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Research on the Construction of Innovation Ecosystem for Key Core Technologies Breakthrough

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Abstract: *With the in-depth development of a new round of scientific and technological revolution, China is moving towards a new economic development era with scientific and technological innovation as the core driving force. How to accelerate the accumulation of more innovative resources, improve the ability of independent innovation and master key core technologies is crucial for enterprises. From the perspective of innovation ecosystem, the innovation ecosystem oriented to key core technology breakthrough is constructed by analyzing the constraints of key core technology breakthrough, relevant elements in the system and the correlation between elements. First of all, taking the integrated circuit industry as an example, by analyzing the constraints of tackling key core technologies, it is concluded that it is necessary for enterprises to establish their own ecosphere; Secondly, by analogy with the natural ecosystem, the main elements of the innovation ecosystem are obtained and the correlation between the elements is analyzed. Finally, based on the above analysis, build an innovation ecosystem for tackling key core technologies and promote the deep integration and collaborative innovation development between the main bodies.*

Keywords: *Innovation ecosystem, Key core technologies, Collaborative innovation*

1. Introduction

The rise of a new round of scientific and technological revolution has greatly changed the world's industrial structure, and the ability to master key core technologies has become an important indicator to measure a country's comprehensive national strength. General Secretary Xi pointed out that the key core technologies cannot be obtained, bought or negotiated. Only by taking the initiative of innovation and development in one's own hands is the prerequisite for realizing the independent and controllable key core technologies. However, the current growth of China's external demand is facing strong uncertainty, and many fields are still far from the world's first-class industries. Strategic emerging industries such as equipment manufacturing, electronic communications, new energy and medicine rely on imported technologies and equipment for technological transformation are upgrading, and they face the dilemma of being "stuck in the neck". In this context, relevant enterprises in our country are becoming more and more aware of an important issue: under the current new situation, it is becoming more and more difficult for our country to acquire cutting-edge technologies in "follow-up" by means of introduction, and no individual or enterprise can be immune[1]. The realization of innovation requires an industrial ecology, and the success of innovation needs to be realized in the ecology[2]. Multiple entities should participate together, make concerted efforts and focus on tackling key core technical issues of "stuck neck", so that it is possible to achieve "leap-forward" innovation and breakthroughs in core technologies. Therefore, enterprises must actively link and integrate their core capabilities with external resources to form an ecosystem to ensure their sustainable development. Therefore, how to build an effective innovation ecosystem to drive the deep integration of multiple entities and break the technological blockade has become an urgent problem to be solved in the current new situation.

2. Relevant theoretical basis and literature review

2.1. The connotation of innovation ecosystem

In the digital age, the rise of social and ecological forces has accelerated the process of innovation, and relevant scholars have transformed from a single element or a combination of elements to the perspective of an industrial innovation ecosystem [3-4]; In the study of biological ecosystems, the

ISSN 2616-5902 Vol. 4, Issue 13: 38-45, DOI: 10.25236/AJBM.2022.041306

ecosystem is defined as a system of all interacting organisms found in a specific physical environment[5]. By analogy with biological ecosystem, relevant scholars believe that innovation ecosystem is a complex system of symbiosis, competition and dynamic evolution composed of participants, activities, institutions and relationships (including complementary and alternative relationships), and is a collection of multiple elements and subjects formed through multiple connections [6-7]. The most important feature of this system that distinguishes it from other systems is interdependence and win-win symbiosis[8]. Its basic elements are enterprises, academic research institutions, governments and other species and communities. The process of innovation is the response process of various species and communities to environmental changes and disturbances under the mutual influence and interaction of competition and symbiosis[9]. Different players in the system achieve dynamic evolution in the process of innovation through selective complementation and effective learning based on a common value proposition [10-11]. Yuan et al. [12] studied the innovation ecosystem of key common technologies of artificial intelligence, and believed that various innovation elements in the system would promote the evolution of the system to a higher level through continuous interaction and stimulation. Liu et al.[13] believed that the evolution process of innovation ecosystem is a dynamic cycle process. Relevant studies have shown that SMEs can effectively address some of the challenges posed by open innovation by working closely with other stakeholders in the ecosystem[14]. Gao et al.[15] believed that the innovation mechanism of complementary advantages formed by the main bodies of the innovation ecosystem through joint research and development and alliances can create value that cannot be created by a single main body. Zhang et al. [16] believed that the fundamental purpose of collaborative R&D among members of the innovation ecosystem is to jointly "extract" industry profits with the power of the "ant economy" by utilizing the scarce and complementary advantageous resources among members. The above scholars have deeply analyzed the relevant concepts, structural characteristics, evolution laws, etc. of the innovation ecosystem, and have carried out rich discussions on the value co-creation behavior of the members of the innovation ecosystem, which provided certain reference and guidance for enterprises to establish their own innovation ecosystem.

