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Research Article

Sustainable Development of the Innovation Ecosystem from the Perspective of T-O-V

Ruixue Yan,[1] Jianlin Lv,[2] and Qingshi Meng[2,3]

[1]*Institute of Economics, Chinese Academy of Social Sciences, Beijing 100836, China*
[2]*School of Management, Shanghai University, Shanghai 200444, China*
[3]*Department of Library, Information and Archives, Shanghai University, Shanghai 200444, China*

Correspondence should be addressed to Jianlin Lv; lvjianlin@shu.edu.cn and Qingshi Meng; mengqingshi@shu.edu.cn

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The innovation ecosystem is a dynamic network system of competition and cooperation between entities and enterprises as the core in order to achieve value cocreation. Technology provides growth power for the innovation ecosystem, organization provides management support for the innovation ecosystem, and value has a guiding effect on the innovation ecosystem. From the perspective of technology-organization-value to study the sustainable development of the innovation ecosystem, build a system dynamics model, take the automotive industry innovation ecosystem as a research case, and find that technological elements have the most significant role in promoting innovation performance and organizational elements have a role in promoting economic benefits. Most notably, the coordinated adjustment of technological elements, organizational elements, and value elements is conducive to improving the innovation performance and economic benefits of the innovation ecosystem, and corresponding management measures are proposed from the dimensions of technology, organization, and value, which further promotes the sustainable development of the innovation ecosystem.

1. Introduction

The technological upgrading and market environment update brought about by industrial reforms have put forward higher requirements for the development of enterprises in the new era. The realization of high-quality development of enterprises can not only rely on the advantages of resources and capabilities but also change the innovation model and gradually change from being single-closed towards sharing and openness [1]. The innovation ecosystem formed with the enterprise as the core provides a new perspective for solving the problem of high-quality development of enterprises. The innovation ecosystem is different from the previous linear paradigm innovation and systematic paradigm innovation. The innovation ecosystem aggregates diversified participants, recombines the heterogeneous innovation resources in the innovation ecosystem, and transforms individual innovation into cooperative innovation. The innovation entities in the system rely on the synergy of innovation to achieve the goal of cocreating value beyond individual accumulation in a common innovation environment [2, 3]. Adner explicitly defines innovation ecosystem as a complementary network of core enterprises, upstream suppliers, users, and downstream suppliers [4]. Innovation ecosystem strategy is a process in which an enterprise can achieve value cocreation and value optimization by establishing a mutual dependence relationship with other enterprises [5].

Under the background of knowledge economy, innovation has become the first driving force of development, and sustainable innovation is the key point of sustainable development of innovation ecosystem [6]. The diversity of innovation subjects has accumulated strong innovation power for the sustainable development of innovation ecosystem. The heterogeneity among innovation subjects enhances the relevance of innovation individuals, improves the cohesion and density of innovation ecosystem, and promotes the more stable and sustainable development of innovation ecosystem [7, 8]. In the innovation ecosystem, the

open cooperation between innovation subjects can create continuous innovation opportunities and value for each participating enterprise, help enterprises overcome the disadvantage of resource shortage, and help enterprises to innovate and develop [9]. The main bodies in the innovation ecosystem gather together because of the common goal. By integrating the innovation resources and innovation ability owned by each innovation body, it affects the absorption, transformation, and flow of knowledge and resources in the innovation ecosystem and then affects the balance and sustainable development of the innovation ecosystem [10, 11]. Innovation ecosystem has changed the relationship between enterprises. There is a complex and dynamic competition and cooperation relationship between innovation subjects [12, 13]. The whole system has the ability of independent iteration and balanced evolution [14].

Scholars have analyzed innovation ecosystem from different disciplines and perspectives. Tamayo-Orbegozo et al. developed a transferable and sustainable innovation solution model for regional innovation ecosystem [15]. Burmaoglu and Saritas analyzed the paradigm transformation of innovation ecosystem from the perspective of innovation policy [16]. Yin et al. analyzed the innovation performance and sustainability of innovation ecosystem with the help of sustainable intelligent products [17]. Bandera and Thomas discussed the policy suggestions of using innovation ecosystem to improve enterprise performance and achieve regional economic development goals [18]. Only few scholars study the sustainable development of innovation ecosystem from the micro level. This paper will discuss how to achieve the sustainable development of innovation ecosystem from the perspective of technology, organization, and value by using the system dynamics analysis method. This paper uses system dynamics to analyze the sustainable development process of the innovation ecosystem and uses the case data of the automotive industry innovation ecosystem to clarify the kinetic energy effect of technical factors, the supporting role of organizational factors, and the guiding effect of value factors. From the perspective of T-O-V coordinated adjustment, we propose building a technological innovation system, strengthening organizational cooperation, and playing a value guiding role to promote the sustainable development of the innovation ecosystem.

2. Literature Review

2.1. Technical Dimension Analysis. In order to achieve a specific goal, innovation ecosystem needs to carry out continuous technological innovation, which requires each innovation subject to establish a technical connection in order to form a specific technological innovation ecosystem [19]. Technological innovation and upgrading is a highly complex, dynamic, nonlinear development process, and a variety of factors interact with each other [20]. Technology development, technical rules, and market demands all play an important role [21, 22] in this process. The technological innovation power of a single subject is limited. To realize the commercial value of innovative technologies and increase the commercialization rate of innovative technologies, it is necessary to build a technological innovation system of the innovation ecosystem. Multiple innovation entities collaborate around technology research and development and technology applications, integrate the resources of the innovation ecosystem, and form a technical support structure that is compatible with technology innovation research and development [23].

Technological innovation is the driving power for the sustainable development of innovation ecosystem [24], and data sharing is the basis for the construction of technological innovation system of innovation ecosystem. These two factors require the efficient circulation of technological knowledge, data resources, and other elements among various innovation subjects [25]. The improvement of technological innovation ability also needs the protection of intellectual property rights, and each innovation subject carries out collaborative innovation with different advantages. In the whole system, roles of the supplier and the demander are integrated to jointly improve the level of innovation performance [26].

2.2. Organizational Dimension Analysis. The premise of sustainable development of innovation ecosystem is to have a healthy and stable organization system. The stability of interaction and cooperation of innovation subjects directly affects the direction and efficiency of innovation ecosystem evolution [27]. In order to achieve a specific goal, the main subjects in the innovation ecosystem are demand-oriented and establish a common vision and clear goals for strategic collaboration [28]. Multilateral community is a unique organization formed in the evolution process of innovation ecosystem, which is conducive to stabilizing the network relationship of innovation ecosystem, opening the boundaries between subjects and communities, and promoting the breakthrough of innovation ecosystem level by cross-border integration [29].

