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IMPROVEMENT OF INNOVATION MANAGEMENT AT THE PRESENT STAGE

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CONTENT

INTRODUCTION

Relevance of the research topic

One of the characteristic features of modern global economic development is the transition of leading countries to a new stage, which is characterized by special attention to the creation, dissemination and application of knowledge. Innovations allow creating new products and services, improving existing technologies and processes, increasing labor productivity and its efficiency, as well as opening new markets and business opportunities.

Adoption of new technologies and innovations contributes to improving the competitiveness of companies, which leads to the expansion of production and business. In addition, innovation contributes to the development of new sectors of the economy, which leads to the creation of new jobs and an increase in GDP.

It is important to note that in the current stage, effective innovation management plays a key role in the successful implementation of innovative solutions.

The Chinese economy over the last 20 years has been characterized by high growth rates, China is the world's largest exporter with a growing share of manufacturing in the export of goods. The Chinese government is very interested in developing innovation and promoting advanced technologies. China's experience can be used in the development of innovation activities in Russia. With the strengthening of Sino-Russian relations, China and Russia have reached an unprecedented level of mutual trust. Therefore, it would be useful for Russia to learn some key strategies and methods of China's successful experience in innovation development and adapt them to its own conditions in order to optimize the path to innovation development.

Management science and practice are faced with the task of developing proposals to improve innovation management in Russia, taking into account the best practices of the Chinese experience in response to new challenges and threats. In this regard, the research aimed at identifying the key factors determining the successful functioning and development of national innovation systems, finding ways to strengthen innovation science and technology centers as a form of innovation management and creating conditions for sustainable socio-economic development of the country is even more relevant. The choice of the research topic and the definition of its goal and objectives are conditioned by the special importance of solving the problems of innovation management in Russia.

The purpose of the study is to develop proposals for improving innovation management in modern Russia.

To achieve the **goal**, the following tasks were set in the dissertation research:

1.Consider the history of development and theoretical foundations of innovation and innovative development.

2.Summarize various methodological approaches used to study innovation management.

3.Identify the structural forms of innovation management.

4.Examine the evolution of China's innovation development strategy and the model of innovation development in China.

5.Identify the priority factors of innovation development in China through econometric modeling.

6.Compare Chinese and Russian key approaches to innovation management. To substantiate the necessity and possibility of applying the Chinese experience of innovation management in the development of innovation management in Russia.

7.Analyze the role and importance of innovation science and technology centers in the sphere of state innovation management.

8.Develop recommendations for the improvement of innovation science and technology centers in Russia.

The object of the study is innovation management at the national level.

The subject of the study is the improvement of the mechanism of innovation management in Russia based on the use of Chinese experience.

Theoretical and methodological basis of the thesis research are the works of Russian and foreign researchers in the field of national innovation system and national management (Paul Romer, Joseph Schumpeter, Paul Samuelson, Bengt-Åke Lundvall, Christopher Freeman, Richard Nelson, Edquist Charles, Keith Pavitt, E.M. Anokhina, T.I. Bezdenezhnykh, V.L. Baburin, A.G. Granberg, S.P. Zemtsov, N.I. Ivanova, E.A. Kolomak, Yu. Kolomak, Y.V. Kuznetsov, Y.A. Malenkov, E.M. Korostyshevskaya, V.P. Oreshin, S.V. Valdaitsev, G.G. Fetisov, A.G. Shestakovich, K.A. Klochikhin, Hu Angang, Zhang Xing and Hu Hongru, etc.), publications in scientific and business journals, as well as materials of research, consulting and analytical organizations.

The information basis of the study includes: regulatory legal acts; international, foreign and national statistical databases; materials of periodicals and the Internet; analytical and informational materials published by Russian and foreign organizations.

Methodological basis

The methodological basis of this study is conditioned by the use of the following methods of scientific cognition:

1.Based on the inductive method of research, taking into account the literature review and analysis of historical data, the forms of innovation management and methodological approaches to the study of innovation management were generalized. Special attention was paid to the role of state regulation in innovation management. In addition, by applying the method of historical logic, we found patterns in the evolution of the theory of innovation and innovation development.

2.By means of comparative analysis of innovation management in China and Russia, taking into account specific numerical data, the features of national systems of innovation management in these two countries are outlined. This allows us to use the method of induction to prove that China's experience in national innovation management can help Russia to improve innovation performance.

3.The thesis employs quantitative research methods, including statistical data analysis and economic-mathematical modeling. One of the economic-mathematical modeling techniques is the principal component regression method to analyze the relationships between various factors affecting innovation in China. This method was applied in order to reduce information loss and reduce the negative impact of strong correlation between explanatory variables, thus identifying the main factors influencing innovation management in China.

4.A number of graphical methods were applied to visualize and illustrate the results of the study.

Hypothesis of the study. The study is testing the following interrelated hypotheses:

1.The development and effective application of innovation management strategies in the modern world are an integral part of ensuring sustainable and successful innovation development. In a rapidly changing economic and technological environment, the ability of states to effectively manage innovation becomes a key factor in strengthening their competitiveness.

2.China, by continuously developing its national innovation system and a variety of innovation management methods, demonstrates how a successful innovation system contributes to the revitalization of innovation capabilities and sustainable economic growth. By learning from China's experience and applying the approaches used in China, Russia can improve the efficiency of innovation development, stimulate innovation research, including the creation of new companies, and form a favorable infrastructure for innovation initiatives at the national level. This exchange of experience can help improve the competitiveness of innovation management in Russia.

3.Innovation science and technology centers play an important role in the development of innovation in Russia. They facilitate the integration of science and business, the creation of new technologies and products, and the attraction of investment. However, to optimize their impact on innovation development, their further improvement is necessary, which includes improving funding, supporting start-ups, developing modern infrastructure and helping to attract talent. By improving innovation science and technology centers, it is possible to ensure long-term and successful innovation development in Russia.

The following **provisions** are put forward for defence:

1. The new model of Russia's economic development is associated with innovation and the development of high-tech industries. The development and improvement of innovation management technologies is the most important component of successful innovation development in the rapidly changing economic and technological environment. The instability of the external environment predetermines the need for state support of strategic directions of innovation activity.

2.The practice of innovation management in China demonstrates that a developed innovation system contributes to the activation of innovative opportunities and determines the trends of sustainable economic growth. The use of the best practices of Chinese innovation management in Russia will have a favourable impact on the Russian innovation management system and will contribute to the further development of innovation activity in the country.

3. In modern conditions, the role of innovation science and technology centres in the development of innovations in Russia is significant. In order to enhance the influence of innovation science and technology centres on innovation development in the rapidly changing conditions of the external environment, it is necessary to improve their activities. This process involves improving the material, technical and financial base of STCI development, formation of modern infrastructure, support for start-ups and development of human resources, including the attraction of talented specialists.

Scientific novelty of the dissertation research. The scientific novelty of the study lies in the practical confirmation of modern methods and strategies of innovation management. By analyzing the practice of public innovation management in China and investigating the factors affecting innovation development in this country, the study provides a comparative analysis of the differences and similarities between China and Russia in the field of innovation management. In addition, the improvement of innovation science and technology centers in Russia will enhance the level of innovation.

1.Refined theoretical approaches to the study of the evolution of innovation activities demonstrated the significant impact of innovation on economic growth and development. It is determined that the role of state support in the development of the national innovation system is to create a favorable environment and stimulate innovation in the economy. It is shown that diverse structural forms cause different approaches to innovation management, and they are chosen by organizations depending on their goals, resources and needs (items 4, 8 of the Passport of specialty 5.2.6. "Management").

2.Based on the study of the process of establishing a national innovation system in China, it was found that it is necessary to follow a step-by-step strategy for the successful development of innovation at the national level. The five-stage model for the formation of a national innovation system includes technology introduction, development of new technologies, development of its own innovation potential, expansion of the domestic market, and active development of human resources. This model can serve as a reference point for the development of the innovation system in Russia (item 8 of Passport of specialty 5.2.6. "Management").

3.Using the econometric analysis of principal components the priority factors influencing the development of the national innovation system of China were determined. The results of the study confirmed that international cooperation, self-innovation, human resources training policy and public investment in innovation are the factors that have the greatest influence on the development of China's national innovation system (items 8, 19 of Passport of specialty 5.2.6. "Management").

4.The most promising structural forms of innovation management at the present stage - innovation scientific and technological centers - have been identified. Innovation science and technology centers play a key role in modern innovation development due to the feasibility of expert assessments, the ability to collaborate, access to resources and funding, as well as the possibility of commercialization and educational initiatives. At present, innovative scientific and technological centers provide the greatest effect in innovative development (item 8 of Passport of specialty 5.2.6. "Management").

5.The directions of improvement of innovative scientific and technological centers as a form of innovation management at the present stage in Russia are defined. They include the following: the use of the strategy of "pre-incubation abroad + acceleration of start-ups in the local market", the involvement of innovative specialists of different levels, the development of the system for assessing the innovativeness of organizations, the provision of intellectual property with the help of blockchain technology. In addition to the above, we also emphasize the reliance on strategic priorities (paragraphs 4, 8, 19 of Passport of specialty 5.2.6. "Management").

Practical significance lies in the fact that the research in the field of the national innovation system proposed by the author can find practical application in public administration at the federal and regional levels of the process of regulation of innovation activity. In addition, these studies can be useful in the development of new methods and forms of improvement of the national innovation system, for the development of scientific and technological sphere, improving the innovation capabilities of Russia, accelerating economic growth and increasing the international competitiveness of the country.

Degree of reliability of the results and their approbation. The results obtained during the research were repeatedly presented at international and all-Russian scientific conferences in St. Petersburg (Fifth and Sixth International Scientific Conferences "Business Management in Digital Economy", XX International Conference "Evolution of International Trade System: Problems and Prospects", International Conference "Theory and Practice of Management of Entrepreneurial

Structures in Modern Conditions").

According to the results of the dissertation research personally and in co-authorship five works were published, including four articles in journals from the list of editions recommended by the VAK of the Ministry of Education and Science of the Russian Federation, and one article in journals indexed in CNKI.

Compliance of the thesis with the passport of scientific specialty. The area of research corresponds to the requirements of the Passport of specialty VAK RF 5.2.6. "Management": item 4. - "Management of economic systems, principles, forms and methods of its implementation. Theory and methodology of change management in economic systems"; item. 8. - "State management of socio-economic processes. State policy, mechanisms and methods of its development and realization in different historical and country conditions"; item. 19. - "Innovation Management. Innovative abilities of the firm. Management of organizational and technological innovations. Inter-organizational forms of innovation management".

Structure of the dissertation research

The structure of the dissertation research is formed in accordance with the presented list of solved problems and the logic of the research. The dissertation includes Introduction, three chapters, Conclusion, List of used literature and Appendices.

The Introduction substantiates the relevance of the research topic, defines the purpose, objectives, object and subject of the study, its theoretical and methodological basis and information base, formulates the scientific novelty, and presents the practical significance of the work.

The first chapter of the thesis examines the concept of innovation, the process of development of innovation theory and modern directions of research in the field of innovation theory. It also considers the definition of the development process and modern research directions of national innovation systems.

The second chapter of the thesis analyzes the establishment of China's national innovation system to identify the model of innovation management in China. Using econometric principal component analysis, the key factors affecting China's national innovation system are also identified. Based on the key factors, a comparative analysis of China's and Russia's development models in international cooperation, innovation, support for young scientists and public investment is conducted.

The third chapter of the thesis identifies areas in the field of innovation management that need to be developed in Russia and offers recommendations for improving innovation science and technology centers in Russia.

The Conclusion formulates the results of the research, the main scientific results and conclusions of the completed work.

The content of the thesis is set out on 163 pages of typewritten text, including 38 figures, 39 tables and 15 appendices. The study contains a list of used literature from 140 sources.

CHAPTER 1. THEORETICAL ASPECTS OF INNOVATION MANAGEMENT RESEARCH

1.1 Evolution of theories on innovation and innovative development

The term "innovation" comes from the Latin "novation", which means "change", and the prefix "in", which translates from Latin as "in the direction of". If translated literally, "Innovation" means "in the direction of change". The very concept of innovation first appeared in scientific research in the XIX century. There are hundreds of definitions in the literature (see Appendix 1). On the basis of content or internal structure there are technical, economic, organizational, managerial and other innovations. Here are the most significant definitions of innovation.

B. Twiss defines innovation as a process in which an invention or idea acquires economic content[137]. Nelson R. believes that innovation is a set of technical, production and commercial activities that lead to the appearance on the market of new and improved industrial processes and equipment[126]. B. Santo states that innovation is such a social, technical, economic process, which through the practical use of ideas and inventions leads to the creation of better products, technologies, and in case the innovation is focused on economic benefit, profit, its appearance on the market can lead to added income [95]. J. Schumpeter interprets innovation as a new scientific and organizational combination of production factors, motivated by entrepreneurial spirit[132].

The analysis of the above definitions of the concept of "innovation" allows the author to identify three points of view:

The first point of view connects innovation with the concept of "innovation", or "innovation".

The second point of view considers innovation as a process of creating new products or technology, as an innovative element in the field of economics and production management.

The third point of view characterizes innovation as the process of introducing new approaches and elements into production that differ significantly from the previous ones. This concept recognizes that innovation develops over time and has clearly defined stages.

In our view, innovation is a process of creating and introducing new or improved products (services), techniques, technology, production organization and management, which provides various types of effect.

The development of innovation theory mainly consists of four stages: the stage of J. Schumpeter's innovation theory, the stage of technological innovation theory, the stage of institutional innovation theory and the stage of national innovation system and innovation system construction[132].

J. Schumpeter first proposed the concept of innovation as a process in his first English article "The Instability of Capitalism" in 1928 and in his 1939 book "Business Cycles". Schumpeter's theory of innovation involves the following[132]:

- Definition of innovation. J. Schumpeter believes that innovation consists in the establishment of a new production function, that is, the introduction into the production system of a new combination of production factors and conditions of production not seen before, thereby forming new production capacities and ultimately generating potential profits. J. Schumpeter distinguished innovations of five categories: product innovations, technological innovations, market innovations, innovations in resource allocation and organizational innovations.

- Innovation and invention. J. Schumpeter emphasized that innovation should be able to create new value, so he theoretically separated invention from innovation. He believed that invention is the discovery of new tools or new methods, and innovation is the application of new tools or new methods, so invention comes first, followed by innovation. Innovation is not the same as invention. Invention is a new product or a new process offered for the first time, while innovation is a technological act; innovation is the first attempt to put the idea into practice, which is an economic act.

- Entrepreneurial functions and resource allocation. Innovation is a new combination of the entrepreneur's production factors, that is, recombination of existing resources. The activity of recombination of resources is called "entrepreneurial function". J. Schumpeter considered this function as very important. He believed that economic development is a process of change and economic development will be determined by innovation in a certain historical period necessary for change.

Although J. Schumpeter first proposed the theory of innovation and innovation and listed some specific forms of innovation, he did not directly define technological innovation in a narrow sense. The concept of innovation as defined by J. Schumpeter covers a wide range of concepts, including technological innovation, product innovation, as well as non-technological organizational innovation and market innovation.

After J. Schumpeter, the theory of innovation has been mainly studied in two directions. One is the school of technological innovation represented by Edwin Mansfield, Morton Carman, Nancy Schwartz etc. They emphasize on technological innovation and technology. The main role of progress in economic development focuses on the study of technological innovation systems, including technology diffusion, transfer and promotion, and the creation of theoretical models such as technological innovation diffusion and innovation cycle. The second, institutional innovation theory, represented by Douglas North and Lance Davis, combined Schumpeter's innovation theory with the institutional theory of the institutional school to study the impact of institutional arrangements on national economic growth.

Currently, there are many definitions of technological innovation. R. Solow, E. Mansfield, and P. Romer define technological innovation as the entire process of value creation in terms of enterprise production, sales, and benefits. In 1951, R. Solow proposed two conditions for establishing technological innovation, namely as a source of new ideas and the realization and development of later stages[133]. J. Inos in 1962 also provided the first direct and clear definition of technological innovation for the first time in the article "Invention and Innovation in the Petroleum Refining Industry", stating, "Technological innovation is the result of the synthesis of concentrated patterns of behavior. These behaviors include choosing an invention, securing capital investment, creating organizations, developing plans, recruiting workers, and developing the market, etc."[107]. Economist P. Romer argues that endogenous technological progress is the only source of economic growth[130].

Lance Davis and Douglas North put forward the theory of institutional innovation in an article titled "Institutional Change and American Economic Growth" published in the American Journal of Economic History in 1970. They believe that institutional innovation refers to the innovation of economic organization or management methods[102]. D. North believes that historical economic growth is not determined by technological progress, technological progress is only a phenomenon or result accompanying economic growth, and institutional change decisively influences technological innovation. Institutional innovation is the cause of long-term economic growth and social progress of mankind. D. North developed an economic model of institutional innovation and reform and made an in-depth study in terms of property rights system, legal system in general and other changes and innovations of economic structure. Therefore, according to D. North's viewpoint, institutional innovation determines technological progress. Although technological innovation plays an important role in institutional innovation, for example, technological innovation can reduce the operating costs of certain institutional arrangements and increase the potential profits of institutional innovation, but institutional innovation plays an important role in technological innovation.

In the late 1980s and early 1990s, research on national innovation systems became widespread. A common academic feature of the studies is that innovation is viewed as a complex system and they focus on explaining differences in the performance of technological innovation across countries. From a macroeconomic perspective, a broader social and cultural background is offered to examine differences in the conduct of technological innovation across firms. In 1987, Christoph Freeman, based on the study and analysis of the Japanese economy, found that despite its previous technological backwardness, Japan became a major industrialized country due to the rapid development of the economy based on technological innovation complemented by institutional innovation, and for this reason, C. Freeman for the first time introduced a new concept of "national innovation system" [109]. K. Freeman believes that Japan's joining such technologically leading countries as Great Britain, Germany and the USA is not only the result of technological innovation. Many institutional mechanisms and organizational innovations that can be attributed to national innovations are necessary. C. Freeman emphasized the role of public policy, corporate research and development, education and training, and industrial structure in innovation. The success or failure of innovation depends on the ability of a country to adapt its socio-economic system to the requirements and opportunities of the techno-economic paradigm. In the early 1990s, Richard Nelson published the book "National Innovation Systems: A Comparative Analysis". R. Nelson defines the national innovation system as a set of systems, the interaction of which affects the results of technological innovation of firms. R. Nelson analyzes the national innovation system from a broader perspective and considers enterprises, enterprise-related research institutes, public research institutes and higher education institutions as the main part of the national innovation system [126]. R. Nelson pointed out that the modern national innovation system also includes universities that research technical knowledge and institutions that provide public funds and planning[126].

Another founder of the national innovation system is economist B. Lundvall. His research focuses on micro areas of innovation, such as the interaction between innovators and users in the process of technological innovation[121].

In recent years, the research topic of innovation management research has been continuously expanded, the research content has been deepened, and the research methods have been optimized. Research and development mainly focus on the following 3 aspects: innovation process and innovation management strategies, innovation ecosystem and its impact on innovation process, innovation capability and its measurement.

The innovation process and innovation management strategies are key factors in the successful operation of a company. In recent years, there have been many studies that have helped to develop new methods and models of innovation management, as well as to identify the most effective practices of innovation management. The work of S.V. Valdaitsev "Innovation process and innovation management strategies" considers the issues of innovation management strategy, as well as financing and lending of innovation activities [38]. Also, one of the notable works in this area is the book "Innovation management - strategies, implementation, and profits" [111], which presents the results of innovation management strategies, implementation, and profits. [111], which presents the results of research in the field of innovation management and develops new methods and models of innovation management. The work contains both theoretical and practical aspects of innovation management. In the work "Innovation Management: A Review of the Literature" [97] the authors reviewed the scientific research results in the field of innovation management and developed new methods and models of innovation management [97], the authors reviewed scientific research in the field of innovation management for the period from 1990 to 2004 and analyzed the most relevant topics and trends in the field of innovation management. The paper "Innovation management practices, strategic adaptation, and business results: Evidence from the electronics industry" presents innovation management practices in the electronics industry and shows the relationship between the use of innovation strategies and the financial performance of companies [103]. In the paper "Exploring the relationship between innovation management and intellectual property rights: A cross-country analysis" the authors investigated the relationship between innovation management and intellectual property rights in different countries [88]. In "Interacting innovation processes" the authors present a general model of a set of innovation processes in order to simulate and analyze the interaction between them. This research can be used in various fields where understanding and managing innovation processes is important [89]. "Digital modeling of strategic sustainability assessments: new approach, recommendations, prospects" considers strategic sustainability of enterprises and offers a digital model of its assessment. It has a direct impact on innovation processes and innovation management strategies. The authors emphasize that assessing the sustainability of an enterprise taking into account current and future changes in the external and internal environment is becoming increasingly important. This approach will help managers to develop more accurate and informative innovation management strategies, which contributes to successful adaptation to the challenges of modern economy[122]. In recent years, many studies have been conducted to develop new methods and models of innovation management and to identify the most effective practices. It is also important to consider a numerical model for assessing the strategic sustainability of enterprises, as this can contribute to a more successful adaptation of national innovation systems to the challenges of the modern economy. These studies and recommendations can be very useful for the development of national innovation management strategies and the sustainability of innovation processes at the state level.

An innovation ecosystem is an integrated approach to creating and maintaining conditions for successful innovation development in society, which includes institutions and resources needed to facilitate the innovation process. In recent years, many studies have been published analyzing innovation ecosystems and their impact on the innovation process. In Building innovation ecosystems: A framework for strategy and action, the authors present a model for creating and managing an innovation ecosystem that includes several components: purpose, strategy, leadership, actors, infrastructure and processes. The authors explore how these components influence the development of innovation in a company and present practical recommendations for managing an innovation ecosystem[138]. In "Innovation ecosystems: A review of their structure, governance, and capabilities", the authors review research on innovation ecosystems and present a typology of innovation ecosystems based on structure, governance, and capabilities. The authors analyze how different types of innovation ecosystems affect the innovation process and firm performance [96]. In "Innovation ecosystem and innovation performance: A conceptual framework", the authors present a conceptual model of innovation ecosystem and its impact on innovation performance of companies. The authors analyze how the participants of the innovation ecosystem interact with each other and how this affects the innovation process and the performance of companies. The authors present recommendations for managing the innovation ecosystem to achieve high performance in the innovation process [95]. The paper "Enhancing high-quality development in regional innovation ecosystems" investigates the impact of technological innovation and corporate financial support on the development of innovation ecosystems in the regions. The results indicate high-quality ecosystem development with the synergistic effect of regional innovation and corporate financial support [116]. The paper "How do Chinese SMEs enhance technological innovation capability? From the perspective of innovation ecosystem" examines the impact of SMEs' participation in the innovation ecosystem on their innovation capability. Research points to the positive impact of collaboration with universities and research institutions on independent and collaborative innovation in SMEs, as well as the inverted U-shaped nature of the relationship with the industrial chain and ecosphere[134]. "Do Innovative Provincial Policies Promote the Optimization of Regional Innovation Ecosystems?" investigates the impact of innovative regional tactics on the performance of innovation ecosystems in different regions of China. The results indicate the positive impact of innovative regional tactics on multidimensional, long-term and stable innovation ecosystems [117]. "Modeling the dynamics of innovation ecosystems" examines the dynamics of innovation ecosystems and how to successfully manage them. The authors identify key factors that influence ecosystem dynamics and develop a systematic model for understanding these dynamics [127]. The above works provide valuable scientific data and practical recommendations on the development and management of innovation ecosystems, contributing to the innovative development of regions and countries.

Innovation capability is the ability of a company or organization to create and implement new ideas, products and processes. Measuring innovation capability allows us to assess an organization's readiness to innovate, identify strengths and weaknesses, and develop strategies to improve capability. In "Innovation capability: Measurement and enhancement", the authors present a model for measuring a company's innovation capability and suggest a number of strategies for improving this capability. The authors analyze various factors that influence innovation capability such as organizational culture, leadership, knowledge management initiatives, etc. [101]. [101]. In "Measuring organizational innovation capability: A review and recommendations for future research", the authors review the literature on measuring organizational innovation capability and offer a number of recommendations for future research. The authors review different approaches to measuring innovation capacity, such as collecting data through surveys, analyzing documents, and observing the innovation process [113]. Measuring innovation capacity: Design and validation of a survey tool for micro, small, and medium enterprises" proposes a survey tool for measuring innovation capacity of small and medium enterprises. The authors analyze the results of the survey and present recommendations for improving the innovation capacity of small and medium-sized enterprises [120]. In the article "Critical inquiry on National Innovation System: Does NIS fit with developing countries?" the authors discuss an important question about the applicability of the national innovation system (NIS) in developing countries. The authors emphasize that innovation is not a random or isolated process, it requires a deliberate and systematic approach to increase innovation in a country[140]. The study "Factors of Innovation Management Transformation in Digital Innovation Ecosystems of Russian Companies" examines the impact of digital innovation ecosystems on innovation management. The authors identify four groups of factors affecting the transformation of innovation management in digital ecosystems[119]. The work "Assessment of the Innovation Potential of Selected Regions" assesses the innovation potential of regions. The author proposes to integrate three main approaches to the assessment of innovation potential and presents an original definition of the innovation potential of a region, paying attention to both the result and the initial, primary resources, as well as the process of their transformation into innovative products[112]. The above studies are important for understanding innovation potential in Russia and contribute to the development of innovation in the regions.

In summary, we see that theories of innovation have evolved over time, from Schumpeter to modern research, focusing on different aspects of innovation development, including technological and institutional innovation. It is also important to note the role of national innovation systems and innovation ecosystems in achieving successful outcomes. Studies focus on measuring and managing the innovation capabilities of organizations, which is essential for achieving innovation success. Overall, the evolution of innovation theories has demonstrated their significant impact on economic growth and development.

1.2 Methodological approaches to the study of innovation management

The theoretical foundations for the study of innovation management systems are J. Schumpeter's theory of innovation and F. List's theory of the state, and the practical justification of NIS is the program documents of the OECD (Organization for Economic Cooperation and Development) of the 1960s, containing a systems approach. J. Schumpeter's study of enterprise systems in terms of innovation and the concept of new technologies gives ideas for the study of national systems, and F. List's study of national systems in terms of the distribution of national resources and common interests based on institutional mechanisms in the state provides the basis for the study of regional systems and enterprise systems [69].

In the late 1980s and early 1990s, a systemic approach to considering and studying the relationship between technological innovation and its effectiveness in economic development emerged in economics, which led to the formation of the National Innovation System theory. Although there is some uncertainty about the date of the first presentation of the NIS concept, it is widely believed that British economist C. Freeman first utilized the concept in his book "Technology Policy and Economic Performance: The Japanese Experience". Since the 1990s, many scholars both at home and abroad have conducted more in-depth research on NIS. Some organizations and institutions, such as the OECD and the Chinese Academy of Sciences, have also contributed to the practical development of NIS theory.

