ecosystem in Yi County.

| Determining factors | Lowest | Lower | General | Higher | Highest |
|---------------------|--------|-------|---------|--------|---------|
| Subject aspects     |        |       |         |        |         |
| Intensity of government support | 2 | 16 | 36 | 18 | 3 |
| Concentration of production scale | 8 | 23 | 28 | 15 | 1 |
| Service level of industry association | 20 | 30 | 22 | 2 | 1 |
| Network aspects     |        |       |         |        |         |
| Intensity of industry-university-research cooperation | 12 | 26 | 23 | 11 | 3 |
| Degree of cooperation between farmers and parks/enterprises | 14 | 21 | 20 | 13 | 7 |
| Degree of tourism drive | 8 | 29 | 25 | 11 | 2 |
| Resource aspects    |        |       |         |        |         |
| Level of agricultural technology personnel allocation | 13 | 26 | 24 | 9 | 3 |
| Intensity of technical training input | 9 | 29 | 22 | 13 | 2 |
| Adequacy of investment funds | 9 | 33 | 22 | 10 | 1 |
| Environmental aspects |    |      |        |        |         |
| Degree of policy perfection | 5 | 22 | 29 | 17 | 2 |
| Extent of the market boom | 1 | 16 | 33 | 22 | 3 |
| Popularity of the Internet | 1 | 11 | 21 | 32 | 10 |
| Degree of unobstructed traffic | 1 | 3 | 26 | 34 | 11 |

Table 7: Index characteristics of agricultural in county areas’ innovation ecosystem evolution stage.

| Determining factors | Gestation stage | Growth stage | Maturity stage | Recession stage |
|---------------------|-----------------|--------------|----------------|----------------|
| Subject aspects     |                 |              |                |                |
| Intensity of government support | General | Higher | Highest | Lower |
| Concentration of production scale | General | Higher | Highest | Lower |
| Service level of industry association | Lowest | General | Highest | Higher |
| Network aspects     |                 |              |                |                |
| Intensity of industry-university-research cooperation | Lower | General | Highest | Higher |
| Degree of cooperation between farmers and parks/enterprises | Lowest | General | Highest | Lower |
| Degree of tourism drive | Lowest | General | Higher | General |
| Resource aspects    |                 |              |                |                |
| Level of agricultural technology personnel allocation | Lowest | General | Higher | Lower |
| Intensity of technical training input | Lowest | General | Higher | Higher |
| Adequacy of investment funds | Lower | General | Highest | Lower |
| Environmental aspects |     |      |        |        |         |
| Degree of policy perfection | Lowest | General | Highest | Highest |
| Extent of the market boom | General | Higher | Highest | Highest |
| Popularity of the Internet | General | Higher | Highest | Highest |
| Degree of unobstructed traffic | General | Higher | Highest | Highest |

In this article, Neiqu County is taken as an example to show the calculation process. According to Table 4, the set \( V = \{v_1, v_2, \ldots, v_4\} = \{\text{gestation stage}, \text{growth stage}, \text{maturity stage}, \text{recession stage}\} \) of the agricultural innovation ecosystem in county areas, the basic fuzzy relation matrix \( H = U \times V \) can be obtained.

To construct the final fuzzy relation, the index characteristics of the evaluation index of the evolution and development stage of the agricultural innovation ecosystem in county areas should be determined at different development stages. Based on the above theoretical research on the evolution characteristics of the agricultural innovation ecosystem in the county areas, and after many exchanges with mentors and experts, the evaluation index characteristics of the evolution and development stage of the agricultural innovation ecosystem at the county level were determined, as shown in Table 7.

On the basis of Table 4, we can obtain the language variable of the evaluation index of the evolution and development stage of the agricultural innovation ecosystem at the county level, \( V = \{v_1, v_2, \ldots, v_4\} = \{\text{gestation stage}, \text{growth stage}, \text{maturity stage}, \text{recession stage}\} \), and after many exchanges with mentors and experts, the evaluation index characteristics of the evolution and development stage of the agricultural innovation ecosystem at the county level were determined, as shown in Table 7.