In order to expand new markets or develop new businesses, the innovation ecosystem will take the initiative to build a management model serving new markets or new businesses and create an appropriate platform system to complete resource integration and partner incentive [30]. The sustainable development of innovation ecosystem needs to integrate resources from the whole industrial chain, which not only involves the upstream and downstream enterprises of the industrial chain but also includes the service institutions around the industrial chain, such as technical service institutions (scientific research institutes, universities, etc.), financial support institutions (banks, insurance companies, etc.), and third-party service institutions (data processing companies, management consulting companies, etc.), to form an innovation ecosystem with deeply embedded industrial chain, close connection between scientific research and production, strong innovation atmosphere, and industry university research cooperation [31], supplemented by coordination mechanism to promote the stable growth of innovation ecosystem.

2.3. Value Dimension Analysis. Value cocreation is the goal of sustainable development of the innovation ecosystem. Each innovation subject in the innovation ecosystem first

conducts value positioning to form the cognition of the innovation subject and the identification of innovation advantages [32]. Secondly, innovation entities conduct resource and information exchange activities by perceiving innovation partners, investing capital, joint research, and development, and forming innovation alliances, forming a value logic of complementary advantages and creating value that a single entity cannot create [33]. Finally, the value created is distributed among the various innovation subjects of the innovation ecosystem to maximize economic benefits and feedback the innovation ecosystem [34]. In the process of value creation, the internal entities of the innovation ecosystem need to open the boundaries of the entities and share resources with other entities to achieve the purpose of value cocreation.

The value realization method of the innovation ecosystem has undergone major changes based on technological innovation and upgrading, and the organization is becoming more and more perfect. Value realization presents the characteristics of individualization, intelligence, and integration [35]. The innovation ecosystem brings together the value advantages of various innovation entities and broadens the channels for value realization. The increase in value gains, in turn, provides a driving force for technological innovation and organizational improvement and promotes the sustainable development of the innovation ecosystem. We have sorted out the main research foundations of the three dimensions, as shown in Table 1.

In order to show the research context of this article more clearly, the research framework we sorted out is shown in Figure 1. This article reviews the research foundation of the innovation ecosystem in the dimensions of technology, organization, and value and proposes that technological upgrading, organizational strengthening, and value guidance are the key points for building sustainable innovation. This research uses system dynamics to analyze the sustainable development of the innovation ecosystem. On the one hand, the system causal cycle diagram shows the interaction among technical factors, organizational factors, and value factors; on the other hand, the system flow diagram depicts the sustainable development trend of the innovation ecosystem. Finally, we simulated and analyzed the model and carried out basic simulation result analysis, trend simulation under key factor adjustment, and T-O-V coordinated adjustment effect test.

3. Construction of the Sustainable Development Model of the Innovation Ecosystem

The innovation ecosystem is a collection of capital, knowledge, technology, labor, and other factors. As a production system and service system, it also has complicated production process and a multivariable and complex structure. There are many subjects in the innovation ecosystem [36]. To reveal the operation mechanism and evolution mechanism behind the sustainable development of innovation ecosystem, an effective and targeted system analysis method is very important. As an analysis method of structure-function targeted simulation, system dynamics systematically analyze the dynamic evolution mechanism of sustainable development of innovation ecosystem by using computer simulation from the perspective of microstructure and growth operation mechanism [37], so as to seek a better implementation scheme for promoting the stable growth of innovation ecosystem.

While using system dynamics to simulate, the model also takes into account three basic objectives: (1) It can not only trace the past development experience of innovation ecosystem but also predict the future dynamic development trend of innovation ecosystem [38]. (2) While making qualitative analysis on the dynamic evolution law of sustainable development of innovation ecosystem, we can also use quantitative empirical analysis to predict the trend of sustainable development of innovation ecosystem [39]. (3) It can not only analyze the feedback relationship between various influencing factors of innovation ecosystem sustainable development from the micro perspective but also evaluate the effect of innovation ecosystem sustainable development from the overall perspective of the system [40]. Therefore, based on the basic characteristics of innovation ecosystem, this paper uses system dynamics to analyze the dynamic feedback and causal relationship between the key elements of sustainable development of innovation ecosystem, deeply studies the essence of the interaction of various factors of innovation ecosystem, and establishes a complete mechanism diagram of sustainable development of innovation ecosystem, so that its growth law can be clearly presented.

3.1. System Causality Cycle Diagram Construction. The sustainable development system dynamics model of innovation ecosystem is analyzed according to the growth mechanism of innovation ecosystem and the guiding effect of technological innovation on innovation ecosystem. The system causality cycle diagram conceives the sustainable development of innovation ecosystem from the three dimensions of technology organization value and follows the two principles of conforming to reality and simplification and abstraction. It assumes the following: (1) During the model observation period, the sustainable development of innovation ecosystem is a systematic, continuous, and holistic process [41]. (2) The impact of natural disasters, nonhuman factors, force majeure, and other accidental events on the sustainable development of innovation ecosystem [42] are not regarded. (3) The main variables of technology dimension, organization dimension and value dimension are shown in Table 2. This paper systematically analyzes the dynamic feedback relationship between each key factor and node of innovation ecosystem sustainable development and finally establishes the causality cycle diagram of innovation ecosystem sustainable development system, as shown in Figure 2.

The system causality cycle diagram vividly shows that the sustainable development of innovation ecosystem is a complete system. Technological elements, organizational elements, and value elements interact to jointly promote the healthy growth of innovation ecosystem. In the process of

Table 1: Research basis from different perspectives.

Perspective	Main research basis
Technology	Technological innovation is the source of power for the sustainable development of the innovation ecosystem Technological innovation and upgrading is a highly complex process, and technological research and development, technological rules, and market demand all play an important role Multiple innovation entities integrate innovation resources around technology research and development to form a technical support structure
Organization	The organization system provides management support for the sustainable development of the innovation ecosystem The stability of cooperation between innovation entities affects the direction and efficiency of the evolution of the innovation ecosystem Integrating resources from the industrial chain and promoting the stable growth of the innovation ecosystem with a coordination mechanism
Value	Value cocreation is the goal of sustainable development of the innovation ecosystem Innovative entities complement each other's advantages, open the boundaries of entities, and achieve value cocreation through resource sharing The value realization channels are broadened, and the value gains are enhanced to provide the impetus for technological innovation and organizational improvement