C. Freeman's theory of the national innovation system

C. Freeman was the first to propose the concept of national innovation system. His theory of national innovation system is based on the assumption of different speeds of development of different countries and analyzes the systemic nature of innovation and the importance of state regulation of the system and structure of industries. Having conducted a study in Japan in 1987, C. Freeman revealed that in Japan, in the presence of technological backwardness, technological innovation, supplemented by organizational and institutional innovation, prevailed. According to Freeman, it took Japan's economy only a few decades to start developing and reach the status of an industrialized country. K. Freeman believes that the experience of Japan's economic development demonstrates the existence of a national innovation system that contributes to the country's economic development, and notes the important role of this system in stimulating economic growth. In his work "Technology Policy and Managerial Efficiency: The Japanese Experience" published in 1987, Freeman conducted an empirical study that highlighted the key role of Japan's Ministry of International Trade and Industry, as well as the role of Japanese companies, the country's unique industrial structure, the education system and the importance of the national innovation strategy. Based on this research, he presented his own theory of the national innovation system [108].

The theory of national innovation system R. Nelson

The book "National Innovation System", published by R. Nelson in 1993, analyzes national institutional systems of financing technological innovations in different countries and regions, such as the USA and Japan. R. Nelson points out that the innovation systems of modern countries are complex structures involving a variety of institutional and technical factors, various institutions such as universities specializing in public technical knowledge, and public funds and planning. He notes that private for-profit firms play a central role in these innovation systems, competing and collaborating with each other. R. Nelson uses the process of technological change and the characteristics of its evolution as the starting point of his study, emphasizing the uncertainty that accompanies the development of science and technology. He puts forward many possible strategic options and believes that the main task of economics is to maintain a "pluralistic structure of technologies". This notion implies the richness of the system as a whole, including the mechanisms for sharing technical knowledge and the interconnectedness that manifests itself in cooperation between institutions and organizations. R. Nelson notes that differences in "sectoral composition" between countries have a strong impact on the shape of the national innovation system. R. Nelson's research focuses on analyzing institutional aspects and his work is often referred to as the Institutional School of National Innovation Systems [125].

C. Freeman and R. Nelson focused on comparing different innovation policies and characteristics of innovation in different countries from a national macro perspective and therefore their research is known as the macro school of national innovation system theory (see Fig. 1).

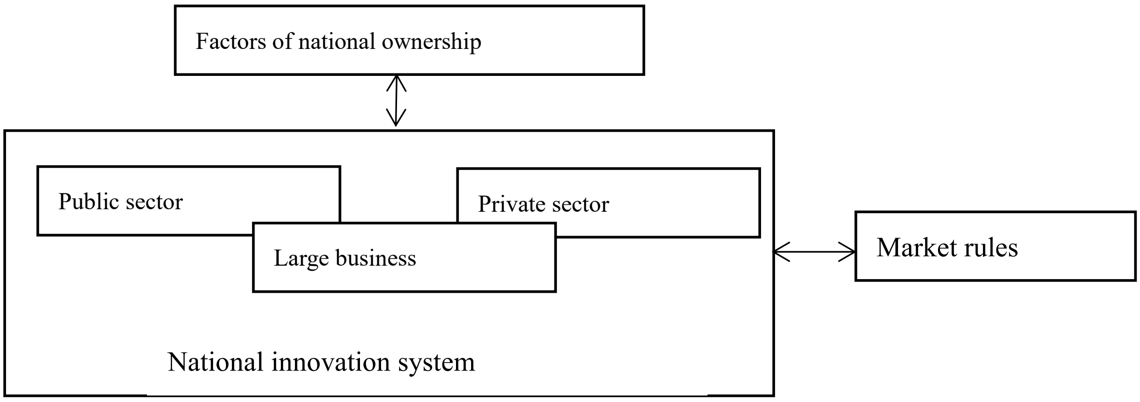


Figure 1. Freeman and Nelson's scheme of the national innovation system

Source: Compiled by the author on the basis of [108],[125].

B. Lundvall's theory of national innovation system

The microschool of NIS theory is represented by a group of scholars including B. Lundvall. Lundvall, and focuses on the study of interactions between users and innovators using the national system as a basis for analysis. This theory focuses on the components of the national innovation system, in particular the interactions between firms, research institutes and universities, as well as each innovation agent considered as an object of study. The focus is on the study of interaction pathways, primarily interactive learning (see Figure 2). Since early 1987, B. Lundvall has been analyzing in detail the impact on technological innovation of interactions between producers and users. In his opinion, the main issue of a country's economic development is the relationship between producers and users, which transforms a chaotic market into an organized market. The relationship between producer and user shapes the path of innovation. B. Lundvall emphasizes that the structure of interaction between users and producers as well as the structure of state production and innovation systems are the product of historical development and cannot be applied in the same way in different countries as factors of production. Therefore, he believes that end-users such as workers, consumers and the public sector play an important role in the innovation process. B. Lundvall concludes that in periods of rapid change in the technological base of an economy, the organized, institutionalized status quo may be the biggest obstacle to the widespread development of new technologies. Innovation may be more important for the creation of national wealth than technological innovation [121]. According to B. Lundvall, technological innovation is the realization of an interactive process between users and producers, and this process can be seen as interaction in the learning process. Consequently, the national innovation system is actually a social system, and the main activity within the innovation system is learning. Learning involves interaction between people and is a dynamic system characterized by positive feedback and self-sustaining. In the modern economy, knowledge has become the most important resource, and learning has become a key economic process. B. Lundvall called modern economy "learning economy". Consequently, the efficiency of a country's national innovation system is measured by the efficiency of production, dissemination and utilization of knowledge with economic value. Innovation is a systematic process and the key to the study of innovation systems lies in understanding how learning and research unfold, flow and create economic benefits within economic systems. B. Lundvall also emphasizes the role of interactive learning in production systems.

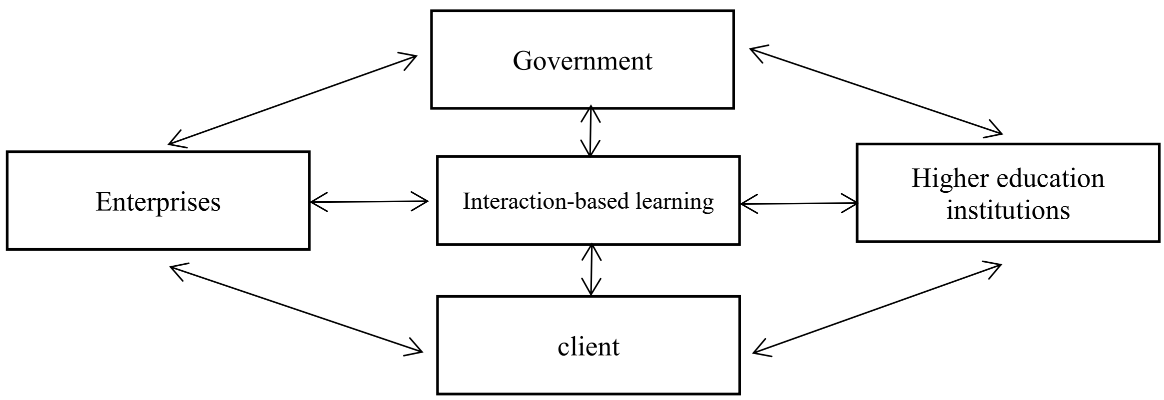


Figure 2. Scheme of Lundvall's national innovation system

Source: Compiled by the author on the basis of [121].

Theory of National Innovation System P. Patel and C. Pavitt

P. Patel and K. Pavitt [127] define the national innovation system as a complex system that determines the direction and pace of integration of new knowledge and technologies in the country. It is formed as a result of the interaction of national institutions, the use of various incentives and in order to increase competitiveness. P. Patel and C. Pavitt argue that the incentive structure of the national innovation system includes a combination of incentives for different actors, including government, firms, educational institutions and the financial support sector, as well as the institutions of the innovation system, such as government policies, firm research and development, basic research, education and training provided by universities and institutions, specialized industrial institutions, and fiscal and financial support that contribute to the development of the innovation system. These incentives aim to enhance innovation and increase the potential for sustainable innovation. In addition, P. Patel and C. Pavitt emphasize the important role of key technologies in the competitiveness of innovation systems. They also add an element of incentives to the theory of national innovation, which allows for the effective integration of theoretical research into public policy. Therefore, their proposed concept of national innovation system is considered as "national innovation system in practice".

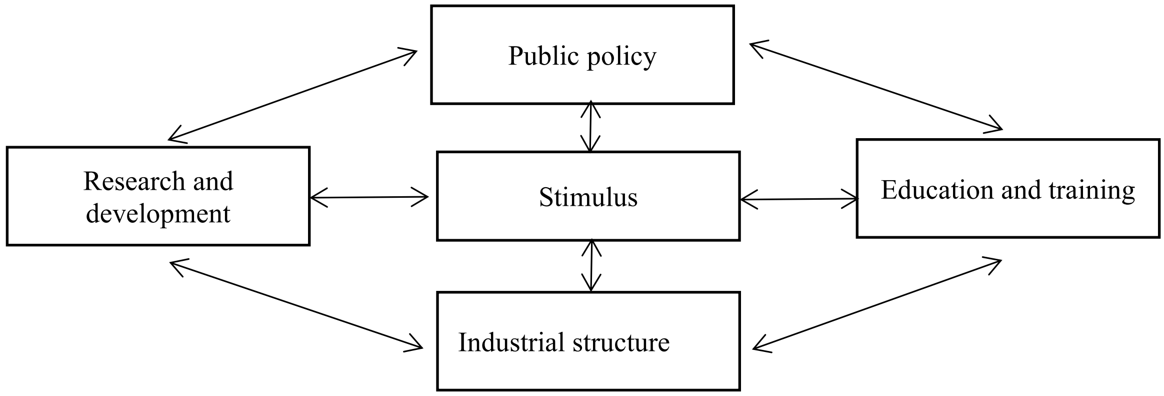


Figure 3. Scheme of the national innovation system Patel and Pavitt

Source: Compiled by the author on the basis of [127].

M. Porter's theory of national innovation system

The most significant feature of M. Porter's research is its ability to link the micro-mechanisms of the national innovation system with its macro-operational indicators and to consider the national innovation system in the context of global economic integration. Therefore, M. Porter's study belongs to the international school of national innovation and is a systemic study. According to M. Porter, the competitive advantage of a country is built on the basis of successful technological innovations of enterprises. The state in this context acts in relation to companies as an external environment that can strengthen or weaken their competitiveness. Therefore, the impact of the state on the innovation process can be diverse. M. Porter believes that the main goal of the government is to create a favorable and innovative environment for domestic enterprises. Each country should develop its own unique innovation system corresponding to its characteristic situation [124], [129].

There is no single universally accepted definition of the national innovation system. Many definitions of the concept of "national innovation system" used in scientific discussions were systematized in Table 1 taking into account the object approach. Table 1 presents the definitions that most clearly illustrate the adherence to one or another concept.

Table 1 - Interpretation of the term "national innovation system"

Presented (year)	Definition of the NIS concept
Freeman Christopher (1992)	Two different understandings are proposed, a broad and a narrow one. In a broad sense, the national innovation system includes the national economy for the introduction and diffusion of new products and the structures of all processes and systems related to them; in a narrower sense, the NIS includes only those institutions that are directly related to scientific and technological activities
Lundvall Bent Ake (1992)	The national innovation system is a set of elements and their interrelated roles in the production, diffusion and utilization of new, economically useful knowledge that form a networked system.
H. Ivanova (2001)	The national innovation system is a set of interrelated organizations (structures) involved in the production and commercialization of scientific knowledge and technologies within national borders (small and large firms, universities, laboratories, technoparks and incubators).
Jia Xiaofeng (2021)	The national innovation system is a social system led by the State, which takes full account of the fundamental role of the market in the allocation of resources, and which is closely linked to and interacts effectively with all types of scientific and technological innovation actors.
He Defang (2023)	The national innovation system is an open system that facilitates the generation, application and diffusion of new knowledge and technologies, the integration, interaction and dynamic development of all types of innovation factors and actors, and is an important guarantor of increasing the potential for scientific, technological and institutional innovation.
Hao Zheng (2023)	The NIS is a network of national research institutes, universities, enterprises, public research organizations, etc. with a clear division of labor and interaction between them aimed at increasing innovation potential and efficiency.

Source: compiled by the author based on [43],[108],[114],[115],[118].

In our view, the national innovation system is a set of research institutions, universities, firms and public institutions that can either contribute individually to the development and diffusion of new technologies or constructively interact in a series of activities to improve innovation capacity and efficiency, thereby contributing to economic growth. Educational institutions nurture innovative abilities, innovative firms produce innovations, and the state not only creates the framework conditions of the system, but also largely forms the motivational basis for the activities of system elements, many resources and institutions of the NIS, provides access to them, acts as a catalyst of processes in the NIS as a partner that reduces innovation risks [39]. The interaction of a number of institutions determines the pace and direction of technological learning and innovation in the country, allowing science and technology to integrate into the socio-economic system and develop in a coordinated manner.

The goal of the national innovation system is the continuous creation of scientific knowledge, its transformation into patents, specialized skills, new products and services through technological commercialization centers and technoparks, as well as the formation of the market of innovative products and services, ensuring the country's competitiveness in the global market [56].

There are several studies on the structure of the NIS: Christopher Freeman and Richard Nelson focused on the relationship between technological innovation, national economic development indicators and international competitiveness at the macro level, arguing that the NIS consists of public policy, education and training, non-industrial research institutions, research and development capabilities of firms, and industrial institutions. At the micro level, B. Lundvall focuses on the fact that the NIS consists of elements and linkages that interact and influence each other in the production, dissemination, and utilization of new knowledge (economically useful knowledge) [121]. In B. Lundvall's main subsystems are: internal organization of firms, inter-firm relations (industry structure), the role of the public sector, the role of the financial sector and other sectors, universities and the research and development sector. P. Patel and C. Pavitt define NIS as the various institutions in a national context, their incentive structures and their capabilities all determine the pace and direction of technological learning in a country [127]. The various NIS institutions include: firms, especially those that invest in innovation; universities and other educational institutions that provide basic research and related training; the public and private sectors that provide general education and vocational training; and the public, financial and other sectors that facilitate technological progress [64].

In general, there is no consensus or definition of what constitutes an NIS, but according to the above analysis of the composition of innovation systems put forward by scholars from different countries and international organizations, we can see that most scholars divide the national innovation system into 3-5 elements. Combined with the definition of national innovation system in this paper, a national innovation system is a set of research institutions, universities, firms and governments that can either individually contribute to the development and diffusion of new technologies or constructively interact in a series of activities to improve innovation capacity and efficiency, thereby contributing to economic growth. Theoretical approaches to the formulation of the national innovation system are based on the triple helix model of G. Itzkowitz and L. Leydesdorff [52],[91]. Thus, the constituent elements of innovation management studied in this paper include enterprises, the public sector and educational and research institutions (Fig. 4). As R. Nelson notes, NIS is a concept denoting a set of organizations whose interaction determines the innovative efficiency of national firms [126].

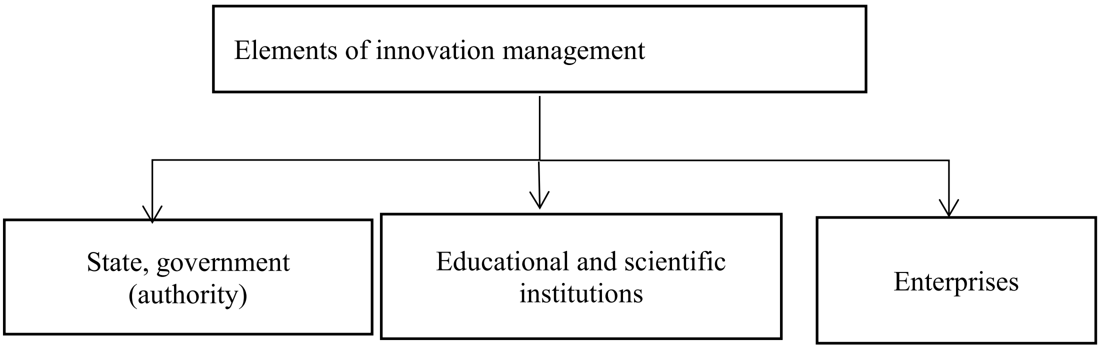


Figure. 4. Elements of innovation management (author's approach)
Source: Compiled by the author.

Innovation management plays an important role in the development of the national innovation system. The role of state support in the development of the national innovation system is to create a favorable environment and stimulate innovation in the economy. Public investment in research and development, creation of science and technology centers, attraction of foreign investment in innovation projects - all these are measures that can contribute to the development of innovation and economic growth.

1.3 Structural forms of innovation management

One of the most important aspects of modern economic development is the effective management of innovation processes. Structural forms of innovation governance play a key role in ensuring competitiveness and sustainable development of the economy. Innovation governance at the national level can be implemented through various structural forms, which are usually oriented towards stimulating and supporting innovation activities in the country. Structural forms of innovation governance can interact with each other to provide an integrated approach to innovation governance at the national level.

Scientific organization

Scientific organization is one of the forms and structures of innovation management. It is an organization (institution, enterprise, firm) where the main type of activity is scientific research and development. Such organizations may include units specializing in scientific research and innovation projects. For example, small and medium-sized research firms may be established near large university centers. They can cooperate with universities, rent land and use the university's laboratory and information technology equipment to conduct their research and development. Thus, scientific organizations play an important role in supporting and promoting innovation in the country.

Venture business

Venture business is one of the forms and structures of innovation management. Venture business is a special type of entrepreneurial activity that grew out of the American practice of organizing research. Venture business is represented by small independent companies specializing in research, development and production of new products. These companies are created by research scientists, engineers, and innovators. Venture business is widespread in the United States, Western Europe, and Japan. Venture capital firms often emerge as subsidiaries or independent entities, receiving financial support from large companies. Large companies usually do not engage in innovation directly, but seek to control the process and its results. Venture capital firms play an important role in creating innovation, and up to 60% of inventions such as the photocopier, microprocessor, and personal computer were created by such firms.

Venture capital firms usually specialize in the growth and saturation phases of innovation activity, as well as in the decline phase of research activity. They are often small and may be subsidiaries of larger firms. Venture capital firms are financed through the purchase of shares in new companies or the provision of loans with the possibility of conversion into shares. Venture capital is created by attracting not only large companies, but also banks, government, insurance, pension and other funds that invest in high-risk sectors such as new, emerging industries.

Thus, venture capital business is a special form of innovation management that promotes the creation and development of new products and technologies.

Explorers

Explorers are firms that specialize in creating new market segments or radical changes to existing ones. Unlike venture capital firms, which are often nonprofits, explorers are in the business of bringing innovative ideas to market. They do not organize production themselves, but rather outsource their developments to other companies such as patients and commutants.

Explorers are often led by engineers, who are the authors of the technical side of the project, and managers with organizational and commercial experience. They operate within the maximum of the innovation cycle and deliver outputs from the outset. Model financing schemes are developed to mitigate risks. Explorers operate within specific timeframes within which they must succeed. For example, financing may be for 48 months. The capital investment in a project is divided into five time periods, with each new investment being made only if the previous one has paid off. In addition, each subsequent investment is larger than the previous one and on more favorable terms for the explorers.

Technology Center and Science Park

The Technology Center and Science Park are established to organize and support high-tech activities. The Technology Center provides scientists and specialists with space, equipment and personnel for a limited period of time to develop new ideas. The Science Park is focused on the innovation process and the development of new technologies, providing infrastructure for the location of innovative enterprises and the implementation of pilot and small-scale production.

Technopark, technopolis, incubator

Technopark, technopolis and incubator are structures specialized in supporting scientific and technological organizations and innovative ideas. A technopark brings together various structures around a scientific center to support small organizations and creative teams in implementing research results into new machinery and technology. Technopolis, similar to a science park, specializes in applied research and development aimed at commercial applications. The incubator is designed to provide economic support to small innovative companies created by scientists and specialists to develop scientific and technological ideas.

Founding Center, Scientific and Technical Alliance

Foundation center and a science and technology alliance are different forms and structures of innovation governance that promote the development and commercialization of science and technology.

Founding center, also known as an "industrial yard", is an organizational form of innovation where enterprises linked by the science-production chain are established in the same territory and managed by a parent firm. This approach promotes closer interaction between research and manufacturing firms.

Science and technology alliance is a sustainable association of firms of different sizes with universities and government laboratories based on an agreement to jointly fund research and development and product development or improvement. Each participant contributes according to the agreement and is entitled to its share of intellectual property.

Innovative science and technology centers

Innovation Science and Technology Centers are one of the forms of implementation of state support for innovative development. They are created and supported by the state to stimulate innovation, scientific research and technological progress. The state provides Innovation Science and Technology Centers with financial support, infrastructure, tax incentives and other advantages so that they can effectively develop and commercialize innovations, cooperate with businesses and contribute to the growth of the national economy. Innovation Science and Technology Centers also play an important role in shaping and improving the national innovation system.

Innovation Science and Technology Centers play a key role in providing access to knowledge, technology and resources, especially in regions where there is no explicit specialization. They serve as places where organizations can learn and adapt new technologies and methods, and facilitate knowledge sharing and foster innovation.

In this way, Innovation Science and Technology Centers are platforms for innovation and knowledge sharing, facilitating the creation of new activities and strengthening the innovation capacity of both regions and organizations.

A clear understanding of the forms of innovation governance is essential to improve the mechanisms of public innovation governance in the modern stage. To achieve this goal, it is necessary to develop and implement effective governance strategies that help to stimulate and support innovation processes, as well as to coordinate the efforts of different bodies and structures in the field of innovation. Table 2 helps to better understand the variety of structural forms used in innovation governance and their main characteristics.

Table 2 - Structural forms used in innovation management

Structural form of innovation management	Description
Scientific organization	An organization with an emphasis on research and development
Venture business	A firm or organization that invests in promising start-ups with high growth potential
Technology center and science park	Specialized structures that promote and support innovative projects and research
Technopark, technopolis, incubator	Organizations and infrastructures that provide conditions for the development of innovative enterprises and startups
Founding center, scientific and technological alliance	Various structures and organizations that play a role in the field of innovation
Innovative scientific and technological center	Platforms for innovation and knowledge sharing that foster the creation of new activities and strengthen the innovative capacity of both regions and organizations

Source: Compiled by the author.

These structural forms provide different approaches to innovation management and can be used by regions depending on their objectives, resources and needs. It is important to choose the structure that best suits the specific situation and innovation objectives.

1.4 Role of state regulation in innovation management

Public governance of innovation development is a process that allows the state to regulate and facilitate innovation in the economy and society to create a favorable innovation ecosystem. This includes developing an effective innovation strategy and taking measures to achieve innovation goals [48]. In recent years, there have been many studies in this area offering various approaches and recommendations for creating a favorable innovation ecosystem [44]. The studies analyze the role of the state, existing problems, methodologies and experience of foreign countries in the state management of innovative development [94]. The tools of state innovation policy and approaches to assessing the effectiveness of innovation policy and strategy are also considered [90]. In general, studies of state management of innovative development are focused on the search for effective methods and solutions that promote the development of innovation and increase the competitiveness of the country.

State support plays an important role in the development of the national innovation system. State support contributes to the creation of a favorable environment for innovation, provides financial, organizational, information and consulting assistance to innovation projects and enterprises. Priority of state support for innovation activities includes allocation of financial resources, provision of logistical support, information component, consulting services, education development and support in foreign economic cooperation of innovative enterprises. State support measures include tax exemptions, educational services for innovation development, information and consulting services, infrastructure and other forms of assistance. This makes it possible to stimulate and develop innovation activities, attract talented specialists, promote technological progress, enhance competitiveness and improve the country's economic growth.

State support for innovation activities includes the following main priorities:

1.Allocation of financial resources for the realization of innovation projects. The state finances socially and economically significant innovation projects by providing budget investments, subsidies, grants, state and municipal guarantees.

2.Provision of necessary material and technical support and property base for innovation activities.

3.Provision of information assistance through the creation of specialized information systems and websites on the Internet, which are primarily aimed at cooperation with innovative SMEs.

4.Provision of advisory services. Innovation support institutes and centers are being established to provide advice on all aspects of innovation and development. Consulting includes the development, adoption and implementation of innovative projects, evaluation of their effectiveness and support in the implementation process.

5.Education development. Innovative development programs are formed for basic and additional education aimed at training specialists with scientific and technical knowledge and skills in the field of innovative activities.

6.Assistance and support in foreign economic cooperation of innovative enterprises. This consists of establishing partnerships with international innovation development organizations and promoting innovative products to international markets through various sales channels.

7.Development of innovation infrastructure at all levels and in all spheres of activity. Innovation infrastructure includes organizations that provide managerial, material and technical, financial, information, personnel, consulting and organizational assistance.

Fig. 5 shows the development of innovation infrastructure in Russia. The scientific and technological center is one of the modern forms of state support for innovation in Russia. The innovation science and technology center provides infrastructural and organizational assistance in the implementation of innovation activities. It brings together highly qualified scientific specialists, engineers and other professionals to promote innovation in various fields.

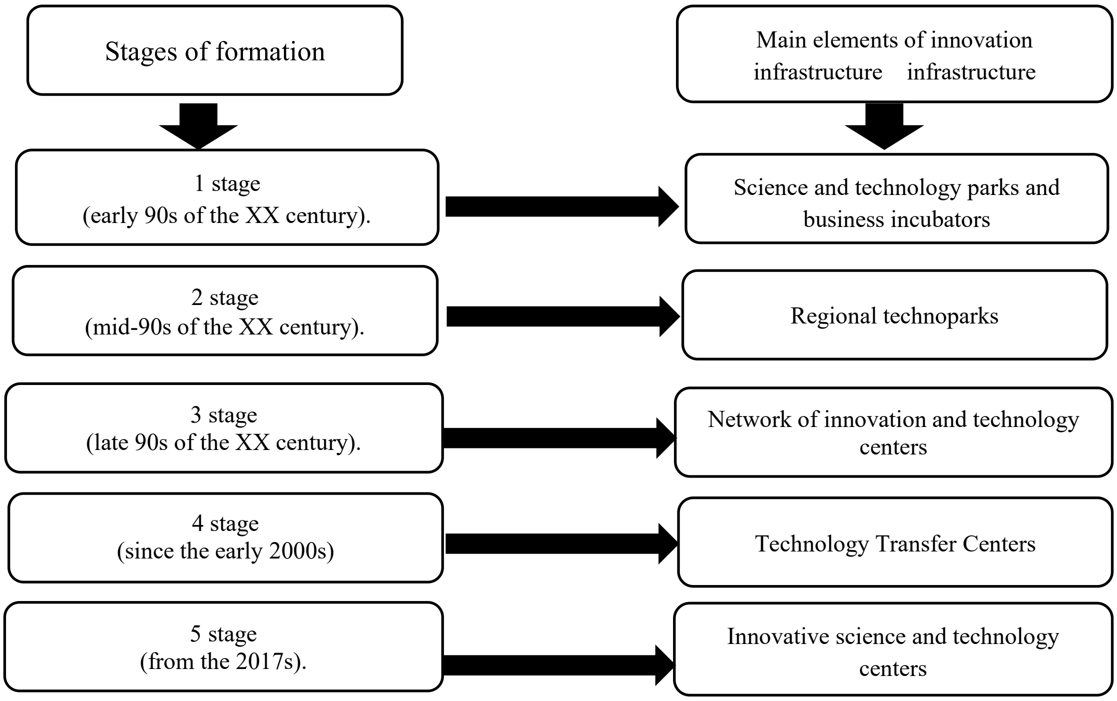


Figure. 5. Development of innovation infrastructure in Russia (author's approach)
Source: Compiled by the author.