2.2. Research on innovation ecosystem and key core technologies breakthrough

Relevant scholars believe that in view of the current "stuck neck" dilemma faced by our country, the focus of enterprise capacity building is not only how to better promote its own development, but more importantly is how to better promote and improve the coordinated development of the entire ecosystem[17]. Relevant data show that the enterprise innovation ecosystem is closely related to major technological innovation breakthroughs[18]. The key to whether the industry can lead the world's advanced level lies in whether it can establish its own novel and powerful innovation ecosystem[19]. The reason why domestic chips are controlled by others in some key core technologies is that they have not established their own strong ecosystem for production, education and research[20]; Cultivating and optimizing the innovation ecological environment can promote the improvement of the core innovation capabilities of enterprises, thereby accelerating the breakthrough process of key core technologies[21]. Chen and Yang [22] put forward an integration framework of "institution-subject-element-organization" for the "institution-subject-element-organization" integration of innovation from the perspective of integration and innovation in industrial development. Li et al.[23] believed that school-enterprise cooperation has played an important role in the process of core technological breakthroughs. Zhang et al.[24] analyzed the evolution characteristics of key core technologies at different stages through in-depth analysis of the deep integration of industry, universities and research institutes, and believed that the deep integration of industry, universities and research institutes would help advance the process of tackling key core technologies. Yuan et al.[25] constructed a measurement system of my country's artificial intelligence key core technologies innovation capabilities based on the perspective of innovation ecology, and expanded the application scope of key core technologies innovation capabilities. It can be seen that the improvement of key core technologies capabilities is a systematic project. The breakthrough of key core technologies not only requires the increase of various innovative elements and the joint efforts of various innovation entities, but also requires the cultivation and optimization of innovation ecosystems. Ecology has become a competition for enterprises. Therefore, this paper by analyzing the constraints of key core technologies research, the components of the innovation ecosystem, and the interaction between the elements, to build an innovation ecosystem for key core technologies research, which is helpful to clarify the relevant relationships among the innovation entities aiming at key core technologies research, and promotes the deep integration and collaborative innovation development among the entities.

ISSN 2616-5902 Vol. 4, Issue 13: 38-45, DOI: 10.25236/AJBM.2022.041306

3. Analysis of the restrictive factors of key core technologies breakthrough

General Secretary Xi has repeatedly emphasized that the control of the core technology, which is the most important weapon of the country, is the biggest hidden danger in our country. If related industries want to truly achieve high-quality development, they must firmly grasp the "bull nose" of core technology, make up for shortcomings, strengths and weaknesses, fill in the blanks, and continue to promote industrial and technological innovation. Therefore, it is necessary to clarify the reasons for technologies lock-in. Taking the integrated circuit industry as an example, the relevant influencing factors in the process of tackling key core technologies are analyzed by drawing a fishbone diagram, as shown in Figure 1:

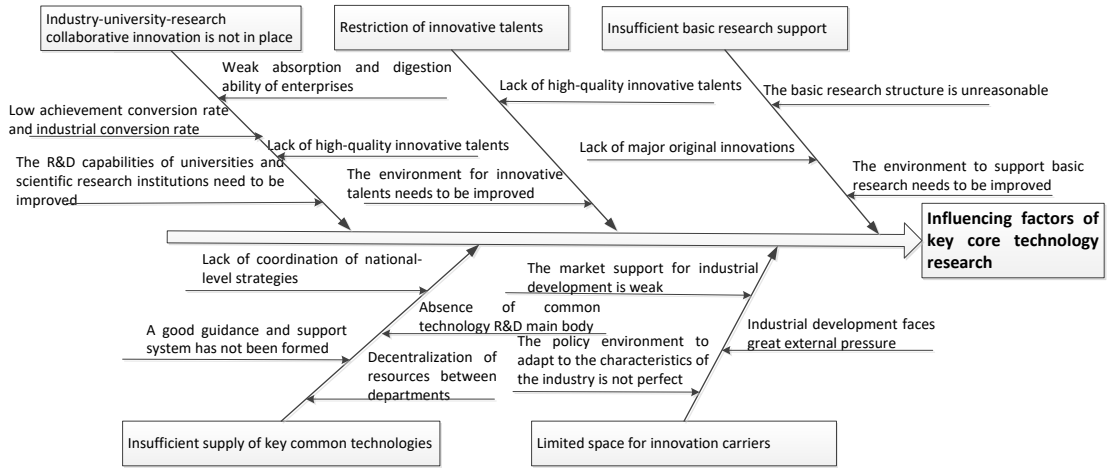

Figure 1: Fishbone diagram of influencing factors of key core technologies breakthrough.

From the analysis of Figure 1, it can be seen that the reasons for the technologies lock-in of the integrated circuit industry mainly include the lack of industry-university-research collaborative innovation, the restriction of innovative talents, the lack of basic research support, the lack of supply of key common technologies and the limitation of innovation carriers. The specific manifestations are as follows:

Firstly, the collaborative innovation of production, education and research is not in place; The weak ability of enterprises to absorb and digest technology, and focus on output rather than R&D, lead to low willingness to basic research, less investment, low conversion rate of scientific research achievements, and the quality of scientific research output of universities and research institutes needs to be improved; The degree of integration of production, education and research is not deep enough, and a large number of scientific research and innovation achievements remain in the stage of papers and patents, which have not been further transformed into real productivity, and the ability of independent innovation still needs to be improved.

Secondly, the increasing constraints of innovative talents; The rapid development of the high-tech industry is in urgent need of high-quality innovative talents. However, there is still a shortage of high-precision and top-notch talents in our country, especially those who are engaged in the research and development of core technologies. The technology self-sufficiency rate is low, and the development environment for innovative talents still needs to be further improved.

Third, insufficient support for basic research; At present, our country lacks major original innovation achievements, lacks scientists with original thinking and can put forward original scientific theories. The environment for supporting basic research needs to be further improved in the whole society, and there are still deficiencies in talent flow and incentive mechanism.

Fourth, the supply of key common technologies is insufficient; The key common technologies have the characteristics of large investment and long cycle. In the face of huge investment and risks, enterprises themselves have insufficient research and development motivation, and various innovation organizations and innovation entities have not yet formed a good market-oriented, close cooperation and coordination. In the situation of joint efforts of innovation, it is difficult to form a sustainable innovation capability, and it is difficult to play its due role in tackling key common technologies.

Fifth, the space for innovation carriers is limited, etc.