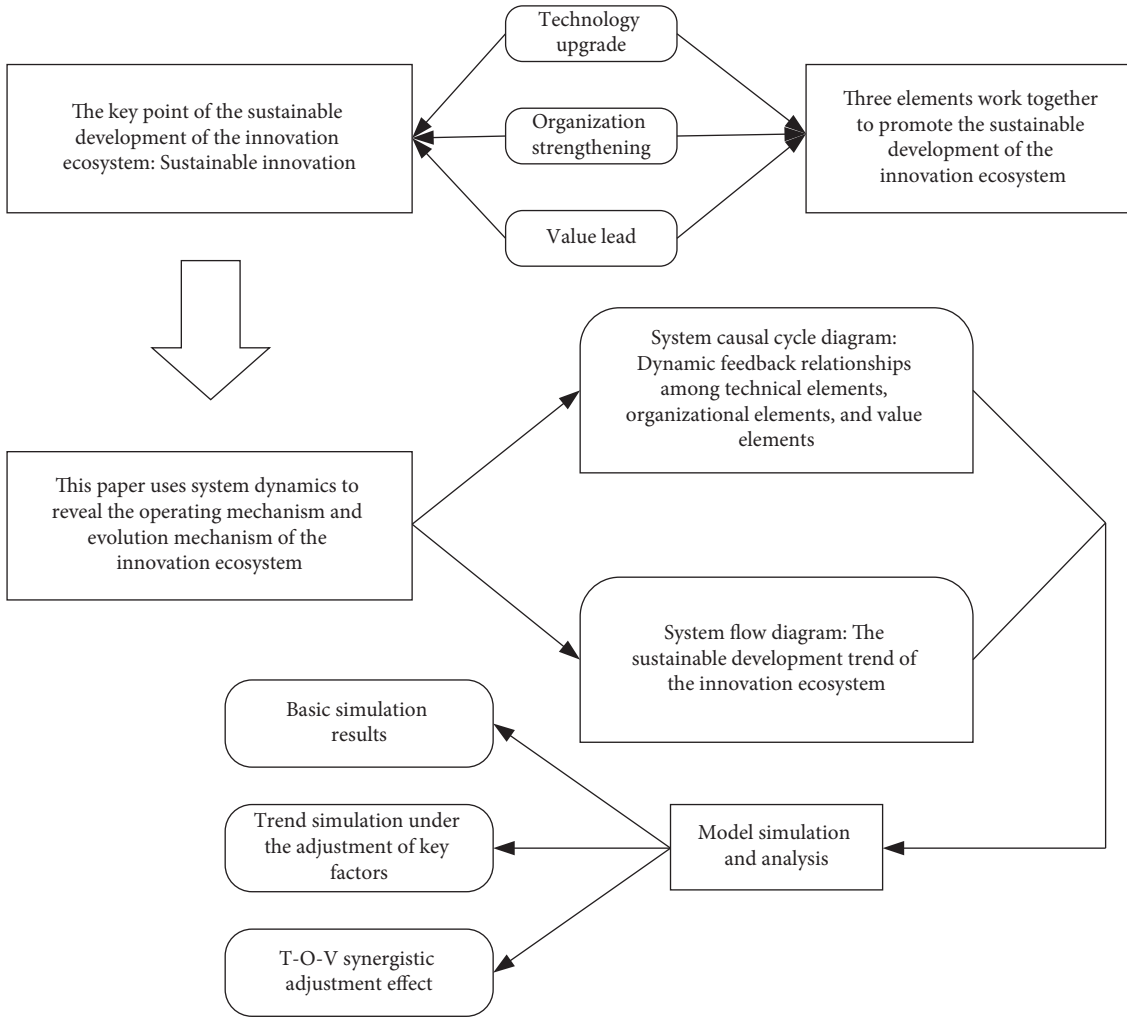

Figure 1: Research framework.

innovation ecosystem development, there will be corresponding output. Economic benefit reflects the economic output of innovation ecosystem, and innovation performance reflects the innovation output of innovation ecosystem. The improvement of economic benefit and innovation performance will in turn promote the sustainable

Table 2: Main system variables.

Technical dimension	Organizational dimension	Value dimension
Data Sharing	Demand-oriented	Value Proposition
Knowledge Transfer	Strategic Synergy	Cognition of Innovation
Intellectual Property Protection	Management Mode	Innovation Advantage Identification
Complementary Advantages	Open Borders	Innovation Partner Perception
Technological Innovation System	Industry-University-Research Collaboration	Value Logic
Collaborative Innovation	Platform System	Profit Distribution
Convergence of Supply and Demand Roles	Resource Integration	Value Cocreation
Innovation Performance	Coordination Mechanism Stabilize Network Relationships Multilateral Community	Economic Benefit

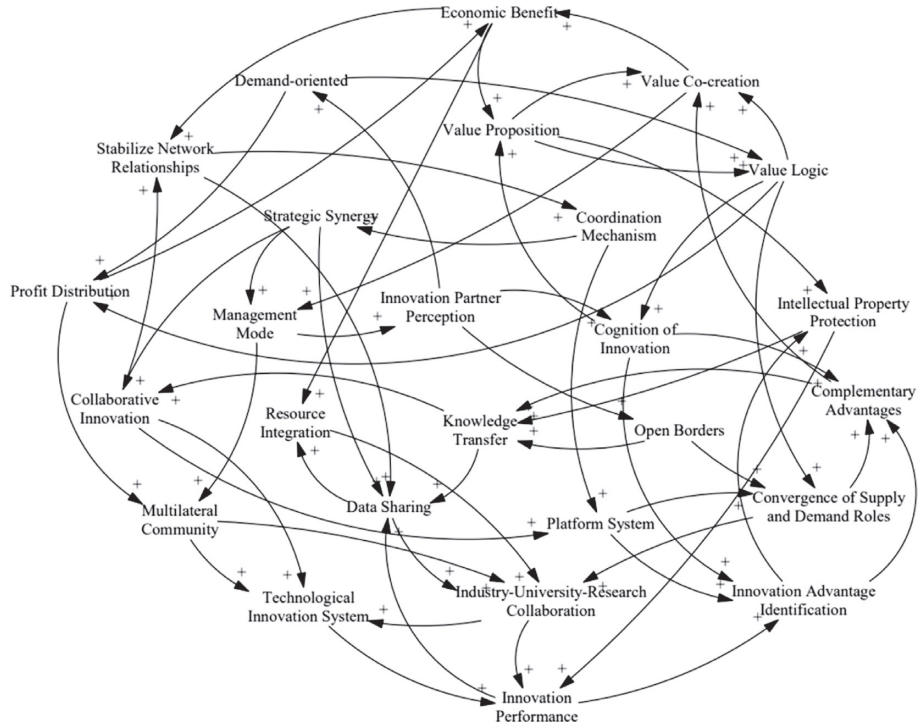

Figure 2: System causal cycle diagram.

development of innovation ecosystem. Therefore, taking the economic benefits and innovation performance of the innovation ecosystem as the system objectives, we can get two main loops of the causality cycle diagram:

Economic Benefit ⟶ Stabilize Network Relationships ⟶ Coordination Mechanism ⟶ Strategic Synergy ⟶ Data Sharing ⟶ Resource Integration ⟶ Industry-University-Research Collaboration ⟶ Technological Innovation System ⟶ Innovation Performance ⟶ Innovation Advantage Identification ⟶ Intellectual Property Protection ⟶ Knowledge Transfer ⟶ Collaborative Innovation ⟶ Platform System ⟶ Convergence of Supply and Demand Roles ⟶ Complementary Advantages ⟶ Value Cocreation ⟶ Management Mode ⟶ Innovation Partner Perception ⟶ Cognition of Innovation ⟶ Value Proposition ⟶ Value Logic ⟶ Profit Distribution-⟶ Economic Benefit.