According to the Federal Law of 23.08.1996 № 127-FZ (ed. from 17.02.2023) "On Science and State Scientific and Technical Policy", state support of innovation activity in the Russian Federation can be carried out by the following methods [25]:

-Provision of privileges on payment of taxes, fees and customs payments.

-Provision of educational services for the development of innovation.

-Providing information support, including access to information about the latest technologies, scientific developments and innovation projects.

-Providing consulting support and assistance in the formation of project documentation, including expert assessments and assistance in the preparation of business plans.

-Forming demand for innovative products by stimulating their use and distribution in the market.

-Financial support of innovation activities, including budget investments, subsidies, grants, credits, loans, guarantees and contributions to the authorized capital [70].

-Realization of target programs, subprograms and carrying out activities within the framework of state programs of the Russian Federation aimed at the development of innovation and science.

-Support for the export of innovative products, including measures to stimulate exports and provide access to international markets.

-Provision of infrastructure for innovation activities, including the creation and development of science and technology parks, innovation centers, technoparks and other infrastructure facilities.

-Providing other forms of support that do not contradict the legislation of the Russian Federation.

Table 3 shows the methods of innovation management support. These support methods can be applied to the development of innovations in the Russian Federation in accordance with the legislation and the state science and technology policy.

Table 3 - Methods of innovation management support

Types of support	Support methods
Allocation of financial resources	Provision of privileges on payment of taxes, fees and customs duties
	Financial support for innovation activities, including budget investments, subsidies, grants, loans, credits, guarantees and contributions to authorized capital
Information support	Provision of information support, including access to information on the latest technologies, scientific developments and innovation projects
Counseling support	Provision of consulting support and assistance in the preparation of project documentation, including expert assessments and assistance in the preparation of business plans
Educational development	Provision of educational services for innovation development
Assistance in foreign economic cooperation	Support for exports of innovative products, including export promotion measures and access to international markets
Infrastructure development	Providing infrastructure for innovation activities, including the creation and development of science and technology centers, innovation centers, technoparks and other infrastructure facilities
Other directions of support	Creating demand for innovative products

Source: Compiled by the author.

Fig. 6 shows the methods of innovation management support. The application of these methods promotes the development and formation of the state innovation system, stimulates scientific and technological innovation, technological transfer and modernization of industry, in general provides the improvement of forms of innovation management.

The first chapter of the dissertation examines the concept of innovation, the process of development of innovation theory and current research directions in the field of innovation theory. It also considers the system approach, the definition of the national innovation system, organisational structure, current topics and trends, as well as priorities and government support measures.

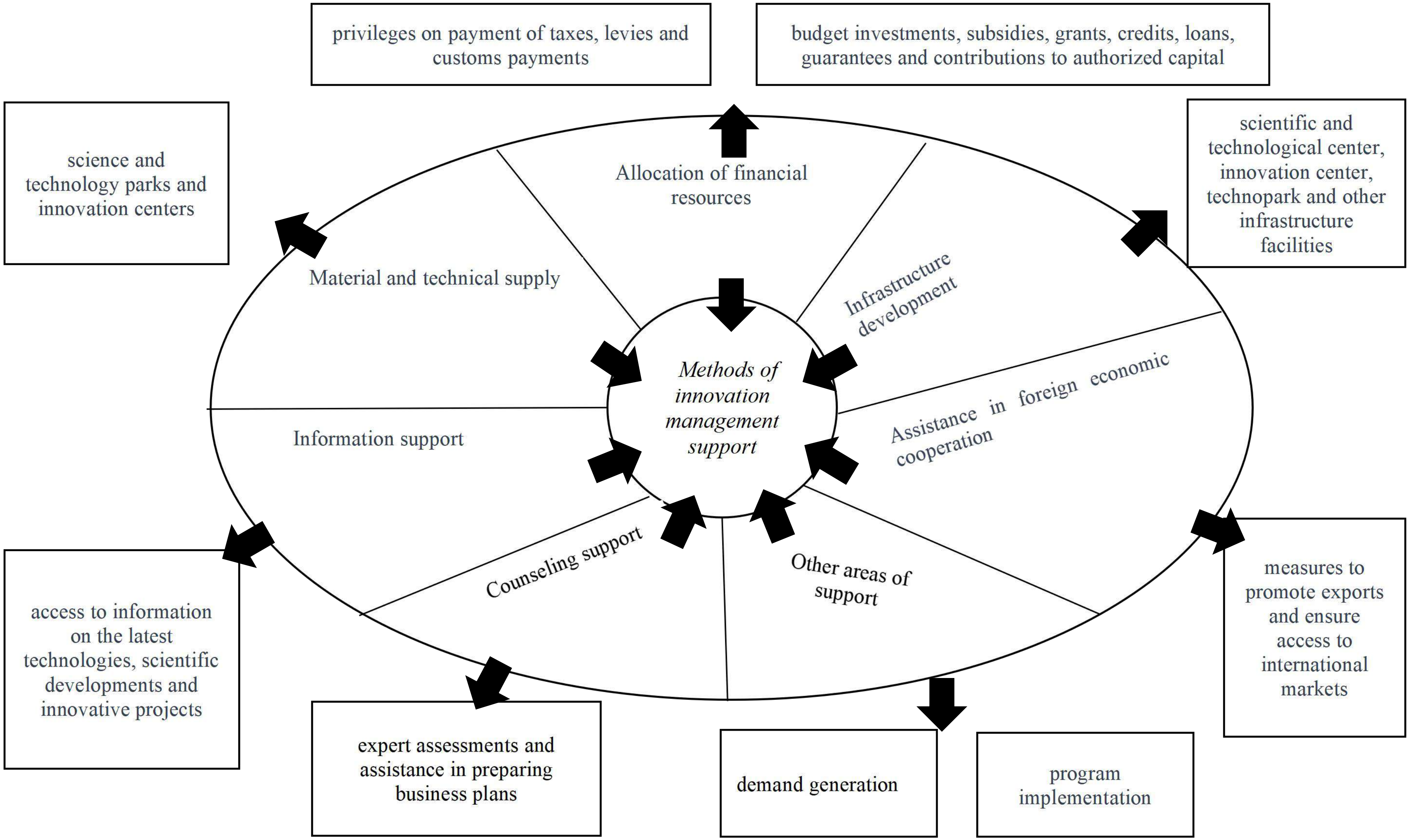


Figure. 6. Methods of innovation management system support

Source: Compiled by the author.

CHAPTER 2. MODELS OF INNOVATION DEVELOPMENT IN CHINA AND RUSSIA

2.1 China's model of innovation development

The construction of China's innovation management model is in accordance with the theory of national innovation system. In China, the NIS theory is widely used in practice and has become the theoretical basis for guiding the development of the national innovation system and its promotion. According to C. Edquist, the concept of NIS includes many historical and evolutionary phenomena. The innovation process develops under the influence of many factors and feedback processes and can be characterized as evolutionary [105],[106]. We believe that the development of China's independent innovation can be divided into four generations: the 1.0 generation is from 1949 to 1977, the 2.0 generation is from 1978 to 1994, the 3.0 generation is from 1995 to 2012, and the 4.0 generation is from 2013 to 2023 [67].

Mao Zedong started a new historical era of independent innovation development in modern China, which is the first generation of China's innovation development strategy. In 1956, the People's Republic of China published its first long-term science and technology plan, called the "Framework for Long-Term Planning of Scientific and Technological Development 1956-1967" [12]. This plan outlined important tasks, including a program to develop "two nuclear bombs and one space star," emphasizing a high degree of unity and centralized leadership in an "all-people system." The plan also focused on education and scientific research with the following objectives:

1.Strengthening the construction of higher education and scientific institutions, raising the level of scientific education, training highly qualified personnel, and developing scientific research.

2.Strengthening vocational education and technical training, improving the skills of technical workers and specialists.

3.Reforming the education system and optimizing the distribution of educational resources.

4.Strengthening international cooperation, studying and applying foreign experience in various fields of science, technology and management.

In this regard, the Chinese government has taken measures to introduce advanced foreign technology (t1), including strengthening scientific and technological exchange and actively recruiting advanced technical equipment and specialists. Between 1956 and 1976, China concluded 1,690 technical contracts with the Soviet Union, about 60% of which were related to various manufacturing industries such as machinery, metallurgy, and chemicals [72]. In addition, there were contracts in basic science, aviation, cosmonautics, electronics, and other fields. These technical contracts mainly included technology transfer, equipment imports, and training, which helped China to accumulate experience and technology in various fields. Such measures enabled China to attract a wide range of advanced technologies from abroad, including computer technology, aviation and aerospace, nuclear power, optics, communications, and others. The introduction of these technologies has predetermined the development of technical innovation in China.

Based on the introduction of foreign technologies, China has also gradually achieved the development of new technologies (t2). For example, in the field of computerization, China has developed its own computer system and application software, including Chinese character processing system, and others. China has also established research institutes and higher education institutions for scientific research and technological development, which has further strengthened its ability of technological innovation development. Fig. 7 clearly shows the rapid growth since the implementation of China's forward-looking S&T development plan for 1956-1967 in 1956, especially from the late 1950s to the mid-1960s. However, spending on scientific research remained relatively small compared to spending on education. Since the early 1970s, China's spending on education has continued to rise, while spending on scientific research has remained stable or even declined. Moreover, the growth in the number of scientific professionals has been erratic but has generally been on an upward trend. This indicates that education has become a particularly important area in China's national development strategy..

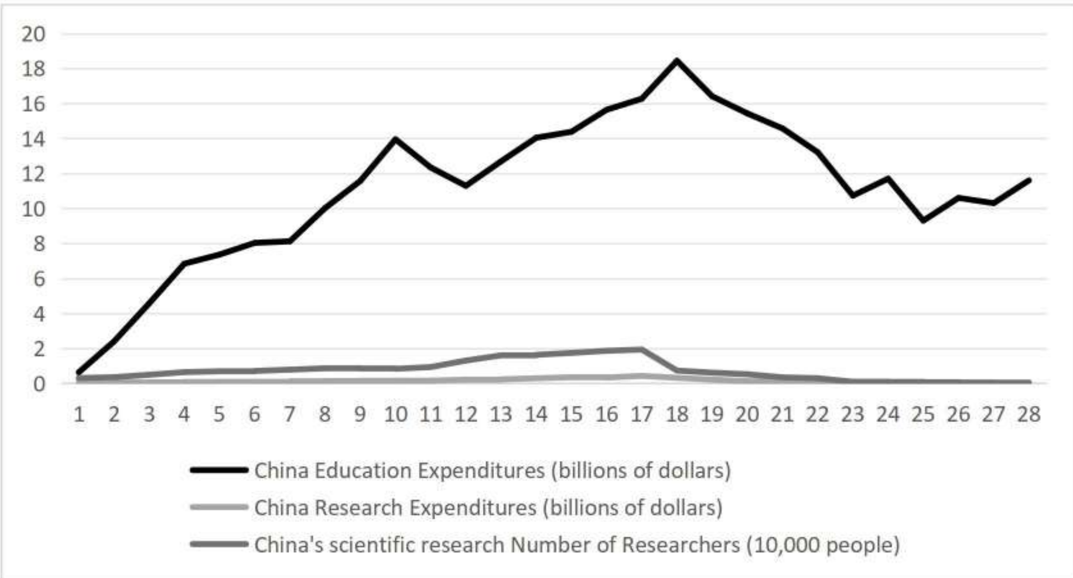


Figure 7. Expenditures on education, research and the number of researchers in China (1949-1976)

Source: Compiled by the author on the basis of [76].

However, it is necessary to pay attention to the fact that the introduction of foreign technologies is only one of the ways of technological innovation development, more important are the development of independent innovation and adaptation of technologies to local conditions [49]. During this period, in addition to adopting foreign technologies, China paid insufficient attention to developing its own technologies and improving its scientific and technological level and innovation capabilities.

Since the 1970s, China began to explore open innovation development. In March 1978, Deng Xiaoping first put forward the famous statement, "Science and technology are productive forces". The major documents on China's innovative development from 1978 to 2004 are shown in Table 4.

Table 4 - The content of innovation in the transformation of innovation policy in China from 1978 to 1994

Year	Policy / event	Content of innovations					
		International scientific and technical cooperation	International scientific and technical cooperation	International scientific and technical cooperation	International scientific and technical cooperation	International scientific and technical cooperation	International scientific and technical cooperation
1978	All-National S&T Conference	●					
1978	All-National Conference on Science and Technology Outside the Country	●					
1978	National Program for the Development of Science and Technology from 1978 to 1985	●		●	●		
1981	Report on China's Science and Technology Development Policy	●		●			
1981	National Conference on Science and Technology Outside the Country	●		●			
1982	Sixth Five-Year Plan for the Social and Economic Development of the People's Republic of China	●		●		●	●
1985	Decision on the Reform of the Science and Technology System	●	●	●	●		
1986	Seventh Five-Year Plan for the Social and Economic Development of the PRC			●	●	●	●
1988	Decision on Some Issues on Deepening the Reform of the Science and Technology System	●		●	●		●

1991	Ten-Year Science and Technology Development Program and Development Plan for 1985-1990	●	●	●	●	●	
1992	National Long-Term Science and Technology Development Program	●	●	●	●		●

Source: Compiled by the author based on [2],[3],[7],[8],[19],[20],[23],[27].

1978-1994 was the second generation of innovation development in China, which exhibited the following features:

1. Innovation was based on the ability to attract technology. During this period, innovation and technology development in China focused mainly on attracting and adapting foreign technology. The Chinese government introduced several developments to attract foreign technical equipment, experts and scientific research to stimulate technology development. Figure 8 shows the number of foreign experts coming to China during this period.

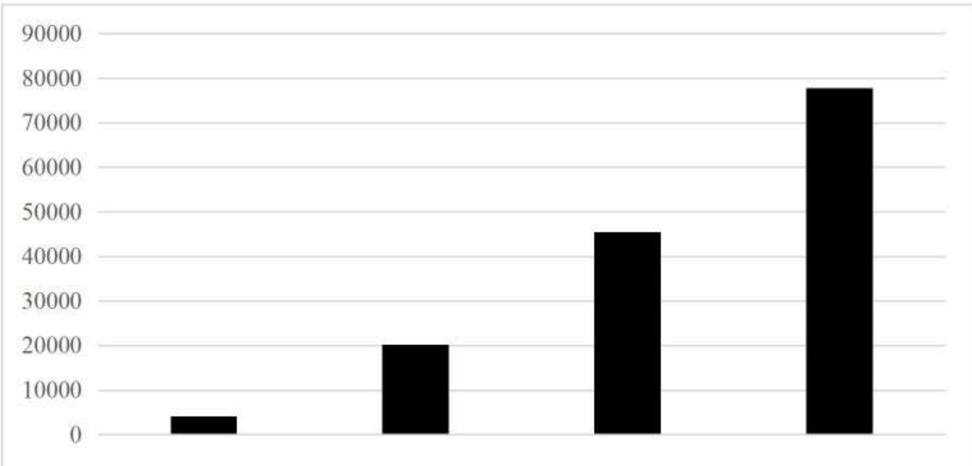


Figure 8. Number of foreign experts who visited China from 1978 to 1990.
Source: Compiled by the author on the basis of [84].

2. Although China's capacity for scientific and technological innovation remained relatively weak between 1978 and 1994, there were notable developments in human resource capacity, independent research, and technological breakthroughs. The Chinese government developed various methods to train and attract highly skilled researchers to the country, building a strong team of scientific professionals and providing support for scientific and technological innovation. Figure 9 shows that from 1949 to 1977, China had a low level of spending on education and research and a small number of scientific researchers. Since 1978, China has gradually increased investment in education and scientific research. In 1994, China's education expenditure amounted to 60 billion yuan, scientific

research expenditure amounted to 3.73 billion yuan, and the number of scientific workers reached 653,000, indicating that China's development level in scientific and technological innovation has improved.

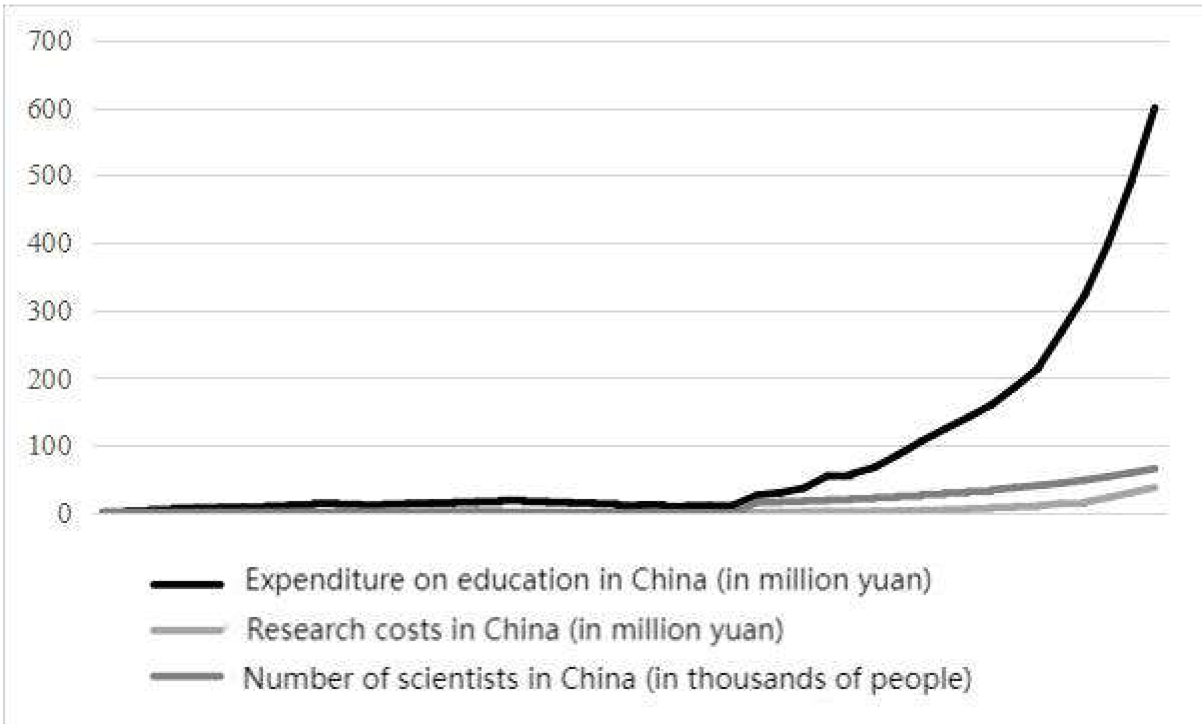


Figure 9. Dynamics of expenditures on education, scientific research and the increase in the number of researchers in China from 1949 to 1994

Source: Compiled by the author on the basis of [84].

The Chinese government has invested heavily in some technological areas, focusing on key technologies and industries. Table 5 shows China's investments in key areas between 1978 and 1994. These efforts yielded significant results in some key industries, such as nuclear weapons and satellites, high-speed railroads, microprocessors, and other technologies, which laid a solid foundation for the development of Chinese science and technology.

Table 5 - Number of China's technology investments from 1978 to 1994.

Year	Amount invested (in billions of RMB)
1978	0.4
1982	2
1986	6.4
1990	25.4
1994	41.2

Source: Compiled by the author on the basis of [84].

3.Formation of China's domestic market. After 1978, China pursued a policy of reform, gradually opening up its domestic market and attracting significant amounts of foreign investment and technology, which promoted the development of innovation in China. Here are a few points to support this:

First, the emergence of more market opportunities: the open market has provided enterprises with greater market prospects and intensified competition. As shown in Table 6, China's per capita expenditure increased significantly from 1978 to 1995, especially for urban residents. Compared with the data from 1952 and the Cultural Revolution and 1965, the consumption rate became higher during the period from 1978 to 1995, indicating the great consumption potential in China.

Table 6 - China's per capita consumption expenditure from 1978 to 1995.

Time period	Per capita living costs in urban areas	Per capita living costs in rural areas
1952	67.9 yuan	-
1965	185 yuan	67 yuan
1978	343 yuan	133 yuan
1995	3,319 yuan	1,249 yuan

Source: Compiled by the author on the basis of [76].

Second, increased inflow of foreign technology and expertise: China has attracted a large amount of foreign capital and foreign companies, which has provided important support for technological progress in China. The technology and management expertise contributed by foreign companies have had a positive impact on the innovation and development of Chinese companies (see Figure 10).

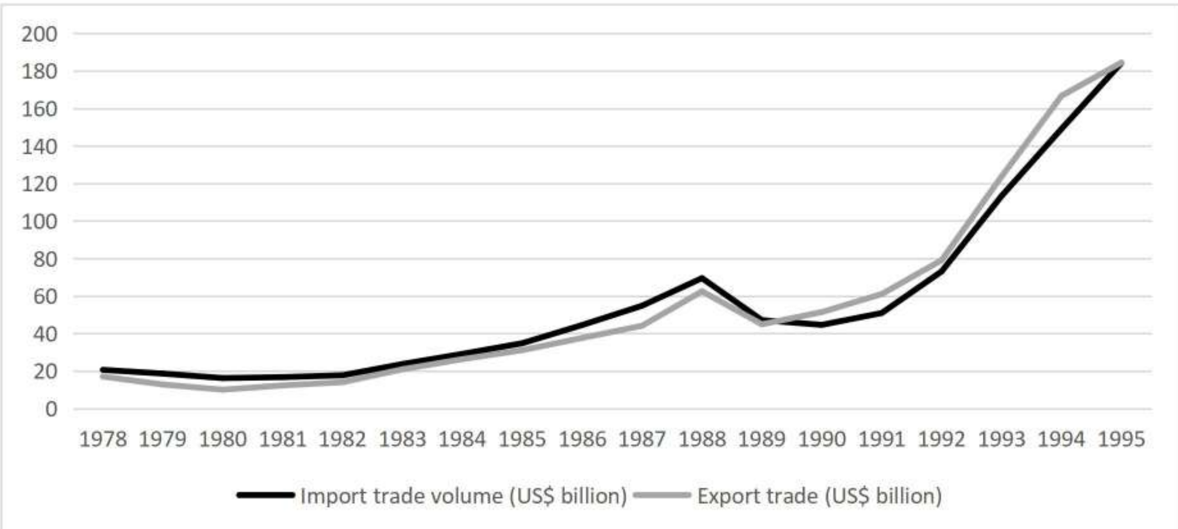


Figure 10. Sum of China's imports and exports from 1978 to 1995.

Source: Compiled by the author on the basis of [83].

Thirdly, the internal resources for innovation have been strengthened: enterprises in the competitive market have to constantly strive for innovation to maintain competitiveness. With the improvement of enterprises' competitiveness, the capacity for internal innovation has been strengthened. The number of enterprises in China from 1978 to 1995 is shown in Figure 11.

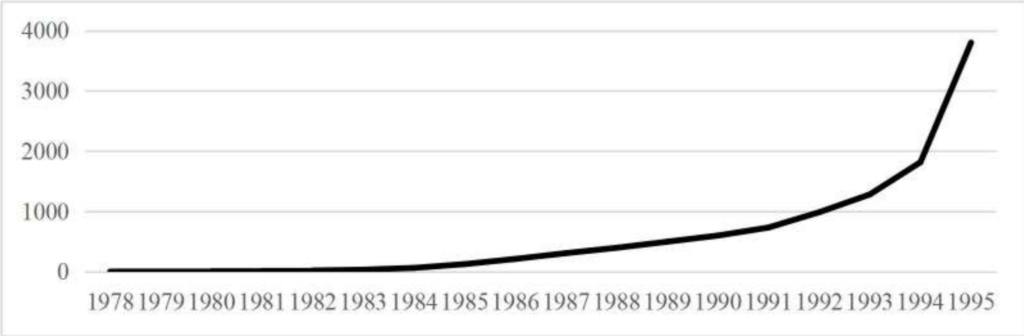


Figure 11. Number of enterprises in China from 1978 to 1995
Source: Compiled by the author on the basis of [83].

Fourth, opening up the domestic market also promoted international cooperation. Cooperation and exchange with foreign enterprises could provide Chinese companies with more innovative ideas and technical support. With the implementation of China's reform and opening-up policy, the number of contracts between Chinese and foreign enterprises gradually increased, and the volume and quantity of foreign direct investment also increased. Until 1980, the level of cooperation between Chinese and foreign enterprises gradually increased, but it was still limited. By 1985, the number of joint projects between China and foreign companies began to increase rapidly, and the scale and amount of foreign direct investment also increased significantly. Over time, the amount of foreign direct investment in China reached 15 billion U.S. dollars in 1990; in 1995, the amount of cooperation between China and foreign enterprises further increased, and the amount of foreign direct investment was approximately 45 billion U.S. dollars (see Figure 12).

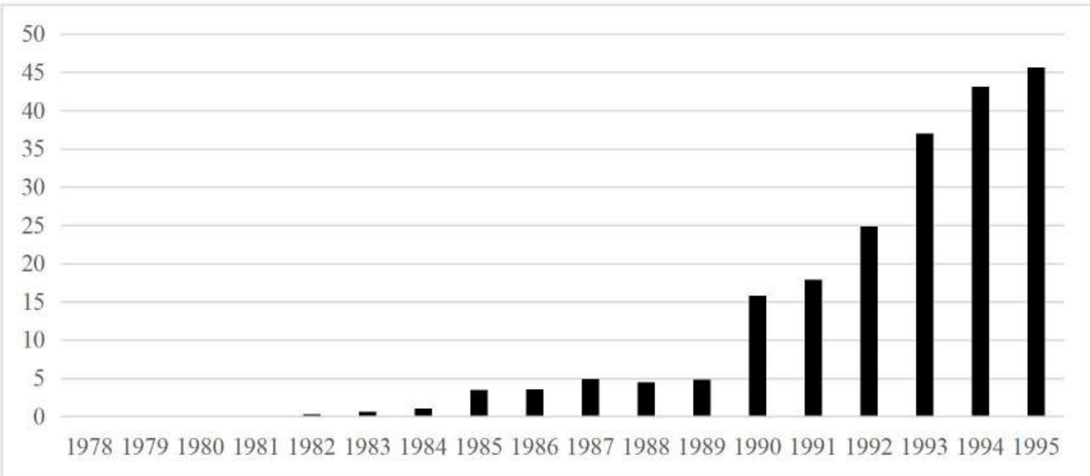


Figure 12: Foreign direct investment from 1978 to 1995 in China (In billion US dollars)
Source: Compiled by the author on the basis of [83].