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\[
R = \begin{bmatrix}
0.2800 & 0.1333 & 0.1200 & 0.0267 & 0.0267 & 0.2133 & 0.0533 & 0.0933 & 0.0267 & 0.1200 & 0.1333 & 0.3600 \\
0.3600 & 0.4400 & 0.3867 & 0.1867 & 0.1867 & 0.1333 & 0.2400 & 0.1467 & 0.4267 & 0.1733 & 0.3867 & 0.4400 & 0.4533 \\
0.1733 & 0.3867 & 0.0533 & 0.3467 & 0.2533 & 0.4400 & 0.4667 & 0.2800 & 0.3733 & 0.2400 & 0.4000 & 0.3867 & 0.2133 \\
0.1467 & 0.4400 & 0.1733 & 0.0667 & 0.1200 & 0.1333 & 0.2133 & 0.0667 & 0.0933 & 0.2400 & 0.0667 & 0.3867 & 0.2133
\end{bmatrix}
\] (16)
5.3. Fuzzy Judgment. A feature fuzzy subset $S_j$ ($j = 1, 2, 3, 4$) is introduced; according to this, the asymmetric closeness formula and the closeness matrix can be obtained:

$$Z = (Z_{ij})_{4 \times n} = (N(\bar{r}_i, \bar{S}_1), N(\bar{r}_i, \bar{S}_2), N(\bar{r}_i, \bar{S}_3), N(\bar{r}_i, \bar{S}_4))$$

(17)

Note that when calculating $N(r_i, S_j)$, the calculation method is different depending on the value of $i$. To standardize the $R$, first put $r_{ij}$, when $|j_1 - j| < |j_2 - j|$ and then put $r_{i,j}$ before $r_{i,j}$; when $|j_1 - j| = |j_2 - j|$, and $j_1 < j_2$, put $r_{ij}$ before $r_{ij}$, obtain standardized sequence: $r_{i,j_1, r_{j_1, j_2}, r_{j_2, j_2}, \ldots}$, and transform postscript for $r_{i,j_1, r_{j_1, j_2}, r_{j_2, j_2}, \ldots}$. This can be obtained through the following calculation:

$$N(r_1, S_1) = 1 - \frac{2}{4 \times 5} [(1 - 0.2800) + 0.3600 \times 2 + 0.1733 \times 3 + 0.1467 \times 4] = 0.7453,$$

$$N(r_1, S_2) = 1 - \frac{2}{4 \times 5} [(1 - 0.3600) + 0.2800 \times 2 + 0.1733 \times 3 + 0.1467 \times 4] = 0.7693,$$

$$N(r_1^{(3)}, S_1) = 1 - \frac{2}{4 \times 5} [(1 - 0.1733) + 0.3600 \times 2 + 0.1467 \times 3 + 0.2800 \times 4] = 0.6893,$$

$$N(r_1^{(4)}, S_1) = 1 - \frac{2}{4 \times 5} [(1 - 0.1467) + 0.1733 \times 2 + 0.3600 \times 3 + 0.2800 \times 4] = 0.6600.$$

(18)

Similarly, the proximity matrix $Z$ can be obtained:

$$H = \begin{bmatrix}
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1
\end{bmatrix}$$

(19)