Innovation Performance ⟶ Innovation Advantage Identification ⟶ Intellectual Property Protection ⟶ Knowledge Transfer ⟶ Collaborative Innovation ⟶ Platform System ⟶ Convergence of Supply and Demand Roles ⟶ Complementary Advantages ⟶ Value Cocreation ⟶ Management Mode ⟶ Innovation Partner Perception ⟶ Cognition of Innovation ⟶ Value Proposition ⟶ Value Logic ⟶ Profit Distribution-⟶ Economic Benefit ⟶ Stabilize Network Relationships ⟶ Coordination Mechanism ⟶ Strategic Synergy ⟶ Data Sharing ⟶ Resource Integration ⟶ Industry-University-Research Collaboration ⟶ Technological Innovation System ⟶ Innovation Performance.

The dynamic feedback loop of causal relationship describes the relationship among the key factors in the process of sustainable development of innovation ecosystem. It presents the dynamic evolution process of sustainable

development of innovation ecosystem and shows the specific path to achieve economic benefits and innovation performance improvement of innovation ecosystem.

3.2. System Flow Diagram Construction. The system causality cycle diagram constructs a qualitative structural description for the sustainable development of innovation ecosystem. In order to deeply analyze the kinetic energy effect of high-quality development of innovation ecosystem, we must continue to study the characteristics of each influencing variable. The interactive relationship between the growth mechanism and variables of innovation ecosystem sustainable development is expressed with convincing mathematical function expression and intuitive symbol [43]. In order to ensure the credibility of the system dynamics model, we need to use authoritative and reliable data to test the model, which needs to select the appropriate case. The research object is the innovation ecosystem of automobile industry, which is a typical industry of innovation development. As an industry with abundant labor resources, high level of knowledge accumulation, and significant investment effect, the automobile industry has a complex manufacturing system with strong nonlinearity, complicated process, high order, and multiple variables, which is of referential significance for revealing the growth mechanism behind the sustainable development of innovation ecosystem [44, 45]. In order to use real and credible data to replace the system dynamics model for analysis, the data collection of this study covers the network information, media reports, literature, and periodicals about the automobile industry innovation ecosystem, as well as the annual reports of the core enterprises in the innovation ecosystem. According to the logical relationship between the variables of innovation ecosystem sustainable development, the estimation of system dynamics model parameters and the expression of operational equations are completed, and the system flow diagram is constructed, as shown in Figure 3.

3.2.1. Model Description. Following the principle of operability, based on the consideration of not affecting the correlation between the change trend and the main nodes, the innovation ecosystem sustainable development system flow diagram refines the variables in the system causal cycle diagram. From Figure 3, it can be seen that the process of the sustainable development of innovation ecosystem to achieve the double improvement of economic benefits and innovation performance is a system, and the process of the sustainable development of innovation ecosystem should be studied systematically.

The system flow diagram of sustainable development of innovation ecosystem shows the mechanism of correlation and interaction among various influencing variables, which shows that the sustainable development of innovation ecosystem is a dynamic evolution process. The feedback path in the system flow diagram describes the whole picture of the sustainable development of innovation ecosystem, presents the coordinated role of technology, organization, and value in promoting the sustainable development of innovation ecosystem, and directly reflects the path of sustainable development.

3.2.2. Variable Content and Attributes. The quantitative data in the system dynamics model of the sustainable development of the innovation ecosystem uses the queried data of the innovation ecosystem of the automobile industry to design variables, and the improvement of economic benefits uses the indicator "total assets" that can explain the operating status of the innovation ecosystem. It is said that the improvement of innovation performance is represented by the "number of patents" with the attributes of innovation achievements. Consider the sustainable development path of the innovation ecosystem from the three dimensions of technology-organization-value. The technological dimension constant includes technical personnel and technology R&D investment, the organizational dimension constant includes management expenditure and management scale, and the value dimension constant includes government subsidies and talent structure. The variables involved in the system dynamics model are shown in Table 3.

3.2.3. Variable Relationship and Parameter Determination. After distinguishing the nature of the variables in the sustainable development system dynamics model of the innovation ecosystem, the relationship between the variables is expressed by mathematical equations, and simulation is carried out with Vensim software, so as to find that the sustainable development system dynamics model of the innovation ecosystem existing changing trends and dynamic characteristics. On the basis of theoretical analysis and comprehensive and multilevel comprehensive application of different methods for logical conception and judgment, the established innovation ecosystem sustainable development system dynamics equation is as follows:

(1) Economic Benefit = INTEG (Increase in Economic Benefit, 4149); the initial value is 4149

(2) Innovation Performance = INTEG (Increase in Innovation Performance, 1961); the initial value is 1961

(3) Increase in Economic Benefit = Economic Benefit ∗ Economic Benefit Growth Rate

(4) Increase in Innovation Performance = Innovation Performance ∗ Innovation Performance Growth Rate

(5) Innovation Performance Growth Rate = Industry-University-Research Collaboration ∗ 4% + Technological Innovation System ∗ 3%

(6) Economic Benefit Growth Rate = Value Cocreation ∗ 2% + Profit Distribution ∗ 2%

(7) Technological Innovation System = Convergence of Supply and Demand Roles ∗ 0.6 + Collaborative Innovation ∗ 0.4

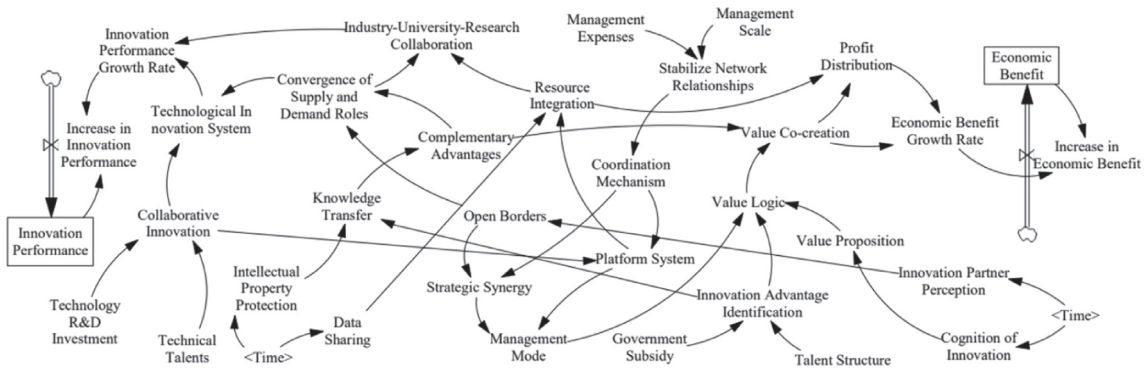

Figure 3: System flow diagram.