Overall, the open domestic market (t4) has provided Chinese enterprises with greater development opportunities, increased the inflow of technology and expertise, boosted domestic innovation capacity (t3) and promoted international cooperation. All of these had a positive effect on stimulating innovative development in China. This was the second generation of China's innovation development strategy. During this period, a socialist market economy with Chinese characteristics was established, a unified open domestic market was gradually formed, and more investments were made in education and independent innovation development, which led to a significant improvement in China's ability to import technology (t1) and develop new technology (t2), which in turn gradually narrowed the technology gap between China and economically developed countries. Although China's economy continues to grow rapidly at present, this high growth rate is based on China's dependence on foreign technology, lack of technological expertise, and lack of long-term competitive advantage, making it difficult to transition to advanced technologies.

The late 20th century and early 21st century was a phase of advanced innovation in China. In 2001, China's accession to the WTO occurred, which had a significant impact on China's innovation in global markets. WTO accession not only increased the openness of the Chinese market (t4), but also promoted trade cooperation between China and other countries, providing more opportunities for Chinese enterprises to cooperate with enterprises from other countries and promote innovation in the global market (t5). In February 2006, the State Council of the People's Republic of China issued the "Long-Term Program for the Development of the Country's Science and Technology 2006-2020" [5], which formulated the guiding principles of S&T activities as "independent innovation, achievements in key areas". The promotion of independent innovation capability (t3) is prominent. At this stage, China has embarked on the path of "importing basic technologies from developed countries - introducing independent innovation - commercializing technologies in the domestic market - promoting and commercializing technologies in the international market". This is the beginning of China's construction of national innovation system. The main documents of China's R&D from 1995 to 2011 are summarized in Table 7.

Table 7 - Innovation Content of Innovation Transformation in China from 1995 to 2001

Year	Policy/event	Content of innovations							
		Independent innovations	Technological imports	Attraction personnel	Departure of personnel	Attracting foreign investment	Investing abroad	Foreign research and development of enterprises	International cooperation of research institutions
1995	Decision on Accelerating Scientific and Technological Progress		●	●	●	●	●	●	●
1998	Ninth National Science and	●	●	●	●				

	Technology Development Plan and Long-Term Program for 2010								
1999	Decision on significant technological innovation development, development of high technologies and their implementation in industrialization	●	●	●			●	●	
2001	Program of Key Projects for International Scientific and Technological Cooperation	●		●	●				
2006	Long-term program for the development of science and technology of the country for 2006-2020	●	●	●	●	●	●	●	●
2010	Long-term program for the development of human resources for 2010-2020			●	●			●	●
2011	Long-term program for the development of scientific personnel for 2010-2020	●		●	●		●	●	●

Source: Compiled by the author based on [1],[4],[5],[6],[15],[21],[22].

1. From 1995 to 2011, the rate of foreign technology attraction by enterprises has increased significantly, with the focus on the attraction of foreign key technological knowledge during this period. Technology licensing and translation, technology consulting and technical services related to patent technologies have been increasingly emphasized. In this period, the cost of attracting technology from abroad and buying domestic technology is increasing faster than the cost of attracting technology in the previous period (Figure 13). This indicates that Chinese enterprises are facing increasing technology and innovation needs in this period, and they need to increase investment in technology imports and independent development to meet the ever-increasing market competitiveness and product quality requirements. At the same time, it also indicates the efforts of Chinese enterprises to promote technological innovation and independent scientific research, continuously improving innovation utilization and competitiveness..

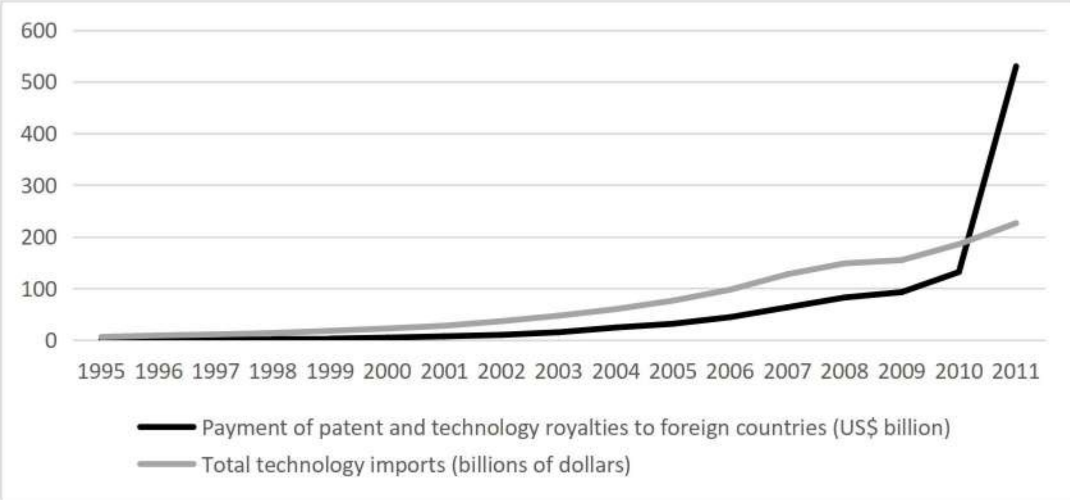


Figure 13: Payment of patent and license fees for providing technology abroad and China's total technology imports from 1995 to 2011

Source: Compiled by the author on the basis of [83].

2. The Chinese government increases investment in science and technology, encourages enterprises to innovate independently, and strengthens intellectual property protection through a series of measures, gradually promoting independent innovation and industrial upgrading. From 1995 to 2011, the Chinese government increased spending on education and science from year to year (see Figure 14). Education spending increased from 94.27 billion yuan in 1995 to 7874.26 billion yuan in 2011, an increase of about 8 times, and scientific research spending increased from 4.89 billion yuan in 1995 to 706.1 billion yuan in 2011, an increase of about 14 times. This shows that the Chinese government continues to increase its investment in education and science and its support for scientific research. In 2008, China formulated the National Intellectual Property Framework Strategy, which gave the protection of intellectual property rights the status of a national strategy..

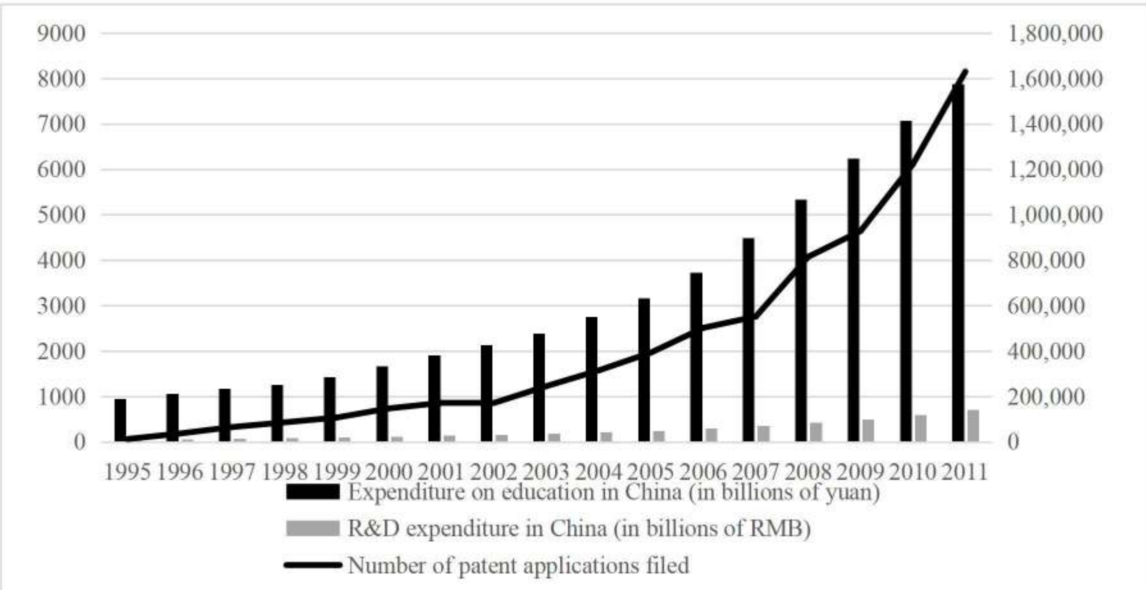


Figure 14: Trends in education expenditure, R&D expenditure and patent filings in China from 1995 to 2011

Source: Compiled by the author on the basis of [84].

3. China's growing outward investment has provided Chinese enterprises with a wider market and access to resources, making it easier to learn and borrow technology and management expertise, and broadening horizons and ideas for innovation. Figure 15 shows the annual trend of China's overseas investment volume from 1995 to 2011. It can be seen that the overseas investment volume started to increase from 1995 with 7.7 million USD and reached 7.722 billion USD in 2011, increasing nearly 1,000 times. Since 2004, China's overseas investment has started to grow rapidly, which is also due to the fact that China is gradually becoming the world's second largest economy and the world's top exporter. These indicators show that Chinese outbound investment has become an important player in the global economy and business arena. Outward investment has brought new technologies, management expertise and access to market resources, improving the technological and innovation capabilities of enterprises and accelerating the technological upgrading and self-innovation of Chinese companies.

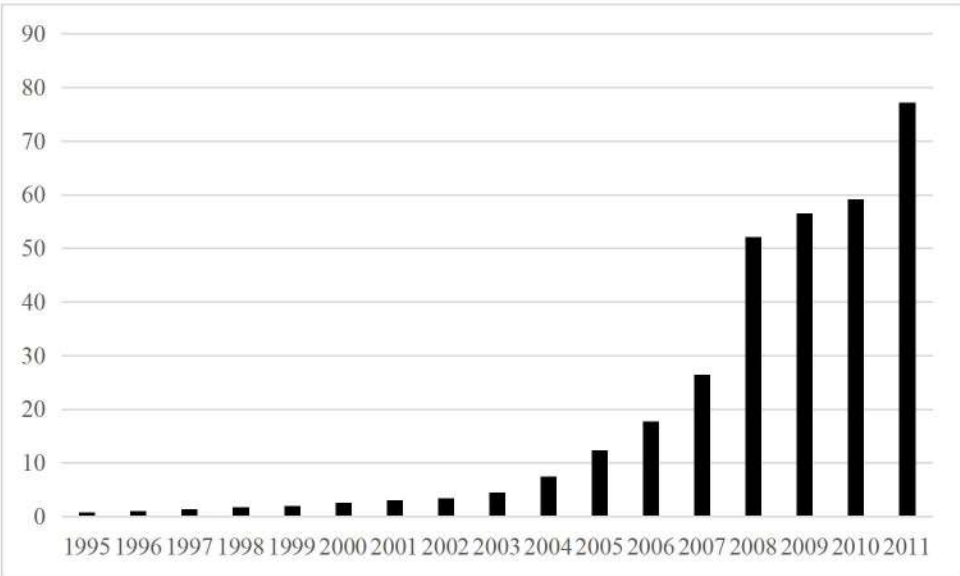


Figure 15. Amount of Chinese investment abroad from 1995 to 2011

Source: Compiled by the author on the basis of [83].

4. 4.China continues to increase investment in supporting young scientists by encouraging startups, attracting outstanding foreign researchers, and developing a system for training high-caliber professionals. This has improved the quality and quantity of the talent pool, which provides significant support for China's economic development and technological innovation. Figure 16 shows that the number of foreign experts coming to China increased from 5.77 thousand in 1995 to 26.57 thousand in 2011, the number of Chinese scientific researchers increased from 705 thousand in 1995 to 1.66 million in 2011, and the number of university graduates increased from 1.249 million in 1995 to 6.996 million in 2011. These data show the importance of China's attracting foreign experts and supporting

local scientific experts and graduates, reflecting China's development trends in science and education.

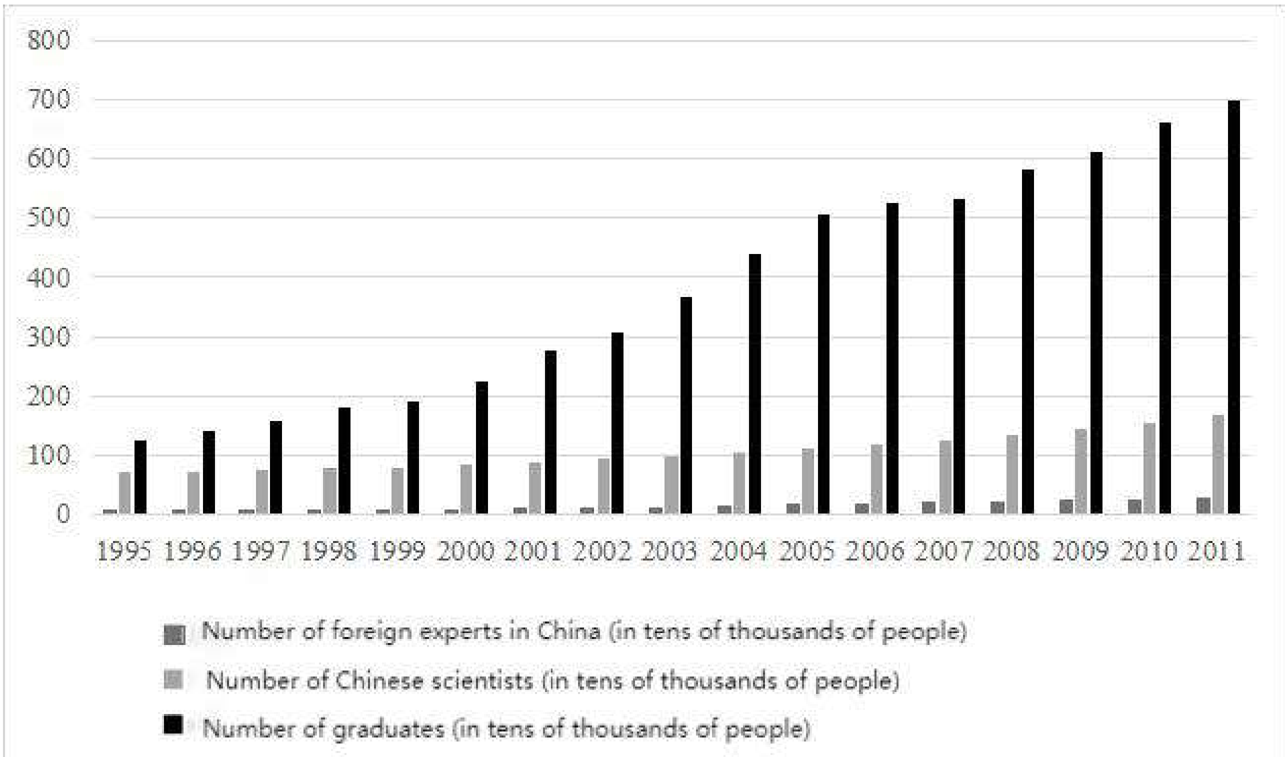


Figure 16. Number of foreign experts, Chinese researchers and graduates from 1995 to 2011

Source: Compiled by the author on the basis of [84].

During this phase, the Chinese government strengthened its own innovation capacity (t3), continued to develop international markets (t5) and domestic markets using budgetary allocations and financial support (t4). This period was the third generation of innovation development strategy, during which China achieved leapfrogging development in scientific and technological innovation. As the ability of firms to apply innovation in the domestic market (t4) and international market (t5) increased significantly during this period, China's technological innovation accelerated and caught up with advanced Western technologies.

Scientific and technological progress is a strategic pillar for improving the country's productivity and overall strength, and should occupy a key position in the country's overall development strategy, and "an innovation-oriented development strategy should be implemented". Since then, China has released a series of policy documents and reform measures, such as the "Opinions on Deeply Reforming the Science and Technology System and Accelerating the Construction of the National Innovation System" and the "General Outline of Innovation-Oriented Development". They were designed to systematically plan and powerfully promote the innovation-oriented development strategy (Table 8).

Table 8 - Innovation content of China's innovation policy transformation from 2012 to 2016

Year	Politics/Events	Innovative behavior					
		Supporting innovation in small and medium-sized businesses	Independent innovations	Establishment of technology parks and high-tech districts	Attracting talent	Sending talented scientists for overseas research	Researching companies abroad
2012	On the deep reform of science and technology system to accelerate the construction of national innovation system	●	●	●	●	●	●
2015	Several views on deep reform of institutional arrangements to optimize the innovation-based development strategy.	●	●	●	●	●	●
2015	of institutional mechanisms to optimize innovation-driven development strategy	●	●		●		●
2016	Manufacturing in China 2025	●	●	●	●	●	●

Source: Compiled by the author based on [9],[10],[11],[17].

Later, there were incidents with ZTE and Huawei, and the policy of technological detachment from the US intensified, which put pressure on China's high-tech industry. In 2016, China released the "Key Guidelines for Innovation-Driven Development Strategy," which formulated tasks and goals to accelerate the implementation of the innovation development strategy, and proposed a series of policy and operational measures, including strengthening basic research and promoting the interaction between manufacturing, education, and science. A key element has been a greater emphasis on self-driven innovation, with an elevation to a new level. This stage can be regarded as a continuation of the systematic promotion of the national innovation system started in 2006, but in fact a new stage in the development of the national innovation system was launched. The features of China's development in this period of innovation development are expressed as follows:

From 2012 to 2022, the Chinese government has provided various financial and tax incentives for innovative enterprises. For example, the establishment of innovative enterprises can be exempted from taxes and receive financial support. In addition, the Chinese government has proposed a strategy to develop a new era of "mass entrepreneurship and innovation" by encouraging people to participate in innovation. The favorable policy environment for the development of innovative enterprises and mass entrepreneurship has created favorable conditions for increasing market innovation forces. As shown in Figure 2.11, by the end of 2021, the number of SMEs in China reached 48 million, 2.7 times that of the end of 2012, and the average daily number of newly established enterprises in China in 2020 was 24.8 thousand, 3.6 times that of 2012. Small and medium-sized enterprises are the largest and most dynamic group of enterprises and have become the driving force of China's economic and social development.

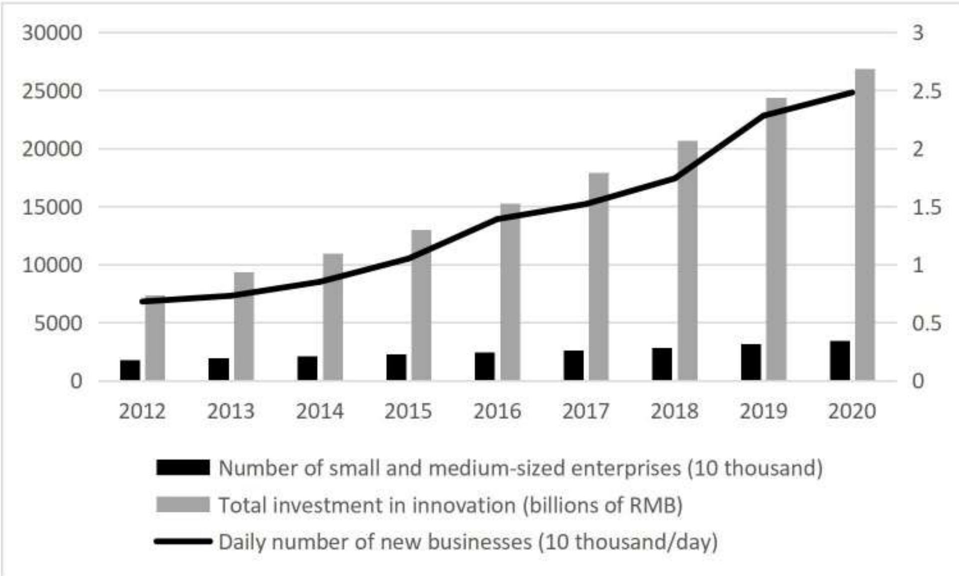


Figure 17: Number of SMEs, total innovation investment and average daily number of new enterprises in China, 2012-2020.

Source: Compiled by the author on the basis of [83].

The second aspect is the rising strength in regional innovation. In 2012, the total S&T expenditure of local financial authorities exceeded the total S&T expenditure of the central government for the first time, and this trend continued to strengthen. As shown in Table 2.2, in 2020, the S&T expenditure of China's financial authorities totaled 10717.4 billion yuan, an increase of 12.6% year-on-year. Specifically, the S&T expenditure of the central government increased by 11.6% to 4173.2 billion yuan, and the S&T expenditure of local financial authorities increased by 13.2% to 6544.2 billion yuan. The rising strength in regional innovation is conducive to the growth and development of local economy, enhancing the competitiveness of regional industry, attracting more investment and talents, and can stimulate progress and innovation in science and technology, promote technology transformation, and promote industrial upgrading and transformation. In addition, each province plans to develop specific science and technology innovation plans for the period from 2021 to 2025 based on the Fifteen-Year Plan and the long-term program until 2035. Each province conducts research and analysis according to the local situation and needs of S&T development, closely links its strategic plans with the development of the local economy, identifies areas of shortage and launches major S&T innovation projects, and realizes S&T innovation parks (see Table 9).

Table 9 - Spending on science and technology in China in 2022

Type of activity	Expenses (billions of yuan)	Growth rate	Percentage of expenditure
General	307823.9	10.1 %	100 %
Basic research	2023.5	11.4 %	6.57 %
Applied research	3482.5	10.7 %	11.3 %
Experimental design	25276.9	9.9 %	82.1 %
Subject	Expenses (billions of yuan)	Growth rate	Percentage of expenditure
Enterprises	23878.6	11 %	77.6 %
State-owned research institutions	3814.4	2.6 %	12.4 %
Higher education institutions	2412.4	10.6 %	7.8 %
Other subjects	677.5	22.3 %	2.2 %

Source: Compiled by the author on the basis of [76].

The third aspect is the increasing digital innovation. At present, there is a profound evolution of the digital technology system, which generates digital technology innovation and industry changes [66]. At this special moment, China is skillfully seizing the opportunities of the digital technology system and making some progress in digital technology innovation, application innovation and commercial models. Figure 18 shows the data of China's digital economy scale, digital economy share of GDP and e-commerce volume from 2012 to 2020. The scale of digital economy refers to the total value of digital economic industry per year. It is constantly increasing, starting from 6573 billion yuan in 2012 and reaching 39.2 trillion yuan in 2020. The digital economy's share of GDP shows how much of the GDP the digital economy accounts for, and it also continues to increase as the scale of the digital economy grows. E-commerce volume measures the volume of commercial transactions completed through digital channels such as the internet and mobile internet. This volume has also been steadily increasing, starting from 8.1 billion yuan in 2012 and reaching 316 billion yuan in 2018, but due to the COVID-19 epidemic, it has slightly decreased in 2020. Figure 18 reflects the rapid growth of the digital economy and its important contribution to China's economy. Digital technologies enable enterprises and innovators to release products and services faster, conduct experiments and feedback loops. These technologies also provide innovators with more data and information and expand the market and opportunities for enterprises and innovators. With digital technologies, innovators can collaborate and share experiences with experts and peers around the world, allowing them to work more effectively on innovation. Representatives of major digital platforms such as Alibaba, Tencent, ByteDance and others have become symbols of China's innovation power in the digital industry.

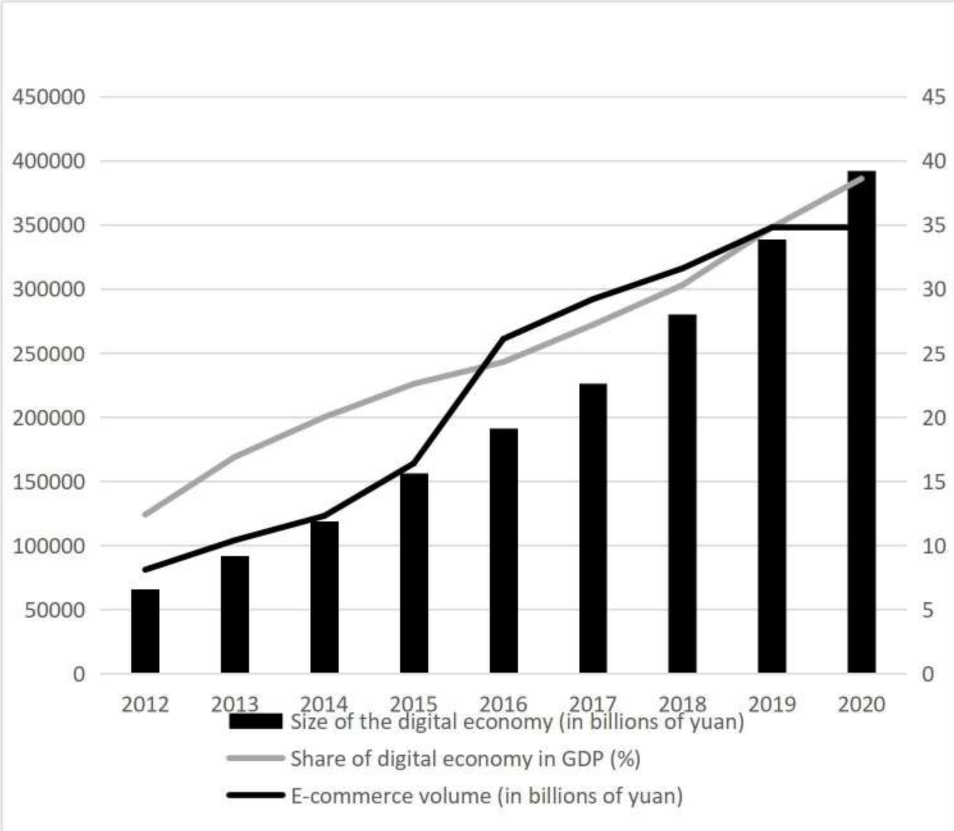


Figure 18: Dynamics of China's digital economy size, digital economy share of GDP and e-commerce volumes from 2012 to 2020

Source: Compiled by the author on the basis of [76].

The fourth aspect is to strengthen China's innovation system, promote the integration of science and technological progress with production, and encourage innovative development in various sectors of the economy, which has increased the innovation capacity of the whole country. China actively develops the innovation system, including various areas such as technology attraction (t1), innovation in science and technology (t2), independent innovation (t3), domestic market innovation (t4) and global market innovation (t5), and develops human capital.