According to the closeness matrix, the closeness vector of each evaluation stage can be obtained:

$$C_1 = (0.7453, 0.5333, 0.7494, 0.7346, 0.7413, 0.6907, 0.6480, 0.7653, 0.7653, 0.7000, 0.6880, 0.5546, 0.6907),$$

$$C_2 = (0.7693, 0.6253, 0.8294, 0.7826, 0.7893, 0.7227, 0.6560, 0.7933, 0.7747, 0.7440, 0.7680, 0.6467, 0.7347),$$

$$C_3 = (0.6893, 0.6654, 0.7280, 0.8666, 0.8413, 0.8667, 0.7494, 0.8573, 0.7867, 0.8067, 0.7947, 0.6813, 0.6440),$$

$$C_4 = (0.6600, 0.6813, 0.7427, 0.7706, 0.7947, 0.7747, 0.6707, 0.7853, 0.6693, 0.8133, 0.6627, 0.6760, 0.6200),$$

$$C^+ = (0.7693, 0.6813, 0.8294, 0.8666, 0.8413, 0.8667, 0.7494, 0.8573, 0.7867, 0.8133, 0.7947, 0.6813, 0.7347)$$

$$C^- = (0.6600, 0.5333, 0.7280, 0.7346, 0.7413, 0.6907, 0.6480, 0.7653, 0.6693, 0.7000, 0.6627, 0.5546, 0.6200).$$

(20)

On this basis, positive ideal points $C^+$ and negative ideal points $C^-$ can be obtained:

According to Types 10 and 11, it can be obtained:
The results of closeness between different stages and ideal stages in the three counties show Table 8. In Table 8, the closeness degree of Neiqiu County between the mature stage and the ideal stage is 1.1122, which is the largest. The closeness of the two adjacent stages to the ideal stage is 1.0374 and 0.9708, respectively. From the perspective of closeness, the mature stage is closer to the growth stage, indicating that the apple industry innovation ecosystem in Neiqiu County has been steadily transitioning from the growth stage to the mature stage, but the time needed to enter the mature stage is relatively short, and there is still a large space for innovation-driven development. The closeness degree between the growth stage and the ideal stage in Shunping County is 1.1452, which is the largest. The closeness between the two adjacent stages and the ideal stage are 0.9298 and 0.9559, respectively, indicating that the apple industry in Shunping County is getting increasing government support, the market is becoming increasingly perfect, and rapid growth is occurring through industry-university-research cooperation and innovation, constantly pushing this forward to the mature stage. The closeness degree between the growth stage and the ideal stage of Yi County is 1.1116, which is the largest. The closeness between the two adjacent stages and the ideal stage is 1.1025 and 0.8479, respectively. The closeness corresponding to the growth period is very close to the closeness corresponding to the incubation period, indicating that only a short time is needed for the apple industry in Yi County to transition from the incubation stage to the growth stage, and the operation of the innovation ecosystem has just stepped onto the right track. More policy support is needed from the government, and the initiative of agricultural enterprises, universities, and research institutions should be mobilized to promote the rapid growth of the system innovation ability. The overall evaluation results of the three counties basically accord with the actual situation of innovation-driven development of the apple industry in the three counties.

6. Results and Discussion

The results of closeness between different stages and ideal stages in the three counties show Table 8. In Table 8, the closeness degree of Neiqiu County between the mature stage and the ideal stage is 1.1122, which is the largest. The closeness of the two adjacent stages to the ideal stage is 1.0374 and 0.9708, respectively. From the perspective of closeness, the mature stage is closer to the growth stage, indicating that the apple industry innovation ecosystem in Neiqiu County has been steadily transitioning from the growth stage to the mature stage, but the time needed to enter the mature stage is relatively short, and there is still a large space for innovation-driven development. The closeness degree between the growth stage and the ideal stage in Shunping County is 1.1452, which is the largest. The closeness between the two adjacent stages and the ideal stage are 0.9298 and 0.9559, respectively, indicating that the apple industry in Shunping County is getting increasing government support, the market is becoming increasingly perfect, and rapid growth is occurring through industry-university-research cooperation and innovation, constantly pushing this forward to the mature stage. The closeness degree between the growth stage and the ideal stage of Yi County is 1.1116, which is the largest. The closeness between the two adjacent stages and the ideal stage is 1.1025 and 0.8479, respectively. The closeness corresponding to the growth period is very close to the closeness corresponding to the incubation period, indicating that only a short time is needed for the apple industry in Yi County to transition from the incubation stage to the growth stage, and the operation of the innovation ecosystem has just stepped onto the right track. More policy support is needed from the government, and the initiative of agricultural enterprises, universities, and research institutions should be mobilized to promote the rapid growth of the system innovation ability. The overall evaluation results of the three counties basically accord with the actual situation of innovation-driven development of the apple industry in the three counties.