Table 3: List of model variables.

Serial number	Variable name	Variable type	Serial number	Variable name	Variable type
1	Economic Benefit	Level	18	Management Mode	Auxiliary
2	Innovation Performance	Level	19	Stabilize Network Relationships	Auxiliary
3	Increase in Economic Benefit	Rate	20	Coordination Mechanism	Auxiliary
4	Increase in Innovation Performance	Rate	21	Platform System	Auxiliary
5	Innovation Performance Growth Rate	Auxiliary	22	Innovation Advantage Identification	Auxiliary
6	Economic Benefit Growth Rate	Auxiliary	23	Value Logic	Auxiliary
7	Collaborative Innovation	Auxiliary	24	Value Cocreation	Auxiliary
8	Intellectual Property Protection	Auxiliary	25	Profit Distribution	Auxiliary
9	Technological Innovation System	Auxiliary	26	Value Proposition	Auxiliary
10	Data Sharing	Auxiliary	27	Innovation Partner Perception	Auxiliary
11	Knowledge Transfer	Auxiliary	28	Cognition of Innovation	Auxiliary
12	Convergence of Supply and Demand Roles	Auxiliary	29	Technology R&D Investment	Constant
13	Industry-University-Research Collaboration	Auxiliary	30	Technical Talents	Constant
14	Complementary Advantages	Auxiliary	31	Management Expenses	Constant
15	Resource Integration	Auxiliary	32	Management Scale	Constant
16	Open Borders	Auxiliary	33	Talent Structure	Constant
17	Strategic Synergy	Auxiliary	34	Government Subsidy	Constant

(8) Collaborative Innovation = Technical Talents^0.5 + Technology R&D Investment^0.5

(9) Intellectual Property Protection = With Lookup (Time, Lookup)

(10) Data Sharing = With Lookup (Time, Lookup)

(11) Industry-University-Research Collaboration = Convergence of Supply and Demand Roles ∗ 0.7 + Resource Integration ∗ 0.3

(12) Convergence of Supply and Demand Roles = Complementary Advantages ∗ 0.4 + Open Borders ∗ 0.6

(13) Complementary Advantages = Knowledge Transfer ∗ 0.7

(14) Knowledge Transfer = Innovation Advantage Identification^0.5 + Intellectual Property Protection^0.5

(15) Resource Integration = Platform System ∗ 0.4 + Data Sharing ∗ 0.6

(16) Open Borders = Innovation Partner Perception ∗ 0.6

(17) Strategic Synergy = Coordination Mechanism ∗ 0.5 + Open Borders ∗ 0.5

(18) Management Mode = Platform System ∗ 0.5 + Strategic Synergy ∗ 0.5

(19) Coordination Mechanism = Stabilize Network Relationships ∗ 0.3

(20) Stabilize Network Relationships = Management Expenses^0.5 + Management Scale^0.5

(21) Platform System = Coordination Mechanism ∗ 0.7 + Collaborative Innovation ∗ 0.3

(22) Innovation Advantage Identification = Talent Structure^0.5 + Government Subsidy^0.5

(23) Value Logic = Value Proposition ∗ 0.4 + Innovation Advantage Identification ∗ 0.3 + Management Mode ∗ 0.3

(24) Value Cocreation = Value Logicˆ0.3 + Complementary Advantagesˆ0.7

(25) Profit Distribution = Value Cocreation ∗ 0.3 + Resource Integration ∗ 0.7

(26) Innovation Partner Perception = With Lookup (Time, Lookup)

(27) Value Proposition = Cognition of Innovation ∗ 0.7

(28) Cognition of Innovation = With Lookup (Time, Lookup)

The system dynamics model of the sustainable development of the innovation ecosystem is not very sensitive to the changes of the involved parameters. Some variables cannot be accurately measured. As long as the trend is correct, the model can be reasonably estimated. The system dynamics model involves parameters such as constant values, weight parameters, and initial values. Because the model involves many interrelated and interacting variables, it is often impossible to accurately calculate the optimal value interval of each parameter. Therefore, in order to obtain reasonable parameter estimates, the system dynamics model must be repeatedly debugged and calculated, and the calculation results of the simulation do not depend on the specific parameter values but the behavior mode of the system dynamics model. The model uses 2014 as the starting year and 2030 as the target year and continuously debugs to find the optimal value interval based on the actual operation of the system dynamics model.

3.2.4. Model Validity Check. The validity and credibility of the model need to be tested before the simulation experiment, and historical data can be used for fitting verification. Substituting the data from 2014 to 2020 into the model and analyzing the fit of the system dynamics model from 2014 to 2020, the fit effects of innovation performance and economic benefits can be obtained, as shown in Tables 4 and 5. It can be seen from the fitting effect of innovation performance and economic benefit that the error rate between the simulated value and the real value is below 7%, the error is generally acceptable, and the system dynamics model has a better fitting effect. Therefore, this model is effective and reliable.

4. Model Simulation and Analysis

An effective and reliable system dynamics model that has been tested by history matching can predict the sustainable development trend of the innovation ecosystem. By debugging the relevant basic data and hypothetical environment, we can observe the impact of key variables on the changing trend of the system and the behavior pattern of the system in different environments. By simulating the different situations that the system may encounter in the future development process, it can provide a basis for decision-making for the sustainable development of the innovation ecosystem.

Table 4: Innovation performance fitting effect.

Years	Analog data	Real data	Error rate (%)
2014	1961	1961	—
2015	2398	2444	1.9
2016	2933	2973	1.3
2017	3478	3730	6.8
2018	4124	4281	3.7
2019	4889	4845	0.9
2020	5796	5448	6.4

Table 5: Economic benefit fitting effect.