Table 10 - Five directions (t1-t5) of China's innovation system

Direction of the innovation system	Specific content of innovation
Ability to attract technology (t1)	China actively attracts foreign advanced technology and talents to promote the improvement of technological level. Since 2015, China has become one of the largest countries in the world in terms of technology attraction. China has also strengthened technology transfer and protection of intellectual

	property rights domestically
Ability to recreate technology (t2)	China has made great efforts in technological reconstitution, including bringing innovation, imitation and integration. The efforts of Chinese enterprises in this area are evident, such as the experience of successful companies such as Huawei, Xiaomi and Alibaba
Ability to innovate independently (t3)	China is continuously improving its ability to innovate on its own. At the policy level, China has introduced a series of innovation policies and plans, such as "Made in China 2025", "Innovation Development Strategy", etc. At the practical level, China has increased investment in R&D institutions and enterprises, raised the salaries of scientific and technical workers and incentivized their motivation
Ability to innovate in the domestic market (t4)	The Chinese market provides tremendous opportunities for innovation. The Chinese government encourages enterprises to innovate in the domestic market, namely encouraging digital economy, new infrastructure, green development, etc. These innovations are determining a new impetus for China's economic development
Ability to innovate in the global market (t5)	China also continues to improve its ability to innovate in the global market. Chinese companies obtain new technologies and market resources through international cooperation, mergers and acquisitions, and overseas investment. At the same time, the Chinese government is actively promoting strategies such as "One Belt, One Road" and strengthening innovation cooperation with other countries

Source: Compiled by the author.

In addition to developing the innovation system in five areas including scientific technology import capability (t1), secondary scientific creation capability (t2), independent scientific creation capability (t3), national innovation in the domestic market (t4) and innovation in the world market (t5), since the 18th Party Congress, China has taken a series of measures to strengthen the development of innovation capability. These measures have helped raise the innovation consciousness and entrepreneurial spirit of professionals, promoted scientific and technological progress and production upgrading, and accelerated the transformation and modernization of China's economy. The specific measures are shown in table 11.

Table 11 - Measures of human resource capacity development in China

Policy areas	Specific measures
Human resources policy	The Chinese government has issued a series of policy measures to attract and train high-level cadres. For example, the introduction of the "thousand talents" program to provide benefits for highly skilled cadres, including financial support, priority development opportunities and family placement, etc. The government has also approved a series of policies to strengthen training and recruitment, encourage innovation and new enterprise creation, and protect intellectual property
Education reforms	The Chinese government has increased investment in higher and vocational education, and encourages changes in training programs to cultivate innovative professionals with an entrepreneurial spirit. The government also encourages the integration of scientific and technological innovation and production, and promotes cooperation between schools and enterprises to provide students with more

	opportunities for practice
Knowledge-intensive innovations	The Chinese government has increased investment in knowledge-intensive innovation and has developed a number of policies to support innovation. For example, supporting the commercialization of scientific achievements, encouraging the development of knowledge-intensive enterprises, strengthening intellectual property protection, etc. The government also supports the "dual creation" program, which encourages innovation and entrepreneurship and cultivates more innovative cadres
Human resource mobility	The Chinese government encourages the mobility of cadres between China and other countries to promote the exchange of experience and cooperation. The government has also set up a number of platforms to facilitate communication and cooperation between Chinese and foreign professionals

Source: Compiled by the author.

After more than 70 years of innovation management development, China has already fully established a complete, modern national innovation development system, which includes research institutes, higher education institutions, enterprises and other participants. This is evident not only in the establishment of basic institutional provisions in the cores of the national innovation system, such as technology plans and projects, higher education, scientific research, industrial scientific and technological development, but also in the fact that innovation policy has become a sustainable direction of social and economic development. According to the Global Innovation Index (GII) published by the World Intellectual Property Organization, Cornell University and the European School of Management in 2021, China ranked 12th in the global ranking of innovation capacity. The number of Chinese researchers, scientific articles and patent applications have been leading the world for several consecutive years [77]. The total amount of Chinese investment in research and development ranks second in the world after the United States. China has made significant progress in scientific and technological progress. Since 2012, China has moved to the stage of full-fledged innovative development. Table 12 summarizes the evolution of China's innovation development strategy from 1949 to 2020.

Table 12 - Evolution of China's innovation development strategy (1949-2023)

	First generation(1949-1976)	Second generation (1977-1994)	Third generation (1995-2011)	Fourth Generation (2012-2023)
Main topic	Introduction of technology	Open Innovations	Independent innovative development	General innovation activities
Innovation capabilities and	Introduction of advanced technologies from abroad	International scientific and technical cooperation and	Increase in the rate of adoption of foreign technologies (t1,	Rapid growth in the ability to independently innovate (t3)

innovation mechanism	(t1)	technology deployment (t1)	t2)	
	Independent innovation at the local level (t2)	Significant increase in the rate of assimilation of foreign technologies (t2)	Significant increase in the ability to innovate independently (t3)	Increased capacity for innovative development in the domestic market (t4)
		Formation of the initial level of independent innovation activity (t3)	Continued development of the domestic market (t4)	Increased ability to innovate in the international market (t5)
		Continued development of the domestic market (t4)	Large-scale involvement of innovative global market opportunities (t5)	Integration of innovative capabilities (5t+1)
The way innovation resources are allocated	Emphasis on planning	Establishment of a socialist market economy, active involvement of advanced technological means	WTO accession, integration into the world market and active development of independent innovations	Creation of a national innovation system, transformation into a global scientific and technological powerhouse

Source: Compiled by the author.

In general, the theoretical mechanism of innovation development can be summarized into the "5T+1" model (see Figure 19): human resources are the source of innovation, and training and development of human resources are the root of innovation. Only when human resource quality improvement and human resource development are prioritized can innovation driving force be provided. Innovation capability includes five types: technological adoption capability (t1), technological innovation capability (including innovation adoption, innovation imitation and complex innovation) (t2), self-innovation capability (t3), domestic innovation capability (t4) and international innovation capability (t5). These important components of state innovation capacity, enhancing the innovation ability of "5T" and forming collaborative innovation capabilities are the main ways to build an innovative state and one of the main reasons for the accelerated reduction of the huge gap between developed countries and countries lagging behind.

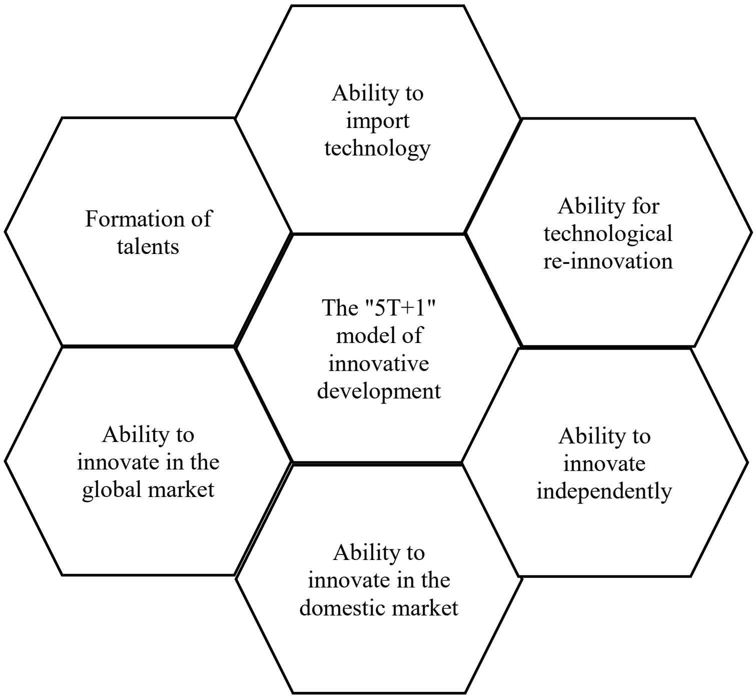


Figure 19: The "5T+1" model of innovative development
Source: Compiled by the author.

This is due to the fact that, according to the innovation theory, most technologically backward countries belong to the category of Catch-up Innovation, when technological development mainly depends on external sources, which ensures rapid growth of technological capabilities. Technologically advanced countries move to the stage of internal innovation (Endogenous Innovation), when technological capabilities grow more slowly due to internal processes [45]. Therefore, if lagging countries can fully utilise the "sequential advantages" brought by t1, t2 and t3, as well as the "first-mover advantages" created in the domestic and global market (t4 and t5), the technological capabilities of such countries can increase several times. Even if a country has a very low starting level of development, it can become a "world technology leader" and achieve the goal of becoming a strong S&T country. This model means that the level of China's S&T development can quickly move from the level of "follower" to the level of "equal partner" and then to the level of "leader", if we use the theoretical framework: from "technology delay", "information delay", "knowledge delay" and "economy delay" to move to a qualitative leap in innovation development. However, it is worth noting that achieving equal partnership and then overcoming it by utilising sequential advantages and creating pioneering advantages has its own conditions: firstly, it depends on the degree of openness of a country, and secondly, it depends on the degree of its ability to assimilate and use national resources.

A review of 70 years of innovation development experience in China shows that the innovation development strategy has moved from the first generation of scientific and technological innovation to the fourth generation of overall innovativeness through the use of the "5t+1" innovation development model (Figure 21). From the perspective of this historical evolution, innovative development means combining technology and trained human resources, technology and industry, technology and market, and combining domestic and international markets to form social innovation capability. This reflects the continuous improvement of the 5t innovation capability. The innovation-oriented development strategy is implemented through maximising the innovation mechanism of "5t+1" by allocating spatial and temporal innovation resources. From this perspective, China's path to innovation-oriented development is a path of "catch-up" development for countries with technological backwardness.

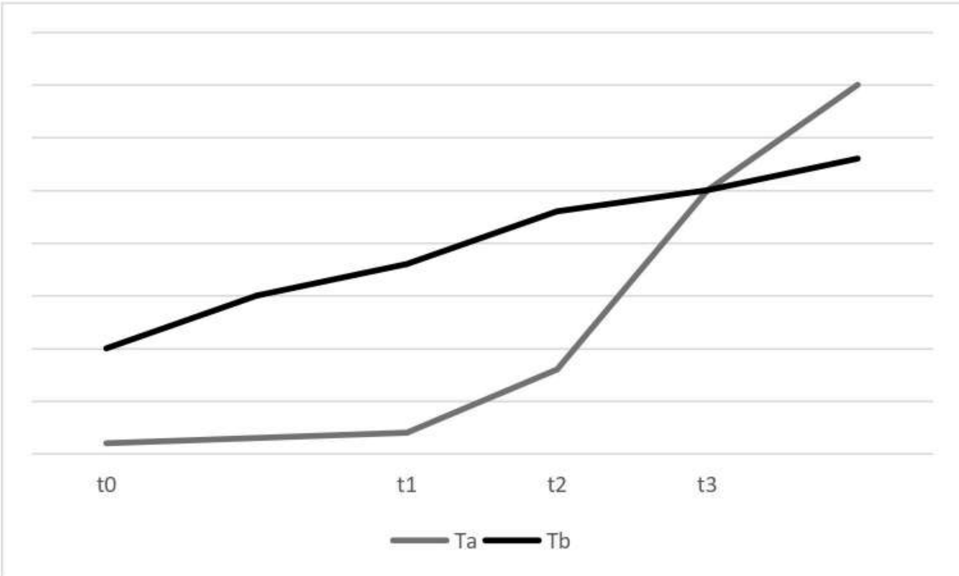


Figure 20: Development model of technologically backward countries: from lagging behind to catching up

Source: Compiled by the author.

This is because, according to the innovation theory, most technologically lagging countries fall into the category of "Catch-up Innovation" countries, where technological development primarily depends on external sources, enabling rapid growth of technological capabilities. Technologically advanced countries transition to the stage of "Endogenous Innovation," where technological capabilities grow more slowly due to internal processes [45]. Therefore, if lagging countries can fully leverage the "sequential advantages" brought by t1, t2, and t3, as well as the "first-mover advantages" created in the domestic and global markets (t4 and t5), the technological capabilities of such countries can increase several-fold. Even if a country starts with a very low level of development, it can become a "world technology leader" and achieve the goal of becoming a strong country in the field of science and technology. This model implies that China's level of scientific and technological development can rapidly transition from being a "follower" to an "equal partner" and then to a "leader" if it utilizes the theoretical framework: transitioning from "technology lag," "information lag," "knowledge lag," and "economic lag" to a qualitative leap in innovation development. However, it is worth noting that achieving equal partnership and eventually surpassing it through the use of sequential advantages and the creation of first-mover advantages has its conditions: firstly, it depends on the country's degree of openness, and secondly, it depends on the extent of its ability to absorb and utilize national resources.

A review of 70 years of innovation development in China shows that the innovation development strategy has transitioned from the first generation of scientific and technological innovation to the fourth generation of overall innovation thanks to the utilization of the "5T+1" innovation development model (see Figure 21). In terms of this historical evolution, innovation development means the combination of technology and trained personnel, technology and industry, technology and the market, as well as the combination of the domestic and international markets to form social innovation potential. This reflects the constant increase in the innovative capacity of the "5T." An innovation-oriented development strategy is implemented by maximizing the "5T+1" innovation mechanism through the allocation of spatial-temporal innovation resources. From this perspective, China's path to innovation development is a path of "catching up" for countries with technological lag.

Implementation of scientific and technological potential	Ability to implement science and technology Ability for technological invention	Ability to implement science and technology Ability to invent science and technology Ability to innovate independently	Ability to implement science and technology Ability to invent science and technology Ability to innovate independently and innovation in the domestic market	
1949–1976	1977–1994	1995–2011	2012–2023	
Opportunities to implement new technologies	Ability to innovate independently	Innovation in the domestic market	Innovation potential in global markets	→
Management of 1st generation R&D	Management of 2nd generation R&D	Management of 3nd generation R&D	Management of 4nd generation R&D	

Figure 21: Utilising China's innovative "5T+1" model

Source: Compiled by the author.

In China, a national innovation system is being developed, built upon the theory of the national innovation system and divided into four generations of innovation development. The "5T+1" model describes the mechanisms of development for technologically lagging countries from the initial stage of lagging behind to achieving an innovation breakthrough, emphasizing the importance of the ability to absorb, imitate, and innovate in this process. The innovation development strategy has transitioned from the first generation of scientific and technological innovations to the fourth generation of overall innovation using the "5T+1" innovation mechanism model.

2.2 Analyzing the factors influencing the development of innovation in China

After reviewing China's "5T+1" innovation model, the purpose of this paragraph is to analyze the factors behind the rapid development of innovation in China. Identifying the factors behind the innovation progress is very important because it will allow us to understand how to stimulate economic growth and independent innovation in China when making relevant decisions [68].

1.Factors influencing China's innovation capability

We hypothesize that technology import ability, independent innovation process, domestic market, international market and human resource development are important factors affecting China's innovation capability [68]. The specific reasons for this are as follows:

The ability to import foreign technology. This capability represents a key element of national innovation development, providing rapid access to advanced technology and knowledge. Lack of this capability makes it difficult to participate in the development of advanced technologies and complicates own innovation.

Self-driven innovative development. Self-innovation is a key element of national innovation capacity, as it is the only way to improve the level of science and technology and ensure competitiveness. If a country does not have independent innovation capacity, it will continue to be technologically backward and struggle to compete in the international market.

Domestic market. The domestic market is an important driver of national innovation development. If the domestic market provides significant demand, it stimulates the innovation enthusiasm of enterprises, encourages them to increase investment in R&D, and continuously improve product quality and technology.

International market. The international market is an important platform for national innovation development. If a country is competitive in the international market, it attracts advanced technology and capital from abroad, which promotes the level of technology at home.

Human resource formation. Highly skilled professionals are a key resource for innovation in a country and an important force for innovation promotion. If the country lacks high-skilled professionals, it becomes difficult to innovate independently and attract advanced foreign technology. Therefore, human resource formation is an important way to improve the innovation ability of a country.

We hypothesize that import of foreign technology, independent innovation, domestic market, international market and human resource formation are important factors affecting China's innovation ability. To confirm this assumption, we used the national innovation system framework (Figure 22), in which technology imports, independent innovation, domestic market, international market and human resource formation together contribute to China's innovation ability.

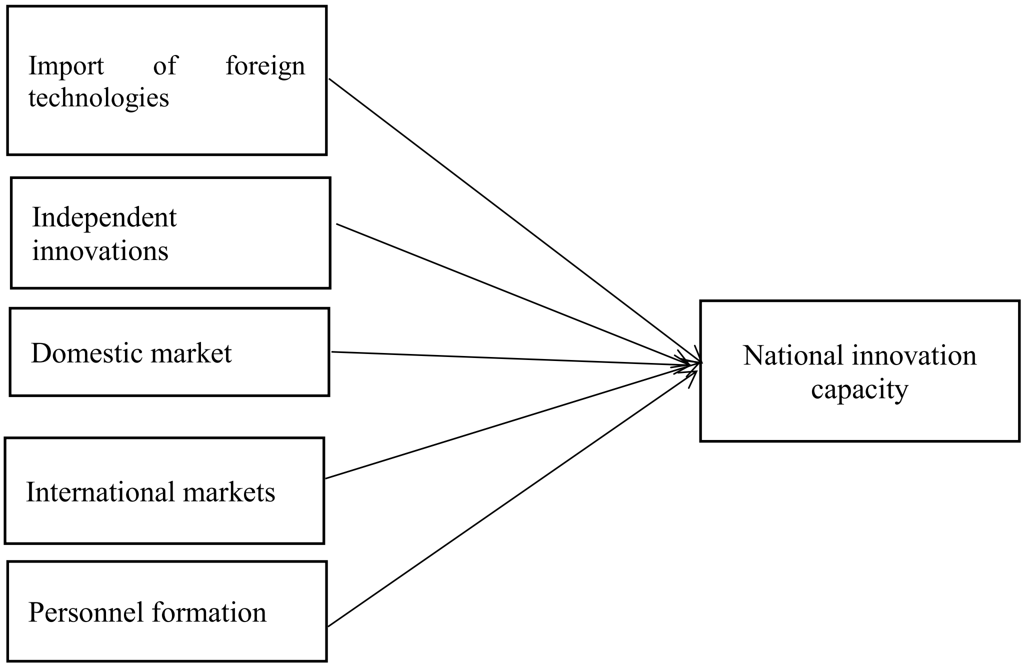


Figure 22: Aggregate factors contributing to China's innovation capability: hypothesis
Source: Compiled by the author.

To better understand the data and highlight major trends, we divided the above five big categories into subcategories.

The number of experts coming to China, patent utilization fees and the amount of technology import contracts can reflect a country's technology import capacity for the following reasons:

- The number of experts coming to China is one important indicator of a country's technological ability. If a country can attract a large number of foreign experts who come to that country for scientific exchange and joint research, it can encourage the import and diffusion of advanced technology and thus raise the level of technology in that country.
- Payment for the use of patents. Payment for the use of patents can reflect the extent and speed of technology imports from abroad. When a country needs to use foreign patents, it needs to pay for the corresponding patents. If a country pays high patent usage fees for technology use, it indicates that the country has a significant need to import technology from abroad and at the same time can obtain some technology in the international market.
- Sum of technology import contracts. The amount of technology import contracts may reflect a country's ability to increase its scientific level in this way. When a country enters into many technology import contracts in the international market, it can obtain advanced technology and knowledge, which in turn will increase its scientific level. In addition, the amount of technology import contracts may reflect the degree of importance that a country attaches to technology imports.

Expenditures on research and development, the number of science and technology parks, the number of patents granted for inventions, and the total output of knowledge-intensive industries are important indicators and criteria for assessing a country's independent innovation potential. The following relationship is observed between them:

- R&D expenditure is an investment by companies or the government in research, which is an important basis for independent innovation development. When the funds invested in R&D are sufficient, companies can create new technologies and products faster, promote the development of high-tech industries and enhance independent innovation ability.
- The number of science and technology parks is an indicator of the concentration level of high-tech industries in a region, and the development of science and technology parks helps create a favorable research environment and provides access to better scientific services, attracts more scientific personnel and investment, promotes the development of high-tech industries and increases independent innovation ability [93].
- The number of patents granted for inventions is an important indicator of a country or region's ability to innovate. The number of granted patents reflects the innovation capacity. An increase in the number of invention patents in a country or region indicates an increase in the ability to innovate independently.
- Technology enterprise incubators are organizations that provide technology innovation incubation services, supporting technology start-ups through the provision of space, financing, technology development, management, etc. The development of technology enterprise incubators promotes the promotion of scientific results to the market, stimulates the development of high technology, and thus enhances the ability of independent innovative development.
- The total revenue of high-tech industries is a measure in a country or region of the economic volume of high-tech industries, the development of which contributes to technological innovation development and modernization of industries. The growth of total revenue of high-tech industries reflects the economic power of a country or region in the field of high technology.

The total revenue of Chinese enterprises, the number of small and medium-sized enterprises in China and GDP per capita are indicators of the level and competitiveness of China's domestic market. These indicators are interrelated, interact with each other and can serve as an important indicator for assessing the ability of China's domestic market.

- The total income of Chinese enterprises is an important indicator of the size of the domestic market and the economic power of enterprises in China. The increase in the total income of enterprises indicates the increase in demand in the Chinese market, the increase in the competitiveness of enterprises and the increase in their market share.

- The number of small and medium-sized enterprises in China is a major factor in the development of China's domestic market and an important driver of China's economic development. The growth of SMEs reflects the stability and competitiveness of the Chinese market and the effectiveness of the Chinese government's policy of supporting and promoting innovation and entrepreneurship.
- GDP per capita in China refers to the average national GDP per capita in China and is an important indicator of the economic level and consumption power of the Chinese population. The growth of average GDP per capita indicates the increase of consumption power in China's domestic market, which provides more strength and opportunities for the development of China's market.

"Total foreign direct investment, number of foreign companies and foreign direct investment abroad" are indicators that can reflect a country's international market power and competitiveness. These indicators interact with each other and can serve as an important criterion for assessing a country's international market power.

- Total foreign direct investment refers to the total amount invested by foreign companies in a particular country and is an important indicator of a country's ability to attract foreign investment. An increase in total foreign direct investment indicates an increase in the level of openness of a country, an increase in international competitiveness and the attraction of foreign companies to that country's market.
- The number of foreign enterprises is the total number of foreign investment enterprises registered in a country, which are an important indicator of a country's ability to attract foreign investment in terms of quantity and quality. An increase in the number of foreign enterprises reflects the effectiveness of a country's foreign investment policy and investment environment in attracting foreign investment, as well as strong competitiveness in the international market.
- The amount of foreign direct investment (FDI) is the total amount that companies in one country invest in another country. It is an important indicator of a country's ability to expand its international market. An increase in the amount of FDI indicates that the companies of a given country have a high degree of international orientation and are competitive in the global market.

Education spending, the number of Chinese graduates, the number of Chinese researchers, the number of overseas students studying in China, and the number of Chinese students studying abroad are all indicators that can reflect the level and competitiveness of China's education and S&T policies. These indicators are interrelated and interact with each other, and can serve as an important benchmark in assessing China's education and scientific training capacity.

- Education expenditure is the Chinese government's investment in education, and it is one of the important indicators for assessing China's education capacity. An increase in education expenditure can help improve the quality of education and resources in this area, as well as increase the country's capacity to train human resources.

- The number of Chinese tertiary graduates is the number of people who graduate from China's tertiary institutions each year, and it is an important indicator for assessing the level of tertiary education and the employability of graduates. The increase in the number of tertiary graduates reflects the spread of higher education in China and its training capacity.
- The number of researchers in China is the number of workers engaged in scientific research, and it is an important indicator for assessing China's science and technology innovation capability. The increase in the number of scientific workers reflects China's investment in science and technological innovation, as well as the increase in its scientific reserves.
- The number of international students studying in China is an important indicator for assessing the extent of international education in China and its ability to attract talent. An increase in the number of international students coming to China reflects the level of quality of education in China and its ability to attract talent.
- The number of overseas students is the number of Chinese citizens studying abroad, and it is an important indicator for assessing China's ability to produce promising cadres with connections and influence abroad. The increase in the number of students studying abroad reflects China's demand for international education policy.

To summarize, we form Table 13, which identifies the factors that may affect China's innovation capability.

Table 13 - Potential factors that will affect China's innovation performance

Tier 1 indicators	Tier 2 indicators
Import of foreign technologies	Number of experts traveling to China
	Royalty payment for patented technologies
	Cost of technology implementation contract
Independent innovation	Research and experimental development costs
	Number of technology industrial parks in China
	Number of patents granted for inventions
	Technology business incubators in China
	Total value of products of high-tech industries
Domestic market	Total revenue of Chinese enterprises
	Number of small and medium-sized enterprises in China
	China's GDP per capita
International markets	Volume of foreign direct investment
	Number of foreign invested enterprises

	Volume of foreign direct investment
Talent formation	Education expenditure
	Number of Chinese university graduates
	Number of researchers in China
	Number of students studying abroad
	Number of foreign students studying in China

Source: Compiled by the author.

2.Choice of research method

The methods of correlation analysis and principal component analysis were used for this study. Correlation analysis and principal component analysis are common methods of statistical analysis that can play an important role in data processing and analysis as outlined below. Correlation analysis can be used to examine the relationship between two or more variables. Correlation analysis allows us to calculate the correlation coefficient between variables and thereby determine the extent and direction of their relationship. With the help of correlation analysis, we can understand the relationships between variables in the data and then perform classification, selection and prediction operations on the data, thus providing a basis for further data analysis.

Principal component analysis can be used to reduce the dimensionality of data and simplify the data analysis process. It can transform several related variables into several independent variables, called principal components, and thereby improve the efficiency and interpretability of data analysis. By using principal component analysis, we can transform the raw data into a simpler form that better describes the structure of the data and reduce the dimensionality problem in data analysis. The use of principal component regression is due to the fact that there may be significant multicollinearity between the explanatory variables, which leads to incorrect results of the regression model. The use of stepwise regression often results in the loss of key variables and also does not always solve the multicollinearity problem. To reduce the loss of variables and reduce the negative impact of strong correlation between explanatory variables, it is recommended to use principal components regression to analyze the relationship between variables.

3.Building a system of indicators

Data are from the National Bureau of Statistics of China, the Ministry of Education of the PRC, and the Ministry of Commerce of the PRC. The data were selected for the period from 2000 to 2022, reflecting their relevance and comparability. Based on the above discussion of the characteristics of innovation development in China and the data presented, 19 indicators were selected from 5 areas: technology import capability, self-innovation capability, domestic market, international market, and human resource capability to create a system of innovation development indicators in China.

Table 14 - Variable Name

Variable name	The variables represent
Y	China Innovation Index
X1	Number of experts traveling to China
X2	Royalty payment on patented technology
X3	Contractual cost of technology adoption
X4	Expenditure on research and experimental development
X5	Number of technology industrial parks in China
X6	Number of patents granted for inventions
X7	Technology business incubators in China
X8	Total value of products of high-tech industries
X9	Total revenue of Chinese enterprises
X10	Number of small and medium-sized enterprises in China
X11	China's GDP per capita
X12	Total foreign direct investment
X13	Number of foreign invested enterprises
X14	Amount of foreign direct investment
X15	Education expenditure
X16	Number of Chinese university graduates
X17	Number of researchers in China
X18	Number of students studying abroad
X19	Number of foreign students studying in China

Source: Compiled by the author.

4.Principal component analysis

Model customization

To examine the effect of each factor on China Y innovation index, a regression model with the following equation was constructed:

$$Y = \beta_0 + \beta_1 X + \varepsilon \qquad (1)$$

In this model, when all explanatory variables are 0, the mean of the variable we explain is used as the impact factor, including other unaccounted variables that affect the outcome - the so-called random error.