ISSN 2616-5902 Vol. 4, Issue 13: 38-45, DOI: 10.25236/AJBM.2022.041306

4. Analysis of the elements and related relationships of the innovation ecosystem

From the above analysis, it can be seen that whether it is the problem of innovative talents, basic research support or the supply of key common technologies, the key to whether the key core technology problems can be broken through is whether the enterprise can establish a close cooperation, complementary advantages, mutual benefit and win-win ecological relationship with other innovation subjects, whether it can form a good innovation environment, whether it can establish its own strong and stable innovation ecosystem, and whether it can form a sustainable development of innovative capabilities. Therefore, clarifying the relevant subjects and elements in the innovation ecosystem, as well as the correlation between the subjects and elements, etc. will help to promote the construction of a multi-layer linkage innovation ecosystem with the goal of tackling key core technologies. The following first compares the natural ecosystem with the innovation ecosystem to further understand the connotations of the subjects, subject behavior, environment and other related elements in the innovation ecosystem; Secondly, further analyze the elements of the innovation ecosystem and the correlation between the elements, so as to provide a theoretical basis for building an innovation ecosystem oriented to key core technologies; Finally, according to the above analysis, the main constituents and elements are selected to build an innovation ecosystem for the purpose of tackling key core technologies.

4.1. Natural Ecosystem and Innovation Ecosystem

The relationship between the existence of organisms in nature and their living environment is inseparable. Natural ecosystem refers to the ecosystem in which all living things interact with their environment in a certain time or space and maintain a relatively stable state by relying on natural regulation ability; Similar to the natural ecosystem, relevant studies believe that the innovation ecosystem refers to an open and complex system that forms symbiosis, competition and cooperation and dynamic evolution through the connection and transmission of material flow, energy flow and information flow between various innovation communities and innovation environment in an interval[26]; The comparison between natural ecosystem and innovation ecosystem is shown in Table 1:

Table 1: Comparison of natural ecosystems and innovative ecosystems.

Research object		Natural ecosystem	Innovation ecosystem
Main body	Species	Basic unit of taxonomy	Innovation activity unit
	Population	All individuals of the same species in a given time and space	Industry or organizational form
	Community	A collection of populations of various species in a specific time and space	A complex composed of various innovation units such as enterprises, universities, research institutions, etc.
Environmental elements	Substance	Various nutrients	Information, knowledge, capital, talent, service and other elements
	Energy	Source of life	innovative ideas
	Surroundings	The totality of all external conditions that affect the life, survival and development of biological organisms	Talent environment, economic environment, technical environment, policy environment, etc.
Behavior	Transfer	Organisms carry out normal life activities by transmitting different information	Some kind of strategic response of enterprises to deal with competitive behavior
	Choose	Including stability, unidirectionality, divisive selection, etc.	Subject's initiative, adaptive learning and market choice
Others	Gene	The basic unit through which an organism transmits genetic information	Convention
	genetic	Similarities between biological individuals who are related by blood	Risk uncertainty makes maintaining existing technology and innovation practices
	Mutations	Differences between biological individuals who are related by blood	Innovation
	Derivative	Crossbreeding to produce new varieties	Integrate and integrate new innovation resources and realize transformation

4.2. Analysis of Components and related relationships of innovation ecosystem

By analogy and comparison with the natural ecosystem, the innovation ecosystem is an open, multi-dimensional and co-evolution complex network structure formed by the interweaving of a variety of

ISSN 2616-5902 Vol. 4, Issue 13: 38-45, DOI: 10.25236/AJBM.2022.041306

different subjects and elements. The main components of the innovation ecosystem are the innovation subject, the innovation environment, and the flow of innovation resources between the subject and the environment. As shown in table 2:

Table 2: Components of the Industrial Innovation Ecosystem.

Constituent elements	Type		Effect
Innovation subject	Production community	corporate population	Technology Development and Research
		Universities and research institutes	Knowledge creation and scientific research
	Service community	government population	Guiding, supervising and coordinating; promoting technological progress and innovation through a series of industrial policies
		Tech intermediaries population	Resource Convergence and Industrial Diffusion
	Demand community	Various consumer groups	Innovation demander and application user of innovation results
Innovation environment	Talent environment, technical environment, economic environment, policy environment, etc.		Promote the innovative development of related industries, the connection of technological facilities, the circulation of human resources and the exchange of innovation platforms, etc.
Innovative elements	Technology, capital, manpower, knowledge, labor, information, services, etc.		Through the flow and integration between various innovation entities, the advantages of each innovation entity can complement each other, accelerate the process of technological R&D and innovation of enterprises, and promote the co-evolution of the innovation ecosystem