(1) Neiqiu County: Relying on modern agricultural projects, Neiqiu County vigorously develops mountain fruit industry, especially under the drive of the “Fugang Apple” brand. It has formed an innovation-driven agricultural development model integrating apple planting, food deep processing, and tourism. In 1985, the leading enterprise Fugang company was established, and farmers contracted the company’s orchard for planting. The innovation ecosystem is running in the gestation period. During this period, the government played an active guiding role. The village government withdrew the management of the mountain farm and distributed free saplings to farmers for planting. Stimulate the enthusiasm of farmers and enterprises to plant apples, and actively establish contact with experts in Hebei Agricultural University. They jointly govern barren hills and carry out landscape ecological construction. In 1996, Professor Li Baoguo of Hebei Agricultural University led his research team to take root in the post. Opened the apple industry in Neiqiu County industry-university-research cooperation innovation road, the system is running in a period of rapid growth. In this period, the company achieved standardized production through unified management and established long-term and stable industry-university-research cooperation with Professor Li Baoguo’s team. Fugang Mountain Villa has become a project base and experimental base, realizing the combination of research and practice. Innovative varieties such as "gangbottom one, two and three" and high-stock-intensive planting, "128 processes," and other technologies continue to emerge. This launched the Fugang Apple brand. Market recognition and possession gradually increased, and the market mechanism played an important role. In addition, the government has played an important role in infrastructure construction, agricultural technology promotion, quality testing, geographical indication brand building, and other aspects. Together, they have driven the rapid growth of Neiqiu’s innovation ecosystem based on the apple industry. Since 2000, driven by the radiation of "Fugang apple," apple-planting area is of more than 100,000 mu. The establishment of apple modern agricultural park in Neiqiu County has given full
play to the role of the innovation platform. Each innovation subject is more closely linked together, resulting in rural e-commerce, home stay, resort, and other forms of supporting industries. With the participation of China Agricultural University, Hebei Academy of Agricultural Sciences and other universities, the establishment of “Taihang Mountain Apple Town,” the innovation network in the system is becoming more and more perfect, and the output of innovation results in the system is more abundant. The industrial chain continues to extend, and apple-intensive processing products continue to emerge. The all-season tour of “flower appreciation + picking” has attracted an endless stream of tourists, and rural e-commerce is booming. The system has gradually entered a mature stage, with deep integration of “tourism + agriculture” and “Internet + agriculture.” The innovation subjects of the system compete and cooperate with each other, coexist harmoniously, and create value together. It can be seen that the above judgment results are consistent with the actual development of apple industry in Neiqiu County.

(2) Shunping County: As early as 1983, the government of Shunping County established cooperation with Hebei Agricultural University to introduce red Fuji apple-planting technology. Experts and professors from Hebei Agricultural University continue to improve and optimize local varieties and cultivation techniques. The “three excellent” apple cultivation mode with low stock and dense planting was developed, which is suitable for spreading planting in plain and hilly areas of Hebei province. Under the strong guidance of the government, the selfless research and promotion of colleges and universities, and the joint efforts of the entrepreneurial spirit of innovation, Shunping County has established a good agricultural innovation ecosystem of industry-university-research collaborative innovation around the apple industry, and the system has entered the gestation period. In 2013, Shunan Lvsheng Agricultural Science and Technology Development Co., Ltd. was jointly funded by the government, enterprises, and schools. In 2017, it signed an agreement with Hebei Agricultural University and established “Taihang Mountain Agricultural Innovation Courier Station.” It has a strong platform and technology demonstration leading role, promoting the rapid growth of the innovation ecosystem. Under the guidance of strong system innovation ability, Shunping County has realized the transformation and upgrading of the apple industry. It has five functional areas: “Three excellent” cultivation system demonstration area, orchard planting management technology demonstration area, fruit product storage, cold chain transportation and processing R&D and experimental demonstration area, orchard information management technology R&D and experimental demonstration area, and orchard multi-function demonstration area. It has led the large-scale, informatization, and intelligent development of the apple industry in Shunping County, greatly accelerated the extension of the industrial chain, and provided a model for the high-quality agricultural development in Hebei province. It can be seen that the agricultural innovation ecosystem built around the apple industry in Shunping County has formed a stable innovation network. Policy environment is improving day by day, and market competitiveness is constantly strengthened and gradually plays a role together with the government. The industrial chain is gradually improved, which is consistent with the basic characteristics of the growth period of the agricultural innovation ecosystem. Therefore, the judgment result above accords with the actual development trend of the apple industry in Shunping County.