Correlation analysis

To analyze the correlation between data, a correlation coefficient is used, the absolute value of which reflects the degree of correlation and its sign reflects the direction of correlation. If the analysis shows that there is a certain correlation between the variables, it means that the use of the principal component method to reduce the dimensionality of the data is reasonable and can be applied to data processing.

Table 15 - result of correlation analysis

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y	1																			
X1	.950**	1																		
X2	.457**	.847**	1																	
X3	.478**	.956**	.913**	1																
X4	.984**	.913**	.986**	.948**	1															
X5	.974**	.876**	.996**	.936**	.995**	1														
X6	.969**	.902**	.983**	.923**	.992**	.984**	1													
X7	.929**	.799**	.991**	.892**	.960**	.980**	.956**	1												
X8	.976**	.953**	.948**	.945**	.981**	.960**	.985**	.907**	1											
X9	.485**	.923**	.979**	.952**	.998**	.989**	.990**	.950**	.986**	1										
X10	.386**	.785**	.899**	.847**	.902**	.911**	.889**	.881**	.852**	.883**	1									
X11	.490**	.948**	.967**	.964**	.994**	.980**	.986**	.935**	.993**	.997**	.873**	1								
X12	.909**	.903**	.845**	.857**	.907**	.871**	.906**	.785**	.936**	.918**	.762**	.926**	1							
X13	.353**	.976**	.858**	.976**	.912**	.888**	.893**	.822**	.936**	.917**	.833**	.939**	.839**	1						
X14	.324**	.946**	.877**	.897**	.919**	.886**	.936**	.827**	.970**	.929**	.763**	.944**	.901**	.911**	1					
X15	.986**	.937**	.972**	.954**	.997**	.984**	.992**	.940**	.993**	.998**	.881**	.999**	.926**	.928**	.941**	1				
X16	.443**	.993**	.832**	.952**	.902**	.865**	.888**	.783**	.944**	.911**	.785**	.938**	.895**	.981**	.936**	.926**	1			
X17	.985**	.933**	.976**	.951**	.996**	.985**	.994**	.946**	.993**	.997**	.879**	.998**	.921**	.925**	.945**	.999**	.923**	1		
X18	.977**	.968**	.935**	.960**	.973**	.949**	.973**	.899**	.995**	.979**	.833**	.990**	.927**	.952**	.968**	.987**	.960**	.987**	1	
X19	.348**	.931**	.922**	.919**	.955**	.932**	.959**	.885**	.979**	.966**	.747**	.973**	.931**	.893**	.955**	.971**	.917**	.972**	.980**	1

Note: *,** indicate significance at 0.01; 0.05 level of significance, respectively.

Source: Compiled by the author.

As shown in Table 15, all the correlation coefficients between the explanatory variables and Y are significant, but some of them such as X2, X3, X9, X10, X11, X13, X14, X16 and X19 have relatively low correlation coefficients with Y, less than 0.5. Due to the low correlation and wide selection of factors in this study, these variables were removed before applying the principal component method to regress Y. The results are as follows.

KMO and the Bartlett test

Next, the KMO test is performed. In this paper, the threshold value for KMO is chosen to be 0.5, which is a prerequisite for principal component analysis. If the KMO value is greater than 0.5, we can proceed to the next stage of analysis and perform the Bartlett's sphericity test. If the corresponding probability value of Bartlett's test is less than 0.05, it means that there is correlation between the variables, i.e. they are not independent and dimensionality reduction analysis can be performed.

Table 16 - KMO result and Bartlett's test

KMO and Bartlett's Test		0.782
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		822.434
Bartlett's Test of Sphericity	Approx. Chi-Square	45
	df	0.000

Source: Compiled by the author.

The KMO value is 0.782, which is greater than 0.5, and passes the KMO test. The approximate Bartlett's chi-square statistic for spherical model validation is 822.434, the corresponding sig probability value is 0.000, which is less than 0.01, and indicates that there is a correlation between the indicators with a probability of more than 99%, that is, they are not independent, so the selected indicators are sufficiently correct for principal component analysis.

The variance of the common factor and the degree of variance explained

The total factor variance of variables gives an indication of how much information is extracted from each variable. As a general rule, the higher the degree of information extraction, the better; if too little information is extracted from a variable and too much information is lost, it is not suitable for principal component analysis, and vice versa, it means that the degree of extraction of principal component analysis is higher.

Table 17 - Result communality

	Initial	Extraction
X1	1	0.888
X4	1	0.990
X5	1	0.965
X6	1	0.982
X7	1	0.884

X8	1	0.987
X12	1	0.863
X15	1	0.998
X17	1	0.998
X18	1	0.979

Source: Compiled by the author.

The highest variance value of the extracted common multiplier is 0.998, all the extraction levels are 80% or more, so the extraction of variable information is quite efficient, with the extraction level of epidemic-related variables being the lowest.

Then we look at the magnitude of the variance contribution: the larger the variance contribution, the higher the informativeness of the components extracted by the principal components method in the total information. We extract principal components with eigenvalue greater than 1, and the results are presented in Table 18.

Table 18 - Result of variance explanation

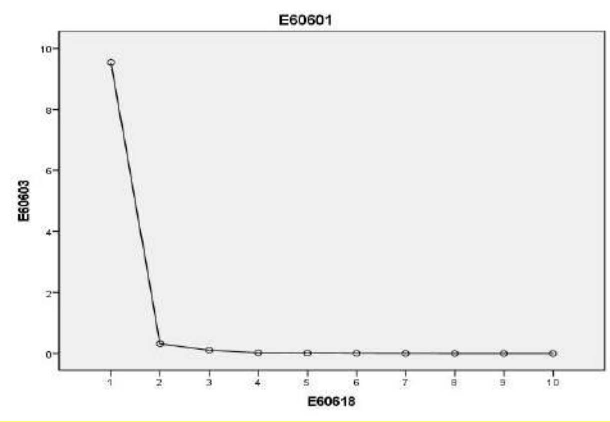
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.513	95.576	95.576	10.513	95.576	95.576
2	0.316	2.869	98.445			
3	0.110	0.997	99.442			
4	0.037	0.341	99.782			
5	0.012	0.109	99.891			
6	0.006	0.054	99.945			
7	0.005	0.043	99.988			
8	0.001	0.007	99.995			
9	0.000	0.003	99.997			
10	0.000	0.002	100.000			

Source: Compiled by the author

It can be seen in the table that one eigenfactor has values greater than one. Therefore, only one factor is selected for analysis. The first factor explains 95.576 % of the total variance. As a result, one selected factor explains 95.576 % of the total variance.

Graph of eigenvalues

The eigenvalue criterion is based on the magnitude of the eigenvalue: usually, the larger the eigenvalue, the higher the informativeness of the corresponding factor. Thus, the graph of eigenvalues clearly demonstrates a gradual decrease in the level of information extraction.



PFigure 23: Graph of eigenvalues

Source: Compiled by the author.

The eigenvalue plot shows that the first principal component has a steeper section, which means that it contributes more information. With the second principal component, the curve is already less steep, so extracting the first principal component is more reasonable.

Matrix of component evaluation coefficients

The component score coefficient matrix provides numerical scores for each principal component.

Table 19 - Matrix of component evaluation coefficients

	1
X1	0.099
X4	0.104
X5	0.103
X6	0.104
X7	0.099
X8	0.104
X12	0.098
X15	0.105
X17	0.105
X18	0.104

Source: Compiled by the author.

Expressions for the coefficients are given below:

$$F_1 = 0.099 * ZX_{1_t} + 0.104 * ZX_{4_t} + \ldots + 0.104 * ZX_{18_t} \quad (2)$$

where F1 is the corresponding principal component score and

Z denotes the data normalized using principal component analysis..

Regression analysis

Since all data have been standardized in principal component regression to eliminate the effect of excessive variation between units or values, the value of the explanatory variable Y is also standardized to obtain the value of ZY, and the previously obtained values of principal component estimates are regressed against ZY as follows.

Table 20 - Result of regression analysis

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
(Constant)	1.00E-13	0.035		0.000	1.000
F1	0.987***	0.036	0.987	27.246	0.000
R^2	0.975				
F	742.357***				

Note: *** means that the probability of significant effect is 99% or more, ** means that the probability of significant effect is 95% or more, * means that the probability of significant effect is 90% or more, no asterisk means there is insufficient probability of significant effect.

Source: Compiled by the author.

$$ZY = 1.01E - 13 + 0.987 * F_1 \quad (3)$$

Regression R2 is 0.987, the model has a good fit of 98.7%, which is a very high degree of fit. The coefficient of influence of F1 on ZY is 0.987, there is a significant influence, i.e. there is a significant contribution to both Y. Further the influence coefficient of composite index on ZY was reduced to:

$$\begin{aligned} ZY &= 0.098 * ZX_{1_t} + 0.103 * ZX_{4_t} + 0.102 * ZX_{5_t} + 0.103 * ZX_{6_t} + 0.098 * ZX_{7_t} \\ &+ 0.103 * ZX_{8_t} + 0.097 * ZX_{12_t} + 0.104 * ZX_{15_t} + 0.104 * ZX_{17_t} + 0.103 * ZX_{18_t} \end{aligned} \quad (4)$$

At this stage, the obtained coefficients, since they are standardised numerical regression coefficients, are comparable in their degree of influence, with X15 - education expenditure and X17 - number of Chinese scientific workers having the highest influence, and the lowest - total foreign direct investment, which have a significant positive influence, indicating that our choice of variables is reasonable.

Table 21 - Indicators and influence coefficients

Level 1 indicators	Level 2 indicators	Influence coefficients
Opportunities for technology adoption	Number of experts arrived	0.098
Independent innovative development	Expenditure on research and experimental development	0.103
	Number of science and technology industrial parks in China	0.102
	Number of patents granted for inventions	0.103
	Science and technology business incubators in China	0.098
	Total value of output of high-tech industries	0.103
International market	Total foreign direct investment	0.097
Talent development	Education expenditure	0.104
	Number of Chinese researchers	0.104
	Number of students studying abroad	0.103

Source: Compiled by the author.

5.Conclusions

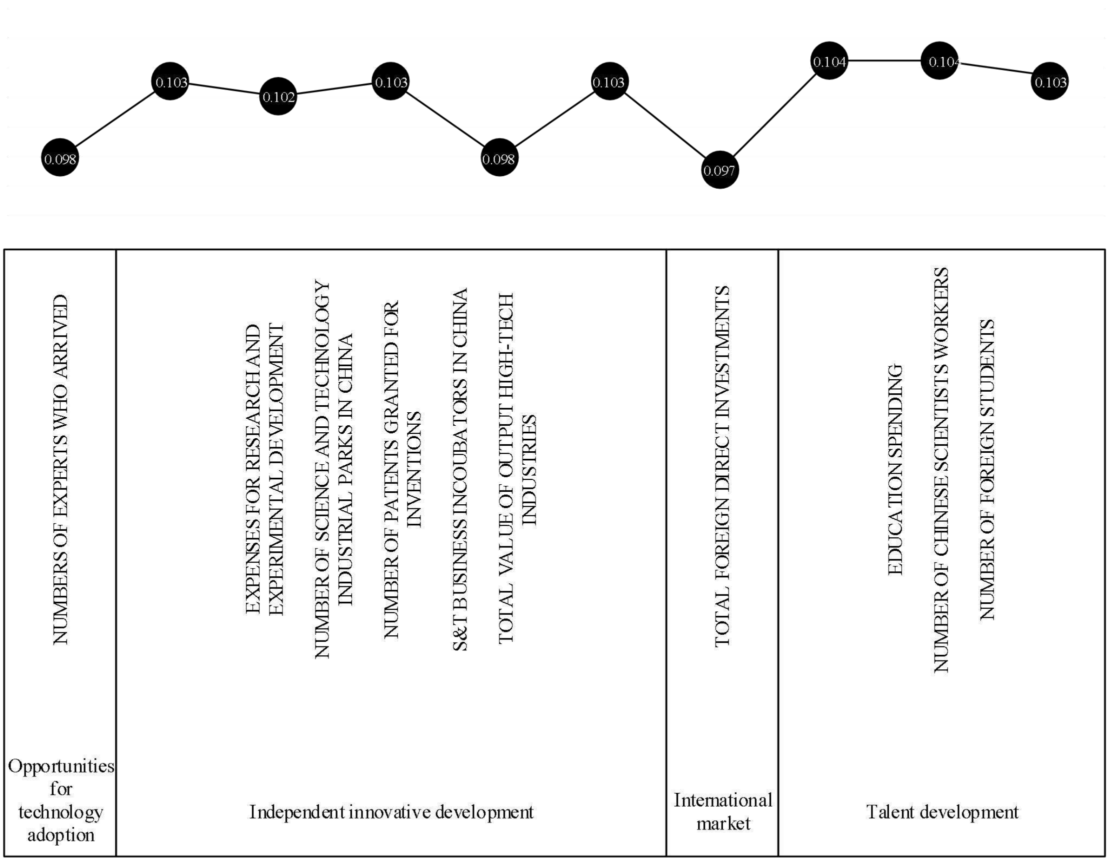


Figure 24. Indicators affecting China's innovation

Source: Compiled by the author.

Firstly, innovation development in China from 2000 to 2022 in five areas: technology import capability, self-development capability, domestic market, international market and capability in training are selected as the research object. A system of 19 indicators evaluating the level of innovation development in China was developed for the study, using the principal component method, clear conclusions were obtained in five areas: technology import capability, self-development capability, domestic market, international market and training capability. The main factors affecting China's innovation development (from greater to lesser) are: the number of researchers in China, education expenditure, research and development expenditure, the number of invention patents issued, high-tech industries, the number of students studying abroad, the number of science and technology parks, the number of foreign experts, high-tech incubators and total foreign direct investment.

Secondly, in terms of S&T import capability, the number of experts coming to China has the least influence on the indicator system, its influence coefficient is 0.098, and for the other secondary indicators, the influence coefficient is 0.103. In the field of self-development, the expenditure on research and development and the total volume of high-tech industry have the highest influence coefficient, both are equal to 0.103, indicating the importance of financing research and development of high-tech industries for self-development. In the field of international market, the impact coefficient of total foreign direct investment is equal to 0.097, indicating that the impact of foreign direct investment on the international market is relatively low. In the field of human resources development, the impact coefficient of the three secondary indicators is quite high, including the impact coefficient of education expenditure and the number of research workers in China is 0.104, and the impact coefficient of the number of international students in China is 0.103, indicating that the role of human resources development in improving the level of science and technology cannot be underestimated.

Third, based on the correlation analysis, considering the primary indicators, it can be concluded that self-development has the greatest influence on innovation in China, then the strong influence of human resources investment and education has a strong influence on innovation in China, and the influence of technology imports and international market is relatively lower than the first two primary indicators.

From the perspective of researching China's national innovation system based on principal component analysis, self-innovation, investment in education and talents, technology imports and international market together promote China's innovation development (see Figure 25).

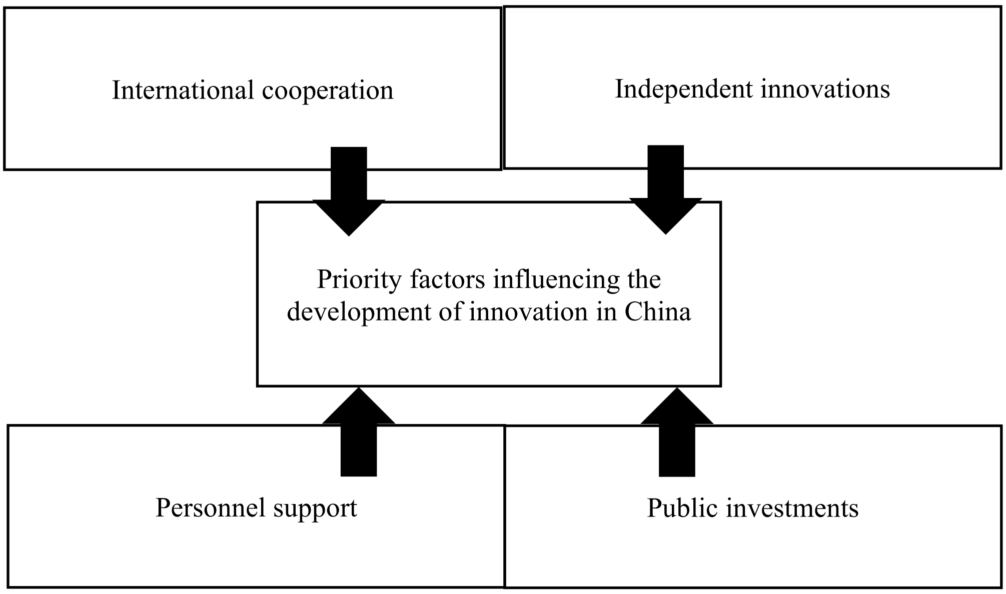


Figure 25: Main factors influencing the development of innovation in China

Source: Compiled by the author.

1. International scientific and technical cooperation

China's international S&T cooperation model has the following four features:

First, 4 types of actors are fully utilized: universities, government, enterprises and relevant foreign organizations [31]. Universities provide resources, including human resources, specialized technology and financing, to companies. This enables enterprises to cooperate with foreign organizations at the initial stage on the basis of mutual respect and mutual benefit and develop smoothly. Enterprises are the main link of innovation internationalization and assume the role of connecting link. Enterprises make full use of the relevant resources already available in universities on which they rely, such as known technologies and promising human resources needed to adopt foreign technologies and specialists, master innovation and develop new products. The government provides support in the form of technology, professionals and capital, and continuously improves regulations related to foreign investment and transnational activities to provide safeguards for the internationalization of enterprises. Foreign organizations stimulate the technological development of Chinese university S&T enterprises and help them firmly establish themselves in the international arena, greatly promoting the internationalization of university S&T enterprises. International S&T organizations are an important form of organizing the S&T community of different countries to exchange and promote the development of science and technology. Universities, government, enterprises and foreign organizations jointly promote international S&T cooperation in China (see Figure 26).

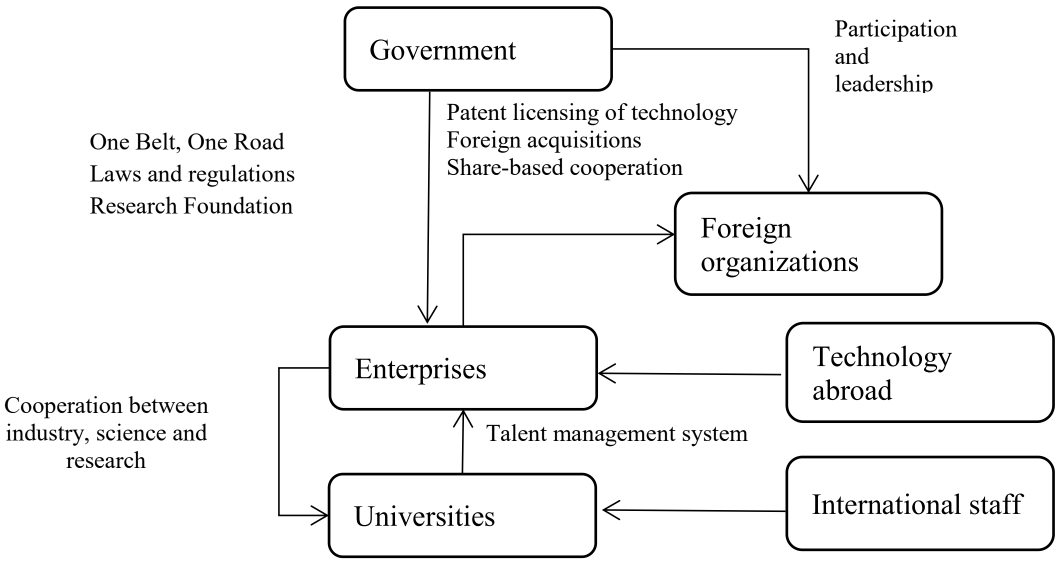


Figure 26: Impact of actors of international S&T cooperation on innovation

Source: Compiled by the author.

Second, technology companies are integrated into international S&T cooperation. Chinese S&T enterprises are mainly included in international S&T cooperation through the following activities:

Participation in international S&T projects. Chinese science and technology enterprises actively participate in international science and technology projects, including joint research projects, technology transfer projects, etc.

- Participation in national S&T development program. The Chinese government publishes a series of S&T development programs every year to encourage enterprises to participate in key national projects. Technology companies can receive government financial support for their own activities or cooperatively, with strengthened communication with universities, research institutions, etc., to enhance their capabilities in the technology innovation sector.

- Strengthening cooperation with foreign technology companies. Chinese technology companies partner with the best overseas technology companies to work together on R&D projects.
- Participation in international science and technology exhibitions. Chinese companies actively participate in international science and technology exhibitions to showcase their technological achievements and products, as well as to explore the international market and industry trends. Participation in exhibitions also provides opportunities for contact and experience exchange with overseas technology companies, facilitating partnerships and expanding the international market.
- Obtaining advanced technologies abroad through three main ways: acquisition of companies, joint investments and licensing of technology patents.

Third, the government supports international S&T integration and actively develops S&T diplomacy. The Chinese government integrates into the global policy innovation system through the following measures:

- Developing technology diplomacy. China has already achieved significant results in technology diplomacy and open cooperation in scientific and technological innovation. The "One Belt, One Road" international cooperation forums, the G20 summit in Hangzhou, and the BRICS leaders' summit in Xiamen can boost China's contacts and interactions with the global S&T community, and improve the international image and reputation of Chinese S&T companies.
- Maintaining cooperation with developed countries in scientific and technological innovation. Establishing partnerships with the global system of scientific and technological innovation allows Chinese S&T companies to obtain more international advanced technologies and resources, improve their technical innovation capabilities and market competitiveness.
- Strengthening cooperation with international organizations. Through strengthening cooperation with international organizations, China participates in the development of international standards and management of S&T issues, which helps Chinese companies better adapt to global requirements and market rules and promotes Chinese companies to a higher level of development.

Fourth, the integration of China's education system into the global education system. Chinese scientific and educational institutions are mainly integrated into the global innovation education system through the following areas:

- Chinese universities have established partnerships with international universities and companies in education and technology to conduct joint research, faculty and student exchanges, joint programs, etc.
- Chinese universities set up joint laboratories and innovation platforms, develop cooperation in

science and technology parks and technology research, and conduct joint personnel training.

- Chinese universities establish and expand cooperation mechanisms and networks for personnel exchange.

With the above-mentioned directions, a model of China's international S&T cooperation was established as shown in Figure 27. This model shows all the major actors engaged in international innovation activities, integrates various international S&T methods, but takes into account the originality of different types of enterprises. Universities and enterprises are combined into "alliances" related to innovation implementation, industrial production and other areas, interacting, with the support of the government, with relevant organizations in financing, technology. Universities and enterprises should make full use of the core technologies obtained through cooperation with foreign organizations, integrate their own special technologies, innovate and develop new higher-level market-oriented products. After gaining competitive advantage, the expansion of enterprises' international actions and participation in international and national market actions are realized.

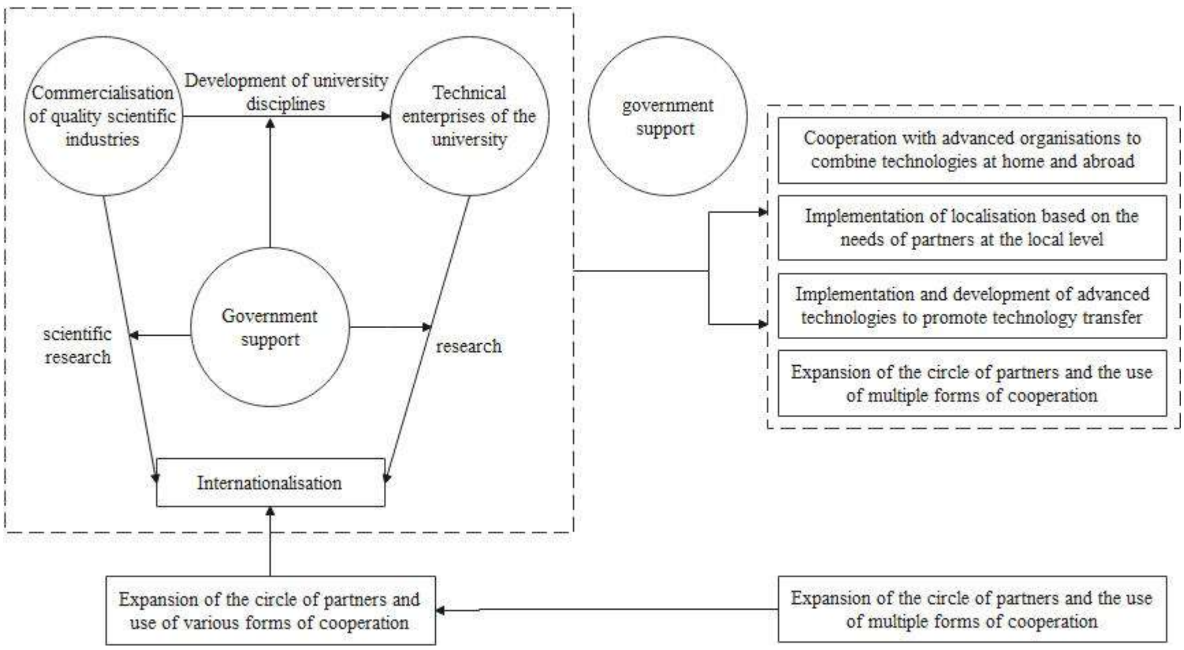


Figure 27: China's model of international S&T cooperation

Source: Compiled by the author.

2. Personnel support

The study of talent development potential gives us an insight into a fairly wide range of views on the place and role of the individual in the country. Human resources in China are gradually forming a new dual-drive structure of overseas talent attraction and domestic training, combining incentives and guarantees. The goal is to make China a destination for high-level international professionals and a center for the formation of young promising cadres, create an innovative system of interaction between highly qualified talents in China and abroad, and enhance national scientific and technological innovation and competitiveness (see Figure 28).

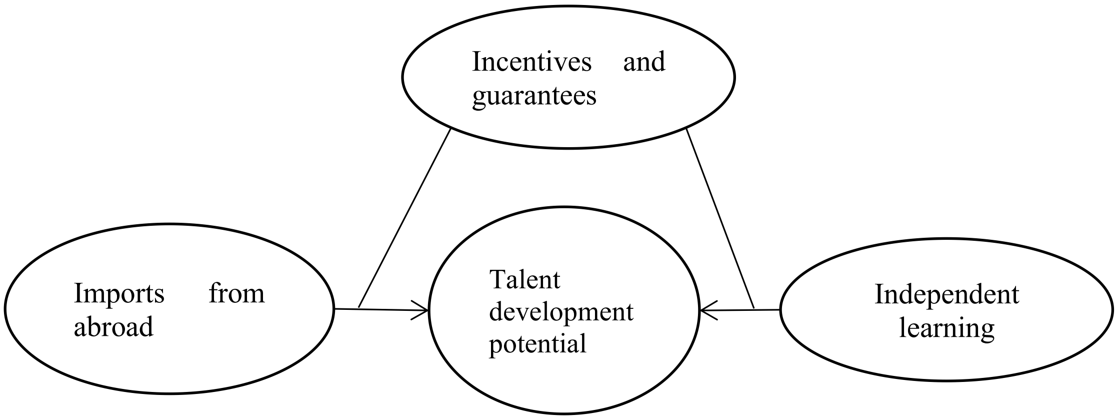


Figure 28: Model of Talent Development in China

Source: Compiled by the author.