Years	Analog data	Real data	Error rate (%)
2014	4149	4149	—
2015	4854	5116	5.1
2016	5680	5906	3.8
2017	6526	6865	4.9
2018	7498	7828	4.2
2019	8614	8493	1.4
2020	9898	9294	6.5

4.1. Basic Simulation Results. Apply system dynamics model to predict the sustainable development of innovation ecosystem. To improve accuracy and representativeness, it is necessary to reasonably determine the time domain of the model. Therefore, the simulation time domain of this model is set to [2014, 2030]. Figures 4 and 5 show the development trend of innovation performance and economic benefits. Under the support policy of innovation-driven development, the quality of innovation ecosystem development has been improved. At the same time, technological progress made in R&D innovation will make innovation performance steadily improved, and the technological strength of the innovation ecosystem will gradually accumulate. Under the combined effect of technology, organization, and value, the economic benefits brought by the high-quality development of the innovation ecosystem will also continue to increase.

4.2. Trend Simulation under the Adjustment of Key Factors. The sustainable development of the innovation ecosystem is a complex and comprehensive dynamic feedback system. The adjustment of certain key factors may have a lasting and effective impact on the system. To clearly judge the impact of certain key factors on the overall system, keep other parameters unchanged, debug key factors separately, and use exclusive analysis methods to determine important controllable factors [46].

4.2.1. Influence of Technological Elements on the Sustainable Development of the Innovation Ecosystem. Technological R&D investment is the basis for technological upgrading. Technological innovation requires the reasonable investment of R&D funds in the innovation ecosystem. Technical talents are the source of technological innovation, and technological progress is inseparable from the continuous scientific research of technical talents. Technology R&D investment and technical talents jointly promote the

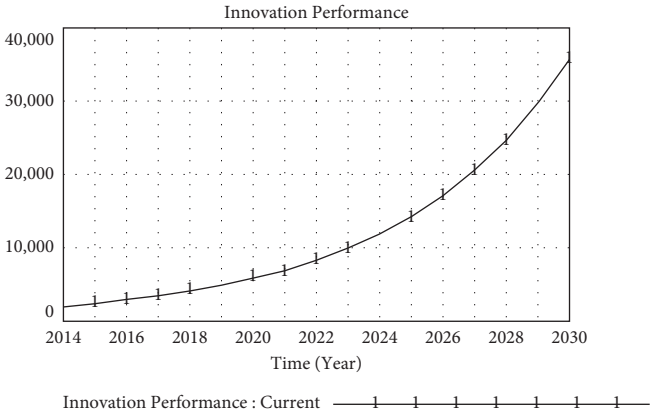

Figure 4: Trends in innovation performance.

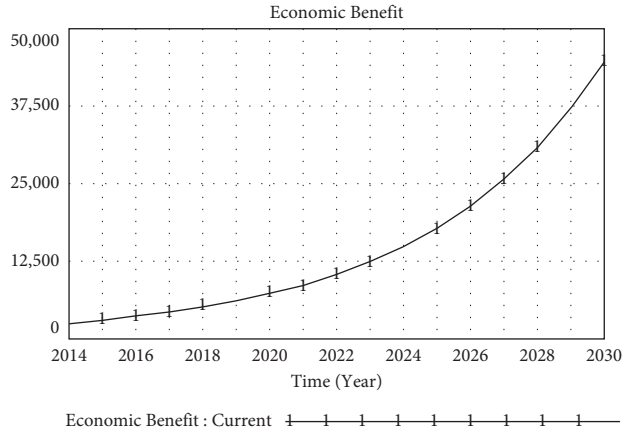

Figure 5: Trends in economic benefits.

technological upgrade of the innovation ecosystem. In order to consider the sustainable development trend of the innovation ecosystem under the adjustment of technological factors, relevant parameters are adjusted up and down by 50%, and other parameters remain unchanged. We have added two databases for simulation, and the simulation results of innovation performance and economic benefits are shown in Figures 6 and 7.

In the comparison of simulation results, Current3 represents the original parameter, Current2 represents that the relevant parameter is reduced by 50%, and Current1 represents that the relevant parameter is increased by 50%. Technological factors promote innovation performance more than economic benefits. In the adjustment of technological elements, the first to be significantly affected is the technological innovation system of the innovation ecosystem. The upgrading of technological innovation is closely related to the innovation performance of the innovation ecosystem. Economic benefits will also be affected by many factors such as market fluctuations and the expansion of sales channels. The influence of technological factors on economic benefits is weak. But, in the long run, technological progress will significantly promote the sustainable development of the innovation ecosystem. As time goes on,

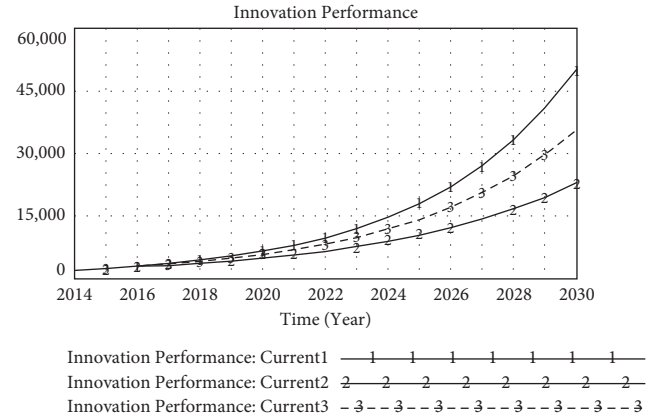

Figure 6: The influence of technical factors adjustment on innovation performance.

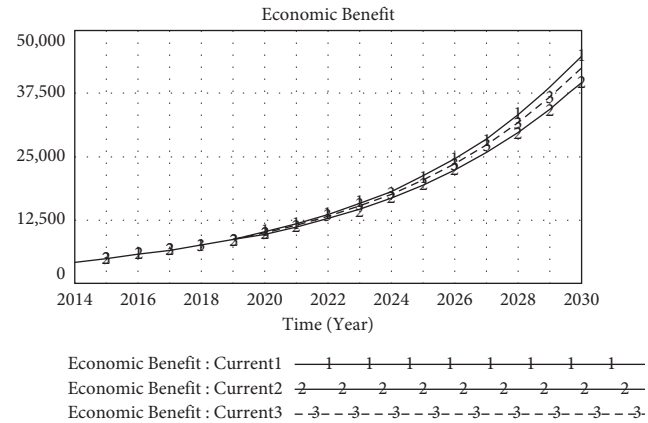

Figure 7: The influence of technical factors adjustment on economic benefits.

the adjustment of technological elements will bring more and more differences to the sustainable development of the innovation ecosystem, which highlights the importance of technological innovation.