(3) Yi County: The industry-university-research cooperation of the apple industry in Yi County can be traced back to the 1980s and 1990s. In the early days, the government encouraged apple planting in suitable areas such as Nanjie by distributing free saplings, and hired experts and professors from Hebei Agricultural University for guidance. An innovation ecosystem has been initially established around the apple industry. However, due to the limited planting area, and the lack of professional and organizational management, the apple industry in Yi County develops slowly, making the system in the gestation period for a long time. With the increase of poverty alleviation efforts in recent years, the Government of Yi County takes this as an opportunity to vigorously develop apple industry poverty alleviation, driving the development of the apple industry in Niugang township in the deep mountainous areas of western China. Under the strong support and recommendation of the county government, niu Gang township government to listen to various opinions established the “three excellent” Fuji apple planting. Since 2014, Niugang township has increased industry-university-research cooperation and innovation, and hired experts and professors from Hebei Agricultural University for guidance. Centering on the idea of building modern agriculture, the cooperative production has promoted the development of large-scale planting, scientific management, and industrialized operation. Niugang township has been listed as “Hebei Agricultural University science and technology Industry demonstration park” and built a 50 mu apple quality technology demonstration park. At present, Niugang township is building a science and technology training center and a high-quality demonstration park. In addition, 3 forest fruit enterprises have been established, and 7 professional forest fruit cooperatives have been registered successively. Infrastructure supporting roads, pipelines,
and water reservoirs have been gradually established. It can be seen that the operation of the innovation ecosystem based on the apple industry in Yi County has just stepped into the right track, and the policy support is increasingly strengthened. Cooperation between enterprises, universities, and research institutes has achieved initial results, and the scale of the industry has increased rapidly. However, the extension of the industrial chain is not enough, and the integration of primary, secondary and tertiary industries needs to be improved. This is consistent with the basic characteristics of the agricultural science and technology innovation ecosystem at the initial stage of growth. Therefore, the actual situation is consistent with the judgment result.

Although the innovation ecosystem of the three counties is in different development stages, it is not difficult to find many common laws in the evolution process of the system through analysis. Firstly, the government plays a key guiding role in the early stage of system formation. Through the formulation of a series of policies and preferential safeguard measures, stimulate the production enthusiasm of farmers and enterprises and actively connect with universities and research institutions. The introduction of new varieties and technologies has laid a good foundation for further industry-university-research cooperation. Secondly, in the evolution of county agricultural innovation ecology, industry, education, and research play a key role. It can stimulate the innovation momentum of the system and enter the period of rapid growth. Individual farmers have differences in consciousness, knowledge absorption capacity, and capital, which cannot form stable industry-university-research cooperation. Enterprises or cooperatives can establish long-term and stable relations with the government, universities, and scientific research institutions, and have sufficient funds to engage in industry-university-research cooperation and innovation. The broad masses of farmers are driven by radiation through equity, trusteeship, employment, and other ways. Thirdly, with the long-term cooperation between enterprises or cooperatives and the government, universities, and scientific research institutions, a more large-scale, standardized, mechanized, and intelligent agricultural park and other innovative platform organizations will be gradually established. The role of the innovation comprehensive service platform will gather and integrate the innovation subjects to better adapt to the changes of the external environment. Finally, the county agricultural innovation ecosystem must evolve towards the integration of primary, secondary, and tertiary industries. Relying solely on the primary industry to produce low added value. Only by extending the industrial chain, vigorously developing agricultural product processing, tourism + agriculture, Internet + agriculture, and making the economic cake bigger can we make every participant in the system benefit. This will further promote the integration of industry and city, and truly achieve the great integration and development of innovation-driven county agriculture. Therefore, the case analysis further verifies the scientific nature of the construction of agricultural innovation ecosystem in this article.