First, China's cadres to promote domestic S&T talents to promote the sustainable development of S&T talent pool. China's education system has gone through years of reform and development, now includes nine-year compulsory education, secondary education and higher education. Higher education is an important stage in the cultivation of highly qualified human resources, and Chinese universities play a major role in this process. The education of cadres in Chinese universities mainly involves the graduation of bachelors, masters, and postgraduate education - the training of graduate students. Bachelor's, master's and postgraduate students are an important reserve of scientific and technological cadres. In order to expand the enrollment of undergraduate, graduate and postgraduate students and improve the quality of education, the relevant authorities have not only prepared the "Law on Higher Education in the PRC", but also adopted many policies to regulate, standardize and stimulate the process. Starting from 1999, Chinese higher education institutions began to expand enrollment: in 1998, higher education institutions enrolled 1.08 million students, and in 1999, the number increased to 1.6 million, by 2022, the enrollment of higher education institutions expanded to 9.6745 million students. The number of graduate students in the country has also increased rapidly from 30,000 in 1990 to 1.107 million in 2022.

Second, human resources attract foreign highly qualified professionals. China is building a multi-level, comprehensive system to attract talents from all over the world, establishing mechanisms to attract talents who are sent to enterprises and organizations, and expanding channels to attract promising talents for private enterprises. First, attracting overseas scientific talents becomes a strategic action of the state. Second, China has almost completed the establishment of the overseas scientific talent attraction system with the "Thousand Programs" as the main guideline. The programs for attracting overseas scientific professionals conducted by various government agencies are the core element and are supplemented by the corresponding programs of provinces and cities. Third, information service platforms and work mechanisms are further improved to attract overseas talents.

Thirdly, China's human resource management also stimulates the training of highly skilled professionals. In particular, there are many policies to attract, train and incentivize talents (see Table 22). To attract and train highly skilled innovative professionals, various departments have developed numerous special programs.

Table 22 - Special training programs and projects

№	Name of specialist program	Managing Authority
1	Young Scientists Research Fund Project	National Natural Science Foundation
2	National Outstanding Young Scientists Fund Project	
3	Innovation Research Group	
4	Joint research project with overseas scholars from Hong Kong and Macao	
5	Overseas Highly Qualified Personnel Program	Central Personnel Committee
6	Young Talent Program (young highly qualified personnel from overseas)	
7	Thousand Man Program (special program to support highly qualified personnel)	
8	Innovative Personnel Promotion Program	Ministry of Science and Technology
9	National level "Million Talent Program"	Ministry of Labor and Social Security
10	Changjiang Award Program	Ministry of Education
11	Innovation Team Development Program	
12	Higher Program for Innovative Introduction of Sciences (111 Program)	
13	Teachers of various disciplines	
14	Hundred Man Program	Chinese Academy of Sciences

Source: Compiled by the author.

In addition to special programs, China is also implementing a "new talent" policy in cities. These policies include measures to attract talents, provide housing, support entrepreneurship, training, evaluation and certification, and establish service institutions. Large cities provide various benefits such as high salaries, housing benefits, and education for children. In addition, regional governments invest significant resources to train and upgrade the skills of promising professionals, establish a fair and reasonable talent evaluation system, and organize various services to provide services for highly skilled professionals in employment, entrepreneurship, housing and education.

China's human resources model is based on the driving force of the two wheels of overseas talent attraction and domestic development. It simultaneously pays attention to the invitation of highly skilled professionals from abroad and the development of local highly skilled cadres. In addition, a model is applied in which incentives through special programs and guarantees from the government, through various programs and measures of provision exist in parallel. The human resources model offers comprehensive and diversified support and guarantees to attract, develop and retain highly qualified personnel in China, which contributes to the sustainable development of China's economy and society.

3. Public investments

Investment in education and the development of national innovation infrastructure are two important aspects of government investment in innovation. Investment in education is an important component of the government's investment in innovation, as education is the main way to educate human resources, disseminate knowledge and skills, and increase innovative capacity. Investment in the development of national innovation infrastructure is also an important aspect of government investment in innovation. It includes government investment in the development of top-level research institutions, science laboratories, technology innovation centers and other national innovation infrastructure, provides high-quality research environment and comprehensive support, and promotes technological progress and industry development (Figure 29).

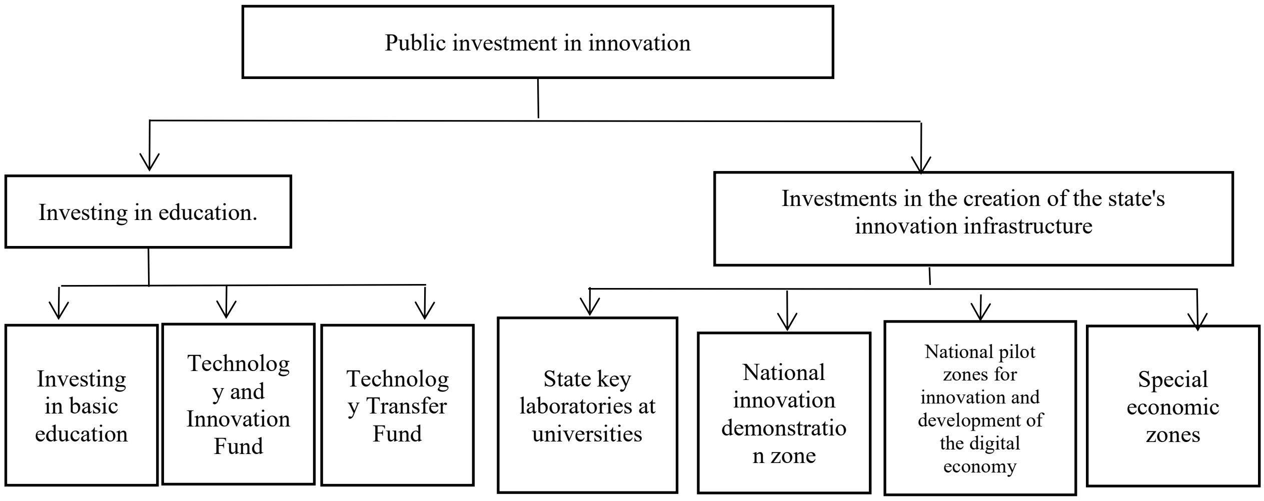


Figure 29: Model of public investment in innovation development in China

Source: Compiled by the author.

Education investment includes various aspects such as improving the level of primary education, improving the quality of educational facilities and resources, talent development, etc. In addition, investment in education also includes investment in science and technology funds, technology transfer fund, etc. These investments are mainly used to support scientific research projects and technological innovation, help scientific research institutions and enterprises make practical use of scientific achievements, and promote technological progress and industrial upgrading. All these investments are aimed at enhancing national scientific and technological capabilities and global competitiveness, as well as promoting economic and social development.

Figure 30 shows China's spending on basic education from 1949 to 2022. It can be seen that since the establishment of the PRC in 1949, spending on basic education has been increasing continuously, especially after the proclamation of the reform and opening-up policy. With the growth of China's economy in recent years, education spending has also continued to increase. In 2019 and 2022, the share of basic education spending in GDP was about 3.8%.

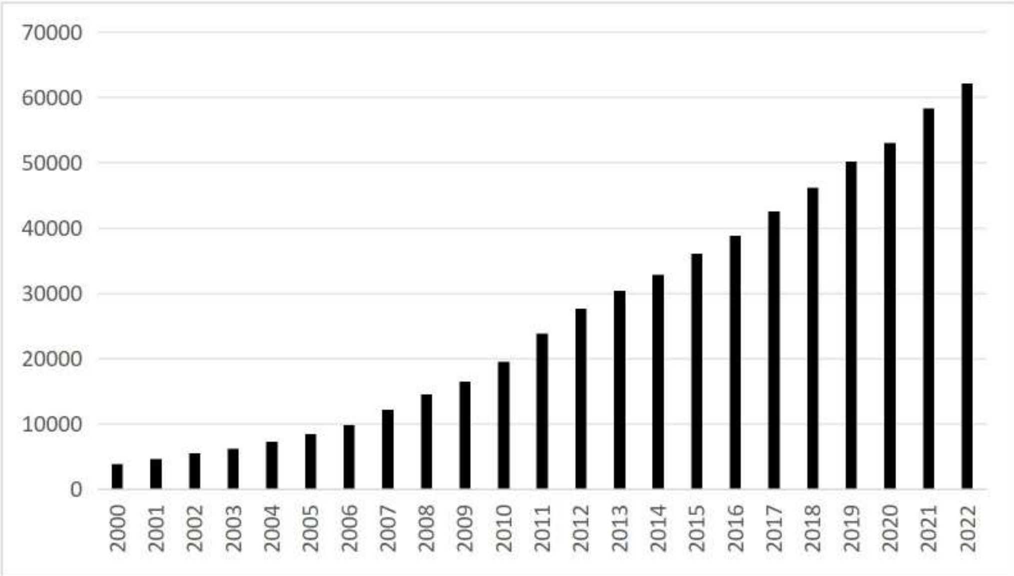


Figure 30. China's spending on basic education from 1949 to 2022

Source: Compiled by the author on the basis of data from the Ministry of Education of the People's Republic of China.

China Science and Technology Innovation Fund is a fund established by the Chinese government to promote scientific and technological innovation. It includes the National Technology Project Fund, National Natural Science Foundation, National Science and Technology Support Program, etc., and aims to support the development of scientific and technological innovation in the country. The Fund was established through the joint investment of the central and local governments, and the sources of financing are government appropriations, government bond issuance and public levies. The investment targets of the China Science and Technology Innovation Fund include research institutions, universities, and high-tech enterprises.

The Technology Transfer Fund was also established to promote technological innovation and the transformation of technological achievements by providing financial support to technology transfer agencies and enterprises. The investment targets of the China Technology Transfer Fund are research institutions, universities, enterprises and other high-tech sectors of the economy. The purpose of this fund is to support investment and promote industrial production and commercialization of technological results through a variety of investment methods, including direct investment, equity investment, bond investment and so on. It can also provide financial services such as loans and guarantees, providing full support and protection for the transformation and commercialization of technological results. The establishment of China's Technology Transfer Fund has not only provided financial support, but also stimulated the combination of scientific innovation and the improvement of industry's technological equipment level, promoting the application and commercialization of technological results and promoting economic development and social progress.

The formation of China's national innovation infrastructure includes four main aspects: independent innovation development of state-owned key laboratories of higher education institutions, National Innovation Demonstration Zone, National Pilot Zones of Innovation and Digital Economy Development, and Special Economic Zones. Let's take a closer look at these development areas.

1) Self-innovation development of state-owned key laboratories of higher education institutions, i.e. institutions established by the Chinese government to promote scientific and technological innovation and development of higher education. These laboratories are usually established by higher education institutions or research institutes to support and stimulate the development of national S&T innovation. The operation of key laboratories of higher education institutions is based on four subsystems: the self-innovation investment system, the self-innovation production system, the self-innovation management system and the self-innovation environment system. The key laboratories of higher education institutions have highly qualified scientific teams, a variety of interdisciplinary resources, and the ability to share large-scale equipment and tools. The structure of the self-innovation system of China's national key laboratories is summarized below (see Figure 31).

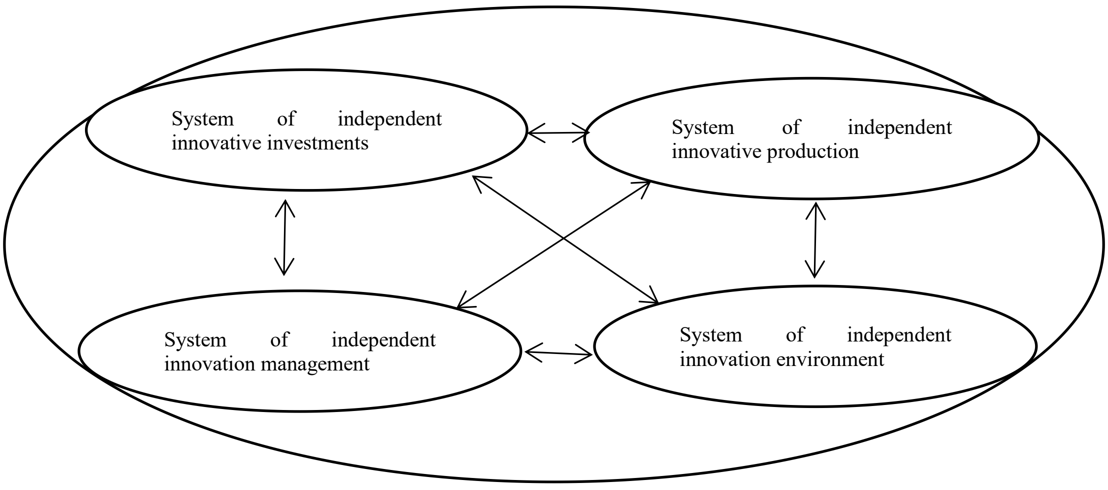


Figure 31. Structure of the self-innovation system of China's national key laboratories
Source: Compiled by the author.

2) 2)The National Innovation Demonstration Zone is an area for early and pilot implementation, research and demonstration of experience in promoting independent innovation and high-tech industrial development. As an area that is the first to test and explore and demonstrate experience in promoting independent innovation and high-tech industrial development, the National Innovation Demonstration Zone has innovation ability, which is an important criterion for verifying its

demonstration effect. By December 2022, 23 national innovation demonstration zones have already been approved. The national innovation demonstration zone in China operates through joint innovation development and open development, joint development of innovation cities and independent innovation zones, joint development of industrial and regional innovation, joint development of multiple cities, zones and platforms, and improvement of innovation and enterprise environment and policies. These five core aspects provide basic design structures for the joint development of groups of state-owned self-innovation demonstration zones (see Figure 32).

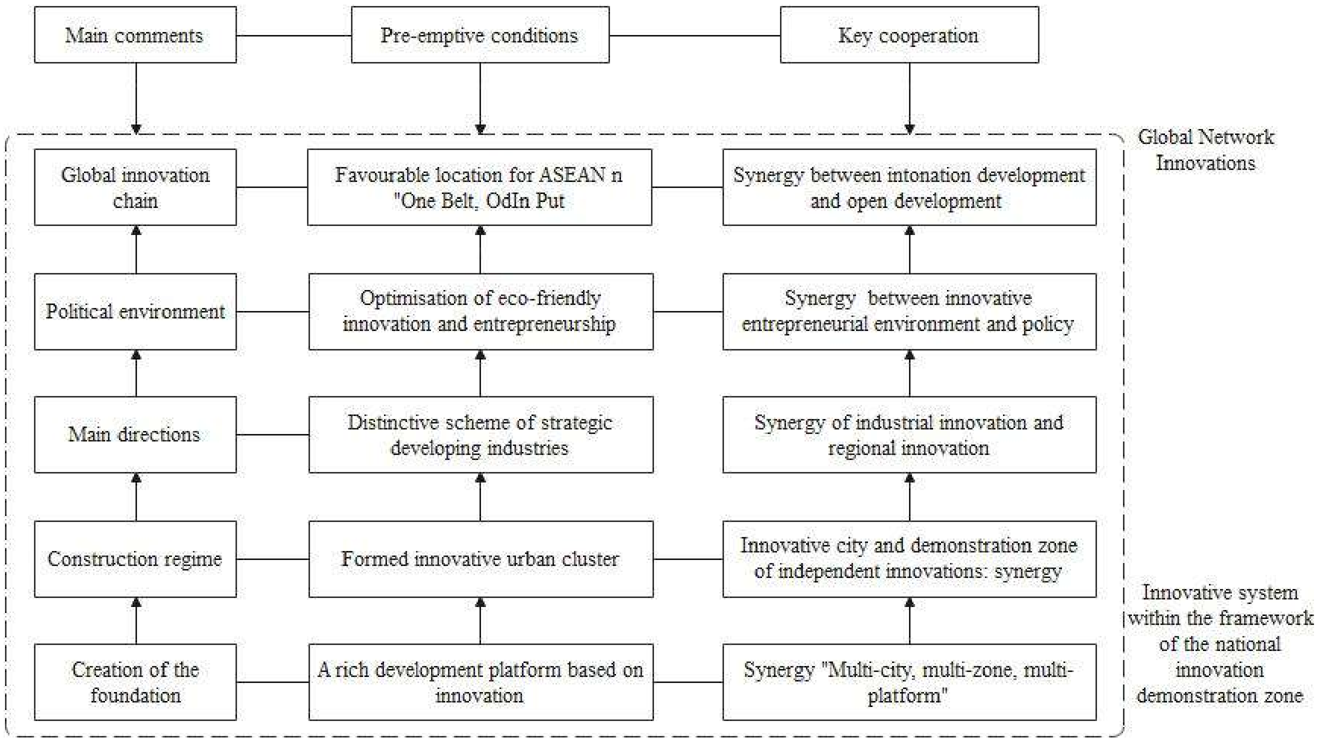


Figure 32. Structure of the National Demonstration Zone for Independent Innovative Development
Source: Compiled by the author.

3) National Digital Economy Innovation and Development Pilot Zones are a special type of area established by the Chinese government to promote the development of the digital economy and accelerate digital transformation. These pilot zones will receive special support from the government to carry out innovative experiments and practices in digitalization and promote the development of digital economy. The main objectives of the national pilot zones for innovation and development of the digital economy in China are: first, to focus on the planning and development of the digital economy. Medium- and long-term plans for the innovative development of the digital economy are researched and drawn up, the guiding ideology and development paths of the digital economy are clarified, and development goals and key expected indicators are put forward. Second, the development of new infrastructures is intensified. The development of platform facilities such as 5G, artificial intelligence,

industrial Internet, Internet of Things and data centers is systematically planned to create a new type of infrastructure for the digital economy that is ubiquitous, inclusive and diversified. Third, building a multi-level and interconnected service platform. Promoting the development of enterprise technology centers, industrial innovation centers and innovation service complexes, and jointly building open source communities for digital technologies and solutions, so as to enhance the digital transformation capability of enterprises. Fourth, the development of industrial ecology for the digital economy. Information technology industries such as artificial intelligence, cloud computing, big data and supercomputing are actively developing, a digital industrial chain of "R&D + manufacturing + supply chain" is being established, and a digital ecology of cross-border integration of "production services + business models + financial services" is being formed.

4)Special economic zones in the new era are economic zones established by the Chinese government to accelerate reform and open up to the outside world. Special economic zones in the new era have the following characteristics:

First, the advantage of early and pilot implementation. Early and pilot implementation is an opportunity for regions to gradually accumulate reform experience by innovating within the existing legal system.

Second, the advantages of market orientation. High-end innovation factors and innovation resources move quickly and directionally around the world, with innovation factors flowing to where there are favorable conditions.

Third, the advantage of industrial innovation. For example, in Shenzhen, the proportion of social investment in R&D relative to GDP in 2017 was 4.13%; the number of international patents totaled 20400, accounting for 43.1% of the national total, ranking first among cities in the country for 14 consecutive years.

Fourth, the advantage of synergy and openness. Guangdong Special Economic Zone in the new era has taken full advantage of the historical opportunities arising from the intersection and overlap of regional development strategies such as One Belt, One Road, Guangdong-Hong Kong-Macau Greater Bay Area, Pearl River Delta National Independent Innovation Demonstration Zone and Guangdong Province Comprehensive Coastal Economic Zone Development Plan, and fully utilized its synergistic openness advantages, strengthening the cooperation between the Special Economic Zone and the Guangdong Provincial Economic Zone.

Fifth, the advantage of innovation and tolerance for mistakes. 40 years of market competition during the reform and implementation of openness have fostered an innovation culture in the SEZ that is open, diversified and tolerant, which provides a significant advantage in innovation tolerance. The innovation culture of the Special Administrative Region allows for a favorable atmosphere of encouraging innovation and tolerance for failure..

4. Independent innovation environment

At present, China is intensively optimizing and upgrading its industrial structure, accelerating the transformation of the mode of economic development, and committing itself to building an innovative country. All these are inseparable from independent innovation and cannot be achieved without a perfect system of independent innovation policy as an institutional guarantee. Through independent innovation, China can continuously improve its international competitiveness and solve its own major scientific and technological problems, and independent innovation has been elevated to the height of national strategy. The main framework of independent innovation policy research is to explore the capacity of the national innovation environment, including the capacity of the innovation market environment and the capacity of the policy environment.

China's independent innovation environment includes establishing an industry-university cooperation system, continuously improving the institutional and legal environment, utilizing the huge size of the market to meet the challenges of innovation development, and promoting international cooperation (Figure 33).

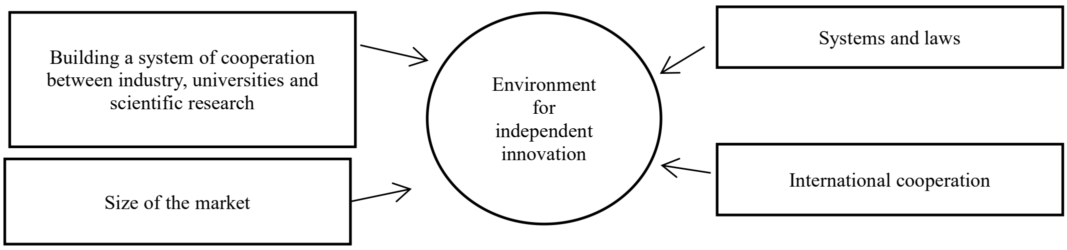


Figure 33. Structure of the system of independent innovation policy

Source: Compiled by the author.

Firstly, the technological innovation system of cooperation between industry, universities and scientific research. Enterprises have gradually become the main body of technological innovation. The role of research institutes and higher education institutions in the national innovation system has been further enhanced. A breakthrough has been made in the reform of research institutes, and the vitality and innovation capacity of these institutions have been greatly enhanced. More than 1,300 development institutes were transformed into enterprises, which solved the problem of the large number of applied development institutes, which had long been isolated from enterprises, and basically established the operation mechanism of science and technology enterprises. In addition, the capacity of S&T intermediary services has been strengthened. There are about 70,000 technology intermediaries of various types, including more than 330 permanent technology markets, more than 3,200 technology trading agencies, more than 500 technology business incubators, more than 1,300 productivity promotion centers and 62 science and technology parks under national universities.

Second, innovation development is driven by the sheer scale of the market. As shown in Table 23 below, China's GDP in 2021 was 114.367 trillion yuan, up 8.1% from the previous year, with a two-year average growth rate of 5.1%. Annual final consumption expenditure drives GDP growth by 5.3 percentage points, gross capital formation by 1.1 percentage points, and net exports of goods and services by 1.7 percentage points. GDP per capital for the year totaled 80,976 yuan, up 8.0 percentage points from the previous year. Gross national income totaled 113.3518 trillion yuan, up 7.9% year-on-year. By increasing domestic demand to stimulate the development of innovative enterprises and thereby stimulating the vitality of market players, consumers can be involved in the development of innovative enterprises and promote innovative development.

Table 23 - Key economic indicators in China in 2021.

Economic Indicator	Value	Growth rate,%
PRC GDP in 2021	114.367 trillion yuan	8,1
Average annual growth rate over two years	-	5,1
Gross final expenditure per year, contributing to GDP growth by	-	5,3
Total capital investment, contributing to GDP growth by	-	1,1
Net exports of goods and services contributing to GDP growth by	-	1,7
GDP per capita	80976 yuan	8,0
National income	113.3518 trillion yuan	7,9

Source: Compiled by the author on the basis of [76].

Third, creating a favorable institutional and legal environment. Most of China's technological innovation policies since the reform and opening-up policy have been aimed at promoting S&T achievements, as evidenced by the implementation of a large number of S&T programs, the great influence of S&T system reform on institutional development, and S&T talent mobility policies. In the new era, the Chinese government pays more attention to creating a favorable environment for technological innovation, as evidenced by the gradual improvement of the relevant legal and regulatory system, the development of various tax incentives, trade policies to promote the export of high-tech high-value-added products, technology market policies to promote technology diffusion, and policies to support the development of high-tech industries. A policy and legal system to encourage innovation is taking shape. China has adopted and promulgated a series of policies and regulations, including the Science and Technology Progress Law, Patent Law, Copyright Law, Trademark Law, Technology Contract Law, Science and Technology Transformation Promotion Law, etc. The recently revised Law on Scientific and Technological Progress, which came into effect on July 1, 2008, provides the legal framework and institutional safeguards for scientific and technological innovation throughout society. The Ministry of Science and Technology, the Development and Reform

Commission and other departments have individually or jointly formulated more than 110 policies to support S&T innovation, and a policy and legal system conducive to S&T innovation is being formed.

Fourth, China's international S&T cooperation model has been established. Universities and enterprises have formed "consortia" in innovation and industrialization and cooperate with relevant organizations through public funding, technology and policy. Universities and enterprises should make full use of core technologies from cooperation with foreign organizations, integrate their own special technologies, innovate twice, and develop new higher-level products that are more market-oriented. After gaining competitive advantage, they can form their own intellectual property rights to quickly enter the international level and participate in international competition in domestic and international markets.

The key areas of development of China's national innovation system are international innovation cooperation, independent innovation, human resources and public investment, which support and promote each other and jointly drive the development of Chinese innovation. In the field of international innovation cooperation, China makes full use of the role of four types of actors - universities, government, enterprises and relevant foreign organizations - and implements the voluntary cycle of internationalization of innovation at home and abroad through the integration of science and technology enterprises into international science and technology cooperation, the government's science and technology diplomacy and the integration of the national education system into the global education system. In terms of talent policy, China attaches great importance to nurturing talented young people and actively establishes a system to train promising young professionals. At the same time, the Chinese Government has introduced a series of policies to support young scholars, including providing high-paying jobs, encouraging research and optimizing mechanisms for evaluating the scientific contributions of young professionals. China's talent policy has gradually formed a new model of a two-pronged approach - international introduction and domestic nurturing, with parallel incentives and safeguards. In terms of public investment, the Chinese government attaches great importance to S&T innovation, increasing investment in S&T innovation and promoting the transformation and application of S&T innovation results. Investment in education and investment in the development of national innovation infrastructure are two important aspects of public investment in innovation. Public investment in education includes both investment directly in education and investment in S&T innovation funds, technology transfer funds and other areas. Investment in the development of national innovation infrastructure is also an important driver of public investment in innovation. This includes public investment in building national innovation infrastructure, such as high-level research institutes, scientific laboratories and technology innovation centers that provide high-quality research environment and scientific and technological support to promote technological innovation and industrial development. In terms of independent innovation, China is committed to building a system of independent innovation, promoting the transformation and application of the results of independent innovation, and continuously improving the innovation capacity and competitiveness of enterprises. The Chinese government develops national innovation environment capacity, including innovation market environment capacity and policy environment capacity.