4.2.2. Influence of Organizational Elements on the Sustainable Development of the Innovation Ecosystem. The management scale is the support of the organization system, and the function of the innovation ecosystem is based on a larger management scale. Management expenditures ensure the smooth management system of the organization system, making the management model of the innovation ecosystem increasingly perfect. The management scale and management expenditure jointly promote the improvement of the management efficiency of the innovation ecosystem. To consider the sustainable development trend of the innovation ecosystem under the adjustment of organizational factors, relevant parameters are adjusted up and down by 50%, and other parameters remain unchanged. We have added two databases for simulation, and the simulation results of innovation performance and economic benefits are shown in Figures 8 and 9.

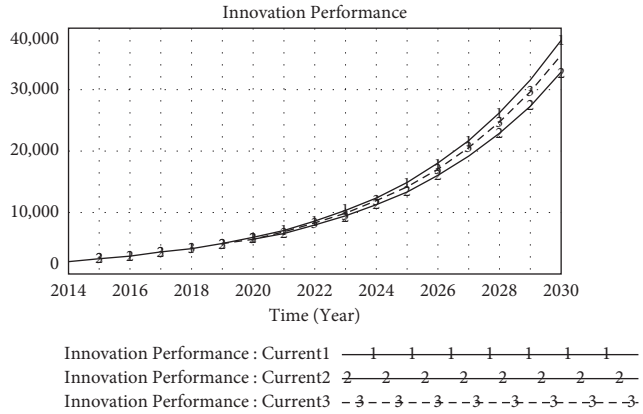

Figure 8: The influence of organizational factors adjustment on innovation performance.

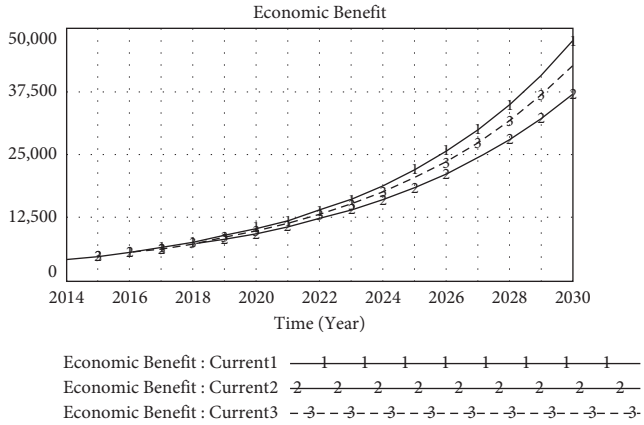

Figure 9: The influence of organizational factors adjustment on economic benefits.

Organizational elements have a relatively obvious promotion effect on innovation performance and economic benefits. Organizational elements provide support for the sustainable development of the innovation ecosystem and provide auxiliary management support for technological innovation. Organizational elements ensure the management efficiency of the innovation ecosystem and condense each innovation subject into the innovation platform system. This not only improves the economic benefits of each innovation subject but also promotes the overall innovation performance of the innovation ecosystem.

4.2.3. Influence of Value Elements on the Sustainable Development of the Innovation Ecosystem. Government subsidies are an economic intervention tool used by the government to support the sustainable development of the innovation ecosystem, helping the innovation ecosystem to achieve value appreciation. Talent is a very precious resource in the sustainable development of the innovation ecosystem, and the optimization of the talent structure is the driving force for the sustainable development of the innovation ecosystem. Government subsidies and talent structure jointly promote the realization of the value of the innovation ecosystem. To consider the sustainable development trend of the innovation ecosystem under the adjustment of value elements, relevant parameters are adjusted up and down by 50%, and other parameters remain unchanged. We have added two databases for simulation, and the simulation results of innovation performance and economic benefits are shown in Figures 10 and 11.

Value elements will not only promote the improvement of innovation performance but also increase economic benefit. Adjusting value elements will have a certain impact on the sustainable development of the innovation ecosystem, and this impact will become more and more significant over time. The adjustment of value elements improves the efficiency of resource allocation in the innovation ecosystem, which not only provides support for technological innovation and upgrading but also lays the foundation for the improvement of economic benefits.

4.3. T-O-V Synergistic Adjustment Effect Test. In the sustainable development of the innovation ecosystem, related variables are often combined. It is an ideal state to only adjust the assignment of certain variables while keeping other variables unchanged. Therefore, it is necessary to comprehensively adjust technology-organization-value related parameters and design different simulation scenarios to observe the operating effects of the innovation ecosystem. The system dynamics model for sustainable development of the innovation ecosystem will be adjusted based on the current status of the system, and the design parameters will be coordinated for simulation. The specific simulation results are shown in Table 6.

The system dynamics model of the sustainable development of the innovation ecosystem takes the original parameter assignment as the benchmark reference item, and a total of 11 simulation scenarios are designed. Analyzing the simulation results of the system dynamics model, we can find the following: (1) The operation effect and influence of the comprehensive adjustment of multiple parameters in the three dimensions of technology-organization-value are more significant than the adjustment of single-dimensional parameters. Parameter adjustments will also have greater differences in the future development trend of the innovation ecosystem. The sustainable development of the innovation ecosystem is affected by the multiple effects of technology, organization, and value. To study the development trend of the innovation ecosystem from a certain perspective, the effect is usually limited. (2) The adjustment of technological elements has the greatest impact on innovation performance, and the adjustment of organizational elements has the greatest impact on economic benefits. In the sustainable development of the innovation ecosystem, technological elements, organizational elements, and value elements play a synergistic role. Technological factors promote innovation performance more than organizational factors and value factors, and organizational factors promote economic benefits more than technological factors and value factors. (3) The coordinated adjustment of relevant

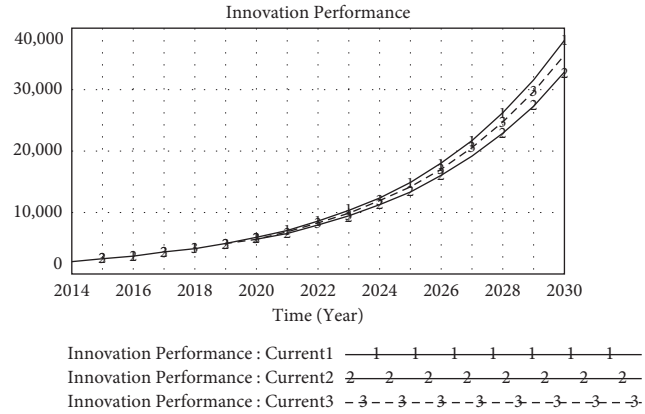

Figure 10: The influence of value factors adjustment on innovation performance.