7. Conclusions

Rural revitalization is a complex and systematic project related to building China into a modern socialist country in an all-round way. In implementing the rural vitalization strategy, high-quality agricultural development is the foundation, and innovation-driven development is the core driving force. Integration of urban and rural development at county level is an effective path. However, there are still some problems at present, such as low level of comprehensive development of agricultural science and technology, insufficient impetus of scientific and technological innovation, unreasonable allocation of resources, and slow improvement of agricultural innovation ability. Moreover, it is becoming more and more prominent and tends to be complex and dynamic, which delays the process of rural rejuvenation. Domestic and foreign practices have proved that agricultural innovation ecosystem can effectively overcome the low-end lock-in of agricultural science and technology innovation. We will improve the quality of agricultural development and promote rural revitalization. Therefore, to solve these dynamic, complex, and systematic problems, ecological theory, which has been widely used in the field of innovation management, needs to be introduced from the innovation paradigm. This helps promote ecological transitions in agricultural innovation systems. In this article, the connotation of county agricultural innovation ecosystem is put forward based on the objective reality of county agricultural innovation. Based on the county resource constraint and the theory of regional innovation system and ecology, a multidimensional county agricultural innovation ecosystem conceptual model was constructed from three levels of micro, medium, and macro, and its constituent elements and levels were deconstructed. Based on the life cycle theory, the life cycle of county agricultural innovation ecosystem was divided, and the periodic characteristics of system evolution were analyzed. On this basis, key identification indicators are selected, and the innovation ecosystem formed by the apple industry in Neiqiu, Shunping, and Yi counties of Hebei province is taken as a case, and the evolution stage of the system is measured by the fuzzy proximity degree method.
The conclusions of this study are as follows. First, the county agricultural innovation ecosystem is a multidimensional spatial model with multiple functions. The system includes microcosmic main ecological layer, meso-interface ecological layer, and macroscopic environmental ecological layer. The microcosmic main ecological layer includes science and technology research and development community, strategic demand community, and auxiliary service community. The R&D community composed of industry, university, and research institute plays a core role in the system. The ecological layer of meso-interface includes agricultural science and technology park, modern agricultural park, characteristic town, agricultural technology innovation alliance, and agricultural industrial technology research institute. The macroenvironment ecological layer includes policy environment, resource environment, market environment, technology environment, cultural environment, and infrastructure environment. Relying on the carrier function of meso-interface, the microsubject carries on the exchange of matter, energy, and information with the macroenvironment more effectively. Second, the main body, structure, scale, and state of county agricultural innovation ecosystem will change with the passage of time. Under the role of self-organization, the system constantly adjusts and revises to meet the new needs of innovation and development. The system is always in the process of evolution, which is a spiraling process from nothing to existence, from disorder to order, from low level to high level. In the process of spiraling evolution, the county agricultural innovation ecosystem will show periodic law. It has experienced gestation period, growth period, maturity period, and decline period. The system at different stages presents different characteristics. Thirdly, in order to verify the scientific nature of the theoretical model and the validity of the evolutionary evaluation index system, this article takes the apple industry in Neiqiu, Shunping, and Yi counties of Hebei province as the research object for empirical analysis. This article judged and identified that the innovation ecosystem formed around the apple industry in the three counties were in the mature stage, growth stage, and growth stage, respectively, and the evaluation results were consistent with the actual development of the three counties.