From Table 2, it can be seen that each innovation environment influences and promotes each other, and acts on the process of enterprise innovation. Various innovation elements flow between the innovation subjects to promote the co-evolution of the subjects. The correlations are further analyzed:

(1) Regarding the production community, it includes the enterprise population and the population of universities and scientific research institutes; Among them, the enterprise population includes the population formed by individual enterprises and various homogeneous enterprises with the same or similar technology, suppliers, consumers, etc. , and enterprise population is the main force of innovation and the main body of technological innovation decision-making, R & D investment, scientific research organization and achievement transformation. It can provide many advantageous resources for academic and research institutions and improve their creative ability; As a think tank, talent pool and source of innovation, academic and research institutions playa an important role in cultivating high-quality innovative talents. They can provide a series of technology supplies for enterprises, transfer technology through technology promotion, technology sales or signing technology development contracts, so that these new technological achievements can be applied to enterprise production and bring certain economic benefits to enterprises.Through material exchange and energy flow, the enterprise population and the academic and research institution population help to create and disseminate knowledge, skills and new products, thereby realizing complementary advantages. Promoting the deep integration of production, education and research is conducive to gathering innovative resources and developing innovative models, thereby accelerating the process of tackling key core technologies;

(2) Regarding the service community, it includes the government community and the scientific and technological intermediary agency community; Among them, the government community promotes technological innovation and progress through a series of industrial policies, by guiding, supervising and coordinating the cooperation between various innovation entities; As a bridge connecting knowledge and technology industries, the group of science and technology intermediaries can provide technology transfer, technology development and related technical consulting and services, and provide innovation entities with results pricing evaluation, all-round services such as collection of research and development expenses, financial support, etc., and improve the timeliness of the transformation of achievements. It is an important carrier to guide enterprises to carry out industry university research cooperation with universities and scientific research institutes, accelerate the transformation of science and technology, and a strong supporting force to promote the development of enterprises;

(3) The demand community refers to various consumer groups; All kinds of consumer groups, including all kinds of users, which are the starting point and end point of innovation;

5. Construction of an innovation ecosystem for tackling key core technologies

Based on the above analysis, selecting the main constituents and elements to build an innovation

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ecosystem oriented to key core technologies; It is mainly divided into three aspects: the core layer innovation subject, the innovation elements and the influence layer innovation environment; Among them, the main innovation subjects at the core layer mainly include the knowledge creation subject academic research institutions, the technological innovation subject enterprises and the regulation subject government; The elements of innovation mainly include information, capital, knowledge, talents, services, etc.; the innovation environment of the influence layer mainly includes the talent environment, technical environment, policy environment and economic environment, etc.; In addition, intermediaries mainly play the role of incubators for scientific and technological achievements such as resource aggregation, provision of technical consultation and services, platform sharing, and collection of R&D expenses in the process of cooperation between innovation entities. The innovation ecosystem for key core technology research is shown in Figure 2:

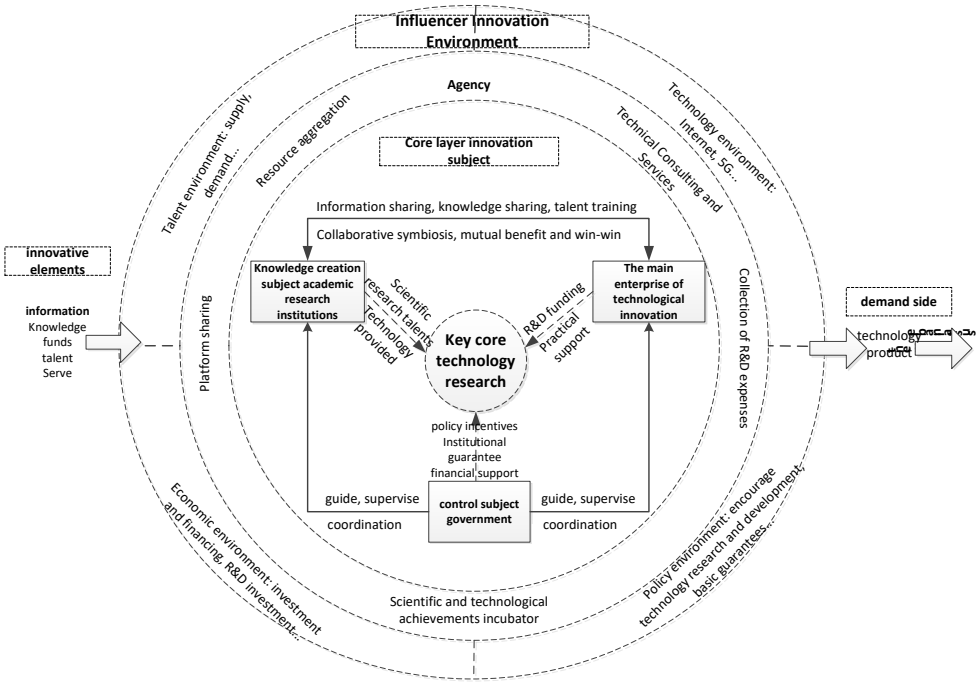

Figure 2: Inovation ecosystem for key core technologies breakthrough.

6. Conclusion

By reviewing, combing, and summarizing related theories and literatures on the connotation of innovation ecosystem, key core technologies breakthrough, and combining existing research, this paper builds an innovation ecosystem for key core technology breakthrough. Firstly, taking the integrated circuit industry as an example, the main reasons for technology lock-in are discussed through fishbone diagram analysis, and it is concluded that the key to whether an enterprise can overcome key core technical problems lies in whether it can establish its own strong and stable innovation ecosystem; Secondly, combined with the comparative analysis of the natural ecosystem and the innovation ecosystem, the main constituent elements of the innovation ecosystem and the interaction between the elements are further clarified; Finally, based on the above analysis, the innovation ecosystem for key core technology research is divided into three levels: core layer innovation subject, innovation element and influence layer innovation environment, so as to clearly describe each innovation subject in the process of key core technology research. The role of the elements, their roles and related relationships, etc., the study draws the following conclusions:

The key core technologies breakthrough is mainly restricted by the lack of collaborative innovation between industry, university and research institutes, the limitation of innovative talents, the lack of basic research support, the lack of supply of key common technologies and the limitation of innovation carriers;

The key to whether an enterprise can overcome the key core technical problems lies in whether it can establish its own strong and stable innovation ecosystem. This is because the various environments in the innovation ecosystem affect and promote each other, and act on the process of enterprise innovation.

ISSN 2616-5902 Vol. 4, Issue 13: 38-45, DOI: 10.25236/AJBM.2022.041306

The flow of various innovation elements among innovation subjects promotes the collaborative evolution between subjects, which helps to establish a close cooperation and mutual benefit and win-win ecological relationship between enterprises and other innovation subjects; The establishment of an industrial innovation ecosystem with enterprises as the core helps to speed up the process of technological R&D and innovation of enterprises with the help of the power of other innovative entities, and form sustainable innovation capabilities.

The research draws the following insights:

Firstly, the main body of innovation should to optimize resource allocation and utilization capabilities, and improve R&D innovation capabilities; Secondly, in the process of cooperation, it is necessary to improve the collaborative innovation mechanism of risk sharing and benefit sharing, realize resource sharing, complement each other's advantages, and fully guarantee the legitimate interests of all parties; The third is to explore the operation mechanism based on ecological synergy to promote key core technologies breakthrough, promote the formation of a "diverse, integrated, dynamic and sustainable" collaborative innovation model, ensure the efficient interaction, integration and smooth flow of various innovation elements, and accelerate the process of technological innovation and breakthrough.

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