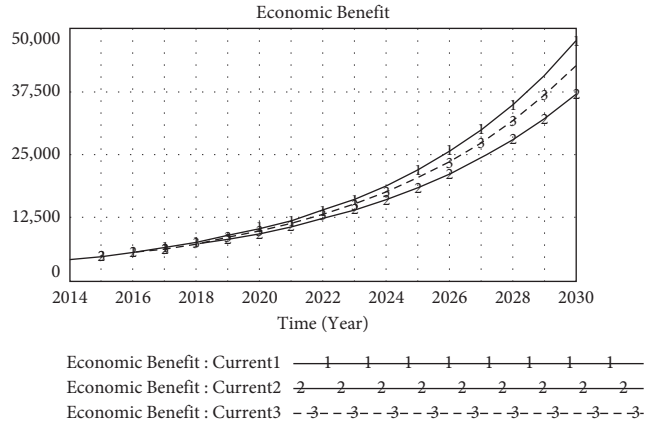

Figure 11: The influence of value factors adjustment on economic benefits.

Table 6: "T-O-V" comprehensive adjustment effect simulation.

Situation	Adjustment range of technical factors (%)	Adjustment range of organizational factors (%)	Adjustment range of value factors (%)	Innovation performance change range (%)	Economic benefit change range (%)
1	+25	+25	+25	+28.5	+13.7
2	+25	+25	−25	+18.4	+3.1
3	+25	−25	+25	+19.5	+0.8
4	−25	+25	+25	−13.8	+6.6
5	+50	+25	+25	+50.6	+16.6
6	+25	+50	+25	+32.4	+19.7
7	+25	+25	+50	+32.6	+18
8	+50	+50	+25	+55.4	+22.8
9	+50	+25	+50	+55.5	+21.1
10	+25	+50	+50	+36.7	+24.2
11	+50	+50	+50	+60.3	+27.4

parameters in the three dimensions of technology-organization-value has a greater impact on innovation performance compared to economic benefits. Innovation performance is greatly affected by technological innovation and upgrading. Technological innovation is closely related to factors such as technical talents, technological R&D investment, and talent structure. The economic benefits will also be affected by environmental changes such as external market fluctuations and changes in sales channels.

5. Conclusion and Inspiration

5.1. Research Conclusion. This paper carefully describes the dynamic mechanism of the sustainable development of the innovation ecosystem from the three dimensions of technology, organization, and value and reveals the development trend and evolution mechanism of the innovation ecosystem. The system dynamics model is simulated with the operation data of the innovation ecosystem of the

automobile industry as an example, and the research finds the following:

(1) The coordinated adjustment among the three factors of technology, organization, and value promotes the sustainable development of the innovation ecosystem. This paper integrates technology-organization-value into the sustainable development system of the innovation ecosystem and builds the growth mechanism of the innovation ecosystem with a complete and orderly operation framework to achieve high-quality development of the innovation ecosystem.

(2) This paper constructs a system dynamics model for the sustainable development of the innovation ecosystem from the three dimensions of technology, organization, and value. By portraying the interrelated causal feedback relationship between technology, organization, and value, this research breaks the limitation of studying the sustainable development of innovation ecosystem from a single perspective and establishes a holistic and systematic research framework. This paper deeply analyzes and demonstrates the growth mechanism and operating effects of the innovation ecosystem, which is highly consistent with the internal logic and operating mechanism of the sustainable development of the innovation ecosystem.

(3) Technical elements are the decisive force for the innovation and upgrading of the innovation ecosystem. Organizational elements provide support for economic benefits. Value elements have a guiding effect on the sustainable development of the innovation ecosystem. Coordinate the input intensity of technical elements, organizational elements, and value elements, continuously promote the transformation of technological upgrading into high-efficiency productivity, and promote the sustainable development of the innovation ecosystem with higher quality.

5.2. Management Enlightenment. The innovation ecosystem needs to pay attention to the technology research and development within the system, invest in technical resources, and strive to cultivate core technologies and businesses, so that the innovation ecosystem can achieve sustainable development. Managers should reasonably consider the industrial location of the innovation ecosystem and their resource endowments and competitiveness, to make the right choice. The growth of the innovation ecosystem requires the investment of more high-quality technical talents to enhance the technological capabilities and absorptive capacity of the innovation ecosystem. Relying on the different resources of heterogeneous subjects in the innovation ecosystem, managers should actively unblock knowledge transfer channels, unite various innovation subjects to innovate collaboratively, and promote continuous technological innovation and upgrading.

Core enterprises in the innovation ecosystem should strengthen cooperation with service institutions and scientific research institutes. Overcome development shortcomings with joint forces, provide management support for the development of new technologies and new products, and continue to maintain the competitive advantage of the innovation ecosystem. Managers can further improve the innovation network composed of innovation entities and auxiliary innovation entities from the perspective of industrial chain, supply chain, and innovation chain. Relying on the platform system, managers can consider establishing a modern technology service system to update the infrastructure required by the innovation ecosystem on time. Organizational policymakers should increase investment in system innovation elements, formulate organizational standard systems that are conducive to the sustainable development of the innovation ecosystem, and promote the smooth development of innovation activities.

The government should give full play to its guiding role to enhance the industrial function of the innovation ecosystem. Through the dual role of "government-market," the market mechanism will be improved to better play the role of market traction and pull, inject vitality into the innovation elements in the innovation ecosystem, and stimulate the sustainability of innovation activities in the system. Accurately identify the unique advantages of each innovation subject in the innovation ecosystem. According to the different value propositions of innovation entities, managers should introduce policies that are conducive to the sustainable development of the innovation ecosystem and absorb each innovation entity into the value cocreation behavior model. The system value leader can optimize the talent structure of the innovation ecosystem, create a good innovation atmosphere, attract more innovative talents, and continuously inject new impetus into the sustainable development of the innovation ecosystem.

5.3. Future Work. This article reviews the existing research foundation of the innovation ecosystem and uses system dynamics to study the sustainable development of the innovation ecosystem from the perspectives of technology, organization, and value. However, this article also has some limitations. First, system dynamics can only analyze the general development trend of the innovation ecosystem but fails to portray all aspects of the sustainable development of the innovation ecosystem in detail. Second, the indicators selected in the three dimensions of technology, organization, and value are limited to those that can obtain statistical data and cannot fully describe the role of technical factors, organizational factors, and value factors.

Future research on the innovation ecosystem can select indicators from a wider range to better demonstrate the effects of technical factors, organizational factors, and value factors. In addition, research can also be carried out from the internal and external interactions of the innovation ecosystem to further reveal the evolutionary mechanism of the sustainable development of the innovation ecosystem.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare there are no conflicts of interest regarding the publication of this paper.

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