The contributions of this study are as follows. Firstly, it has made important theoretical contributions to the research of innovation ecosystem. At present, more and more research began to extend from the developed regional industry to the underdeveloped agricultural field. But at present, the research on agricultural innovation ecosystem is just emerging and lacks systematic theoretical research and empirical analysis. Based on the perspective of innovation ecosystem, this article locates agriculture as a weak industry and county as a basic administrative unit, and constructs a multidimensional structure model of county agricultural innovation ecosystem, a more ecological, organic way to solve the emerging complexity of county agricultural development. It breaks through the traditional agricultural innovation paradigm and enriches the agricultural innovation theory. It also expands the theoretical system of innovation ecosystem to some extent. Secondly, it provides a quantitative basis for subsequent research. Based on the existing research on evaluation of the evolution stage of regional innovation ecosystem, an evaluation index system suitable for county agricultural innovation development was constructed from a more microscopic perspective. It expands the existing theoretical evaluation dimension and more accurately grasps the dynamic evolution and development of county agricultural innovation ecosystem. It can provide quantitative basis with practical value for subsequent research. Thirdly, it reveals the general law of evolution of county agricultural innovation system. Based on the cases of Neiqiu, Shunping, and Yi counties in Hebei province, the fuzzy proximity method is used to identify the evolution stage of the system, and the evaluation results are compared with the actual situation. There are many common laws in the evolution process of county agricultural innovation ecosystem, which provides valuable experience and enlightenment for county agricultural innovation development.

The following suggestions are as follows: (1) promote diversified industry-university-research cooperation by encouraging the co-undertaking of projects, cobuilding of institutions, and cobuilding of entities and establishment of alliances, so that universities and research institutions can participate in agricultural innovation at the county level in more diversified forms. Innovation subjects should be actively guided to participate in industry-university-research cooperation and innovation, establish a reasonable mechanism for the distribution of benefits, advocate the concepts of sharing resources, fruits, risks, and values, and stimulate the momentum of industry-university-research cooperation and innovation. (2) Build platforms and organizations such as parks at or above the provincial level around county agricultural characteristic industries to promote the aggregation of leading industries, transformation of scientific and technological achievements, and innovation of systems and mechanisms. Vigorously deepen supply-side institutional reform in agriculture, optimize industrial structure, extend industrial chains, and develop the primary and intensive processing of producing areas for leading products. Integrate agricultural production and processing with sightseeing, tourism, and leisure, improve supporting industries such as sales and distribution, and promote the extension of leading industries to prenatal and postnatal areas. (3) Encourage and guide the construction of agricultural innovation comprehensive service management platform at the county level, establish a large supporting data research center, and use “Internet +” technology to attract funds, talents, information, technology, and other funds needed for agricultural innovation and development at the county level to gather on the platform. Throughout the process of tracking and supervision, ensure the safety and traceability of every agricultural product, with the support of blockchain technology, to ensure the safety and high quality of agricultural products in the county.

This article explores and extends the theory and basic research of county agricultural innovation ecosystem, and provides reference for better exploration of county agricultural innovation-driven development. In the construction of agricultural innovation ecosystem at county level in Hebei
province, the Internet is regarded as an important virtual platform connecting the microsubject layer and the macroenvironment layer. At present, big data, Internet of things, cloud computing, and artificial intelligence are gradually applied to county agriculture. Therefore, when designing evaluation indexes for the evolution and development stage of county agricultural innovation ecosystem in the future, the indexes related to digital technology should be fully considered. In addition, the county agricultural innovation ecosystem is a long-term, continuous evolution process. Future research needs to collect more typical cases and models to provide more experience and reference for the optimization of agricultural innovation ecosystem at county level.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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