2.3 Features of development of the national innovation system in Russia

The key areas of development of the national innovation system imply a detailed analysis of Russia's innovation development system in four areas: independent innovation development, investment in innovation, training of young scientists and the international market. By comparing the development systems of China and Russia in these four directions, we can identify the main vectors for improving the innovation system in Russia in the third chapter.

In modern conditions, innovation processes in economically developed countries are becoming more and more open [61]. Taking into account the real situation in the development of science and technology in the country, through international cooperation Russia stimulates the creation of a research base in new areas of science and technology, develops interdisciplinary research, increases research opportunities for scientific workers, promotes the commercialization of scientific achievements and technological transfer, and addresses issues of global importance within the framework of multilateral cooperation [39]. The Russian government implements national policy and mechanisms of international S&T cooperation in the field of basic scientific research, applied technology and higher education, which have their own characteristics.

The first is the creation of joint ventures. The creation of joint ventures involving foreign research, investment and technology companies, using public and private funds, is a new promising way of Russia's foreign trade scientific and technological cooperation. To date, many large scientific institutions in Russia have established subsidiaries with foreign capital participation. For Russia, this type of cooperation allows it to reduce the pressure of entering the international market and take less commercial risk.

The second is the creation of technoparks. The creation of technoparks is one of the important forms of expanding Russia's participation in the international division of labor. Technoparks in Russia are usually built on the basis of a major scientific and technical institute, such as the Institute of Technical Physics in Moscow and the biotechnology technopark in Pushchino. These parks usually have technology commercialization centers, risk investment centers, exploration and remote access centers, etc.

The third way is to create companies for commercial risk investment. Investment risks are one of the main factors limiting Russian participation in international scientific and technological cooperation. Russia and Finland have established a Russian-Finnish company for commercial risk investments in St. Petersburg. The main objective of this company is to assist small Finnish companies in establishing links with Russian R&D institutions, developing, producing and promoting products in the Russian domestic and international markets, and facilitating the transition from defense to civilian production in and around St. Petersburg. This investment company also provides services in technology transfer, commercial research, contracting, joint ventures, international cooperation, product promotion and personnel training for Russian and foreign companies. The establishment of a commercial investment company significantly reduces the investment risk in bilateral S&T cooperation, which is a very useful and promising form of bilateral S&T cooperation.

The fourth way is international scientific and technical cooperation of higher education institutions. The Russian government has selected several sites to establish national research universities and supports their international S&T cooperation to strengthen their international ties and enhance their scientific status on a global scale. The main goal of the program of national research universities supported by the government is to raise the level of education to the world level, to build the capacity of personnel capable of supporting and developing science, high technologies and professional education, to stimulate the development of high technologies in the Russian Federation and their commercialization. The program of national research universities is one of the most effective strategic initiatives in Russian higher education for the last 15 years[1].

Fifth, the Russian government pursues multilateral and bilateral S&T cooperation. Russia has always endeavored to develop multilateral and bilateral S&T cooperation, and has established broad S&T partnerships with many countries. Russia actively participates in S&T projects of international organizations such as UNESCO, IAEA, and cooperates with many developing countries including China, India, Brazil, and is involved in technology transfer, training and other types of international cooperation. In the bilateral aspect, Russia has concluded a number of S&T cooperation agreements with the United States, the European Union, China, Japan and other countries, agreements to strengthen cooperation in advanced manufacturing, aviation and space, health care, etc., to jointly promote the commercialization and marketing of S&T achievements. In addition, Russia has established some regional S&T cooperation mechanisms with its neighbors, such as the Council for S&T Cooperation with the five Central Asian states and the S&T cooperation agreement with the

[1] Berestov A.V., Guseva A.I., Kalashnik V.M., Kaminsky V.I., Kireev S.V., Sadchikov S.M. Project "national research university" - a driver of Russian higher education // Higher Education in Russia. 2020. Т. 29. № 6. С. 22-34.

members of the Eurasian Economic Union, aimed at promoting the exchange of S&T achievements and the development of technological innovation.

After the collapse of the USSR, the outflow of scientific personnel from Russia was significant, and the development of a talent pool in science faced unprecedented challenges. To revitalize the dominance of Russia's scientific cadres on the world stage, the Russian government has developed a number of measures, such as increasing investment in scientific research, increasing the salaries of scientific workers, creating a motivational policy for young scientific cadres, attracting the best scientists for scientific research, etc. Over the past two years, the quantity and quality of scientific personnel in Russia have improved, and the country's scientific potential and innovation capabilities are being strengthened.

To solve the problem of scientific personnel outflow, Russia has developed appropriate policies to attract scientific personnel in recent years. Among the most effective of these are the Federal Target Program "Innovative Russia 2009-2013" and the Research Program of Higher Education Institutions of Russia 2010, as shown in Table 24.

Table 24 - Measures to attract scientific personnel in Russia

Scientific and Scientific-Pedagogical Personnel of Innovative Russia for 2009-2013	
Main content	1. A team of specialists and research institutes for highly educated talents has been established 2. Support the establishment of scientific and educational centers 3. Expand scientific research around the world 4. Expand the scope of research activities, not only supporting the development of technical sciences, but also focusing on the humanities and economic sciences
Policy features	1. Emphasize that their own level of scientific research is in line with the world level and improve promising and innovative research 2. Strengthen and support exchanges and cooperation between domestic scientific research institutions and international scientific research institutions 3. With regard to scientific and technological talents, emphasize the practicality and innovation of scientific research technologies
Policy effect	A large investment has been made, inspiring students studying abroad to return to China
Megagrants Program to Support Scientific Research in Russian Higher Education Institutions	
Main content	1. The Ministry of Education and Science of Russia encourages scientific research by selecting domestic and foreign research projects and then provides financial support 2. Provide favorable housing policy for teachers, especially young teachers. Young teachers under the age of 35 will be given the most favorable conditions for purchasing housing: the down payment should not exceed 10%, the mortgage interest rate will be reduced to below 8.5%, and the down payment is recommended to be assumed by the local government. The government provides land for free and allows teachers to build houses 3. In special industries such as medicine, the biggest benefits are given. On the one hand, to encourage young health workers to

	work in underdeveloped areas, the government has set up special funds to encourage and support medical projects. On the one hand, to retain specialists, a one-time subsidy of 1 million rubles is given to young doctors who have worked for a long time (5 years or more). On the other hand, it is necessary to increase the share and size of subsidies for special industries, expand transportation subsidies in the Far East and Siberia.
Features of the policy	Considering the two factors of college teachers' research and training tasks, with the focus on the education and training of schoolchildren, it is believed that the success of education training is directly related to the prospects of future scientific and technological talented young professionals
Policy effect	Between 2010 and 2012, these projects received a total of 5.33 billion rubles in state funding

Source: Compiled by the author based on [16],[26].

From the table we can see the measures aimed at attracting scientific personnel to Russia.

1.Priority of educational training of personnel. The Russian government pays great attention to educational training, which is manifested in many aspects. Firstly, the government encourages young teachers to engage in scientific activities by providing favorable conditions such as housing benefits, subsidies, etc. This can encourage more talented people to engage in scientific research, enhance innovation and practice-oriented scientific research. Secondly, the government pays attention to the training and education of higher education students, believing that successful training is directly related to the prospects of scientific personnel in the future. Therefore, the government provides financial support and subsidies to higher education institutions to improve the quality and level of education.

2.Significant investments have been made to help specialized students studying abroad to return to Russia. For example, between 2010 and 2012, the government supported relevant programs with a total of 53.3 billion rubles, these investments helped encourage international students to return to their home country to pursue scientific activities. In 2013, the Government of the Russian Federation approved the concepts of two federal special programs - "Research and Development in Priority Areas of Science and Technology in the Russian Federation for 2014-2020" (hereinafter referred to as "Research and Development") (hereinafter - "Research and Development") and "Innovation - Science - Personnel in Russia for 2014-2020" (hereinafter - "Personnel") (hereinafter - "Personnel"). The main goal of the new special program "Research and Development" is to form competitive applied research and development units in Russia. The Russian government plans to allocate 202.23 billion rubles (about $65.24 billion) from the federal budget to implement this special program. The purpose of the special program "Personnel" is to ensure high quality training of highly qualified research and scientific-pedagogical personnel and to improve the international competitiveness of Russian personnel. It is planned to allocate 153.48 billion rubles (about 49.51 billion USD) from the federal budget for the implementation of this special program[16],[26].

3.Developing a policy of incentivizing young scientific and technical personnel

4.Attracting leading scientists for scientific research. In 2010, the Russian government adopted a resolution "On Measures to Attract Leading Scientists in Higher Professional Education Institutions in Russia" and decided to organize an annual "Talent Selection" competition, where leading scientists from higher education institutions in Russia will participate in scientific research to qualify for government funding. Each winner will receive 900 million rubles, and the term can be extended for 2 years provided that investments from extra-budgetary sources make up at least 25% of the funding. Through such a systematic and targeted selection, Russia has not only provided an important direction for the formation of the necessary highly qualified personnel, but also gradually established a mechanism for finding and attracting talented personnel so that universities and research institutions can achieve sustainable development in the future.

Russia has always paid great attention to education, considering it as one of the important factors of the country's development. Firstly, the Russian government makes large-scale investment in education. According to the Russian Ministry of Education, the Russian government invests more than 4% of GDP in education every year, which makes Russia one of the countries with the highest level of investment in education in the world. This money is used to improve educational infrastructure, increase teachers' salaries, purchase modern educational equipment, etc. Secondly, Russia has a well-developed education system. Russia's educational system includes several levels such as preschool, primary, secondary and higher education. At each level, students receive a comprehensive and systematic education. Finally, the higher education system in Russia, which is in constant transformation, must respond quickly and adequately to new requirements for professional training [34]. The Russian government actively supports scientific research and innovation, investing a large amount of funds in the training of scientific and technical specialists.

Table 25 lists the various innovation infrastructure facilities in Russia.

Table 25 - Number of innovation infrastructure facilities in 2022

Innovation infrastructure facilities	**608**
Business incubator	65
Industrial (industrial) park	62
Innocenter	4
Cluster	170
Consortium	3
Nanocenter	9
Science city	13
Special economic zone	49
Territory of advanced socio-economic development (ASED)	115

Technological platform	7
Technopark	111

Source: Compiled by the author on the basis of [81].

According to the definition of the National Commonwealth of Business Incubators, a business incubator is an organization that creates favorable conditions for the start-up development of small enterprises by providing a range of services and resources, including providing enterprises with space on preferential terms, communication facilities, office equipment, necessary equipment, conducting staff training, consulting services, etc. Ingria Incubator is one of the leading business incubators in St. Petersburg and was established in 2008 on the basis of Ingria Technopark. This incubator provides large areas for business and job development. The incubator offers additional services such as project support, a system of project expertise, development of an intellectual property protection plan, assistance in organizing production and use of a partner network. Ingria Incubator also provides support to residents and assists them in lobbying for projects with the authorities. Thanks to these efforts, the incubator has already accepted 40 innovative projects, including projects such as 4DSport, Biomedical Modeling and Teksix.

The Russian Association of Industrial Parks defines an industrial park as "a specially organized territory for the location of new production facilities, provided with energy, infrastructure, necessary administrative and legal conditions, and managed by a specialized company". Industrial parks are usually equipped with modern production facilities, warehouses, offices, communications, service centers and other infrastructure that may be necessary for the successful operation of manufacturing enterprises. The creation of industrial parks can lead to increased productivity, improved product quality, new jobs, and attract investment to the region. Industrial parks can also reduce production costs by sharing infrastructure and establishing contractual relationships between residents.

The organizational format of the innovation center allows optimizing the process of implementing an effective idea into a business project, production, etc. The structure of the association has a scientific and technical base, complexes for testing practical samples, sources of attracting financing and a database of ready projects. The organizational format of the innovation center allows to optimize the process of implementation of an effective idea in a business project, production, etc. The structure of the association has a scientific and technical base, complexes for testing practical samples, sources of attracting financing and a database of ready projects [82]. Skolkovo Innovation Center is a complex innovation park that combines research and development, production and housing. The territory of the center hosts many enterprises, laboratories and research institutes covering a wide range of industries, such as information technology, biotechnology, new energy, aerospace and others. The Center offers a range of support services including financial support, business training, technology transfer and intellectual property protection to help entrepreneurs and start-ups succeed in the marketplace.

A cluster is a set of diversified business entities uniting for the purpose of achieving high market performance through the production of competitive and/or innovative products and located in the same territory. Since the end of 2016, support for innovative territorial cluster formations in Russia is realized through the launch of the priority project "Development of innovative clusters - leaders of investment attractiveness of the world level" by the Ministry of Economic Development of the Russian Federation. The purpose of this project is to assist the country's economic growth, ensure its innovative development, increase exports of high-tech products, commercialize innovative technologies and, in general, strengthen national competitiveness [86].

Consortium in the innovation sphere is a temporary association of banks, enterprises, companies, firms, scientific centers on the basis of a statutory agreement between them to implement knowledge-intensive and capital-intensive projects, including international ones. The specificity of the consortium consists in the fact that the partners included in it retain their economic and legal independence, except for the part of activities that relate to the goals of the consortium. In Togliatti, an innovation consortium was established in 2021. In addition to TSU, the consortium includes the state independent institution of the Samara region (SAU SO) "Center for Innovative Development and Cluster Initiatives" - the management company of the technopark "Zhigulyovskaya Dolina", the municipal independent institution of the city of Togliatti (MAU) "Agency for Economic Development" - the management company of the Togliatti Business Incubator, LLC "Technology Transfer Center" - the management company of the venture fund of the Samara region and the Togliatti Academy of Management [75].

Nanocenter is the largest nanotechnology research center in Russia. It was created to develop research, application of nanotechnologies and increase Russia's competitiveness in the global nanotechnology sector. The creation of the nanocenter is of great importance for innovation in Russia. It provides a centralized platform for nanotechnology research, bringing together experts and scientists from various fields to advance the development and application of nanotechnology. In addition, the nanocenter also helps to attract talent, strengthen cooperation with the international nanotechnology sector, and enhance Russia's competitiveness in the global nanotechnology arena.

A science city of the Russian Federation is a municipality, which has been granted the status of an urban district, with a high scientific and technological potential, with a city-forming scientific and production complex. A science city was established to promote scientific and technological innovation and development of the country by bringing together specialists and resources in science, technology and engineering. These cities are often equipped with advanced infrastructure and facilities and attract national and international investment and talent, making them important centers for national scientific and technological research. In addition, science cities are able to attract and support the development of innovative companies and startups, providing an excellent research and business environment.

Russian Special Economic Zones (SEZs) are special zones created to attract direct investment in priority economic activities. There are 45 SEZs, seven of which are technology deployment zones. Residents of these technology introduction zones enjoy special tax conditions, customs regime, business infrastructure, preferential land lease and connection to engineering networks, have high quality labor resources and opportunities to attract highly qualified foreign specialists. In addition, employees of resident companies enjoy preferential terms for renting and purchasing housing, and employees of the SEZ management company provide residents with ongoing support. These advantages guarantee SEZ residents a favorable environment for innovation and stimulate innovative and technological development.

The Russian Advanced Development Zone was created as a special area to accelerate economic modernization and improve living standards in the region. This program focuses on slowly developing regions and cities, mainly single cities and the Far East. The goal of the advanced development zone includes creating favorable conditions for attracting investment, ensuring accelerated socio-economic development of the region and creating comfortable living conditions for the local population. The most important goal is to ensure comfortable living conditions for the population. In addition, the concept of the advanced development zone is aimed at creating specific growth points - more clearly defined centers of economic growth of the region, the rapid growth of which stimulates the development of the surrounding territories. The effectiveness of the advanced development zone policy in Russia is very high and can help the Far East achieve significant growth in the medium term and have a stimulating effect on the national economy.

The Technology Platform is an organization established by the Russian government to promote scientific and technological progress, aimed at stimulating cooperation and exchange of experience between different industries, encouraging research and technology commercialization, and helping to translate research results into practical implementation.

The Technopark, in turn, is a base for innovative enterprises, which facilitates the development of enterprises by providing them with low-cost office space, equipment, services and other support. Technopark also provides opportunities for enterprises to collaborate with other enterprises and research institutions to promote innovation and technology commercialization. Both of these mechanisms have a positive impact on stimulating innovative development in Russia. The technology platform, by encouraging cooperation and exchange of experience between different industries and fields, makes possible a wider use of scientific results and technology commercialization. Technopark, on the other hand, creates favorable conditions for the development of innovative enterprises, which allows them to grow and develop in the field of technological innovation and commercialization. All this contributes to the stimulation of innovative development of the Russian economy.

The environment of independent innovative development of the Russian Federation has the following features.

First, Russia, as an environment for independent innovative development, has a relatively small economic and market scale, insignificant imports and low per capita consumption, which limits the ability to stimulate technological innovation. According to statistics from the Higher School of Economics of Russia, Russia's GDP amounted to 72 trillion 985.7 billion rubles in 2013 and 109 trillion 608.3 billion rubles in 2017 with a growth rate of 3.34%, which is below the average global growth rate. Russia's import volume is also relatively small, at US$227.46 billion in 2019, down 27.9% from 2013. Per capita consumption expenditure was 15974.64 USD in 2013, and 11536.25 USD in 2019. From 2013 to 2019, consumption expenditure in Russia as a whole had a negative growth trend. Overall, these data indicate a relatively low level of domestic demand and economic growth in Russia, which presents a challenge to stimulate technological and self-driven innovation [74].

Second, market mechanisms in Russia are still imperfect, competition in the goods market is weak, intellectual property protection is low, and the degree of monopolization is high. In such a market environment, achieving optimal allocation of innovation resources and stimulating the development of technological innovation may face some obstacles. In 2018, the World Economic Forum published the Global Competitiveness Report, evaluating nine aspects of Russia's product market. Russia's score was 54.2 points, ranking 83rd, with good performance in the position "competition in services", but significantly lower performance in the positions "impact of taxes and subsidies on competition", "market monopoly", "non-tariff barriers", "complexity of customs policy" and "efficiency of customs procedures". In addition, the level of intellectual property protection and the degree of market monopoly may also reflect the level of development of the market mechanism and competitive conditions. In 2018, the assessment of the level of intellectual property protection in Russia amounted to 3.9 points, ranking 85th in the world ranking. The insufficient level of intellectual property protection can directly reduce people's desire and enthusiasm for knowledge creation, leading to low innovation efficiency. On the index of "degree of anti-monopoly", Russia's score was 3.7, which is below the world average, indicating that monopolization in Russia is still quite high.

Third, cooperation between industry, educational institutions and research institutes in Russia is not tight enough. First, the system of education and research institutes in Russia is not fully adapted to the needs of the market and commercial environment, which leads to difficulties in cooperation between industry, educational institutions and research institutes. Secondly, Russia lacks a financial system and policy environment that support innovation in enterprises, which makes it difficult for companies to obtain the necessary funds and support. In addition, the legal framework for intellectual property protection in Russia is flawed, which creates uncertainty and risks in cooperation between industry, educational institutions and scientific institutes, making it difficult to protect and commercialize intellectual property. In addition, large state-owned enterprises in Russia have a strong influence on market monopolization, resulting in a lack of competition and incentive for innovation in industry. Collaboration and communication between enterprises and research institutes face the challenges of language and cultural differences, which limits the depth and breadth of collaboration. Finally, cooperation between industry, educational institutions and research institutes in Russia also faces the challenge of uneven geographical distribution, especially in the Far East and remote areas where resources and support are limited.

Unlike Russia, China's state innovation system in international innovation cooperation:

- Attaches importance to the role of government, enterprises and universities in international innovation cooperation;
- Considers international innovation cooperation as an important strategy for the development of Chinese innovation;
- Actively participates in international S&T organizations and cooperation platforms;
- Supports and encourages the establishment of foreign R&D centers by Chinese enterprises and universities;
- Establishes an international innovation network.

Table 26 illustrates the differences between Russia and China in government support for the provision of innovation personnel.

Table 26 - Differences between Russia and China in state support of innovative personnel provision

Staffing direction	Russia	China
Staff training	Important priority, but less attention	A top priority with strong support for the development of higher education and research institutions
Staffing policies	Less flexible policies	More flexible and proactive policies, such as reforming the innovative talent evaluation mechanism and granting more autonomy to highly qualified personnel
International development	Fewer projects and policies aimed at attracting foreign scientists and highly qualified specialists	Actively promote talent immigration, overseas training and exchange, and actively promote international cooperation with other countries and regions in science and technology to achieve mutual benefits

Source: Compiled by the author.

Table 27 compares the different strategies and investment priorities of China and Russia in terms of investment in innovation.

Table 27 - Directions of investment in innovation in China and Russia

Country	**Main directions of innovative investments**
China	- High-tech industries - Intellectual property protection - Scientific research - Scientific and technological infrastructure - Talent Attraction - National university core laboratories - National self-innovation demonstration zones - New economic zones and pilot zones for digital economy development - Support for high-tech enterprises
Russia	- Innovation infrastructure - Support for innovative enterprises (business incubators, industrial parks, innovation centers, clusters, consortiums, nanocenters, science cities, special economic zones, territories of advanced socio-economic development, technology platforms, technoparks, etc.)

Source: Compiled by the author.

In general, China pays more attention to developing high-tech industries and protecting intellectual property rights, with investment priorities including scientific research, developing science and technology infrastructure and taking care of human resources, while Russia pays more attention to developing innovation infrastructure and supporting innovative enterprises, with investment priorities including business incubators, industrial parks, innovation centers and technology platforms. At the same time, we believe that China's investment in high-tech industries and intellectual property protection is world-leading, which is one of the key reasons for the rapid development of science and technology in China. In addition, Russia's innovation investment measures are more diverse and scattered. Such measures may waste resources and strength, which is not conducive to promoting innovation.

As shown in Table 28, there are obvious differences between China and Russia in creating an independent innovation environment.

Table 28 - Comparison of China and Russia in the field of independent innovation environment

Areas of independent innovation environment	Russia	China
Consumption level of the population	Low	High
Domestic demand	Limited	High
Link between technological advances and commercialization	Relatively weak	Relatively strong
Share of commercialized technological innovations	Relatively low	Relatively high
Intellectual property protection	Imperfect	Relatively perfect

Source: Compiled by the author.

Compared to Russia, China has an advantage in the field of independent innovative development for several reasons. First, the consumption level of the population in China is high, which is conducive to stimulating domestic demand for innovation. Secondly, in China, the relationship between technological achievements and commercialization is relatively strong, and the commercialization rate of technological innovation is higher, which is conducive to its successful implementation in real production and life. Finally, China's intellectual property protection system is relatively perfect, and the patent application and examination processes are relatively simple, which helps to avoid intellectual property infringement problems.

By analyzing four areas in Russia and China: international cooperation in innovation, investment in innovation, human resource policies, and the environment for independent innovation, we can draw the following conclusions: utilizing China's best practices can significantly improve Russia's efficiency and competitiveness.

The second chapter of the dissertation analyses the formation of the national innovation system in China in order to identify the model of innovation management in this country. Using econometric principal component analysis, the key factors influencing China's national innovation system are also identified. Based on the identified key factors, a comparative analysis of China's and Russia's development models in international cooperation, innovation, support for young scientists and public investment is conducted. Based on the analysis of innovation management in China and Russia, including aspects of international cooperation in innovation, staffing, investment in innovation and the creation of an environment for independent innovation, recommendations for the application of Chinese experience in Russia are formulated.

CHAPTER 3 DIRECTIONS FOR IMPROVING INNOVATION MANAGEMENT

3.1 Key areas of innovation management

Based on the comparative analysis of China and Russia in terms of international innovation cooperation, human resources, investment in innovation and the environment for independent innovation conducted in Chapter 2, recommendations for using the PRC's experience in Russia are formulated:

1.Promote joint cooperation among government, enterprises and universities in international innovation. The government, enterprises and universities should strengthen cooperation in innovation and establish mechanisms for joint implementation of innovation projects. The government can formulate policies and provide support, enterprises can provide funding and resources, and universities can provide research and knowledge, creating a chain of cooperation.

2.Creation of international innovation networks. Russia can consider creating international innovation incubators or open innovation centers to attract foreign start-ups and innovators. This would facilitate interaction with the global innovation system, as well as overcome the challenges of sanctions and establish international innovation links.

3.Prioritize the attraction of foreign specialists. Russia can take measures to actively attract foreign specialists, including compatriots with experience of studying and working abroad and foreign experts. This can be achieved by providing them with additional opportunities and support.

4.Flexible and adaptive policy. Russia should develop a flexible and adaptive system of scientific personnel policy that can respond quickly to changes in the national and global talent market.

5. Attention to high-tech industries. Russia can increase investment in high-tech industries such as information technology, biotechnology and artificial intelligence to improve its competitiveness on the global stage.

6.Establishment of innovation demonstration zones and development of digital economy. Russia can establish innovation demonstration zones and actively develop the digital economy to attract innovative projects and resources.

7.Intellectual property protection. Russia should strengthen intellectual property protection measures to promote innovation and technology exchange.

8.Alignment with the country's development program and strategy. Integration into already existing or planned development programs and strategies allows to achieve specific goals and objectives defined in this program or strategy.

The existing system of innovation management in the Russian Federation is constantly improving. In the Federal Law No. 127 "On Science and State Scientific and Technical Policy" the section "main goals and principles of state support of innovation activity" is formulated and actively used in management practice [25].

Table 29 shows some of the documents on Russia's innovation cooperation with various countries in the period from 2010 to 2022. Russia's investment and policy development in international innovation cooperation, as well as the various cooperation agreements signed with other countries, show that Russia recognizes the importance of international innovation cooperation and seeks to promote science, technological innovation and technology transfer. The areas covered by these documents are very broad and include artificial intelligence, 5G, advanced manufacturing, biotechnology, aerospace, new materials, energy, medicine, ecology and much more. This shows that Russia realizes that innovation and development in the field of modern technology requires interdisciplinary international cooperation. The Russian government is taking many measures to encourage international cooperation in innovation. For example, Russia is adopting legislative and legal acts to encourage technological cooperation and technological transfer between domestic and foreign companies. In addition, the Russian government is establishing a number of innovation centers and incubators that provide support and funding to innovators and entrepreneurs in science and technology.

Table 29 - Documents on Russia's international cooperation in the field of innovation in the period from 2010 to 2022

File name		Main Content	Country
Roadmap for Russia-China Co-operation in Science, Technology and Innovation	2019	Strengthening cooperation between Russia and China in artificial intelligence, 5G, advanced manufacturing, etc., stimulating commercialization and technological achievements	China
Strategic Partnership Agreement between Russia and India	2010	Developing high-tech industries, promoting commercialization and technological achievements	India
Agreement between the Government of the Russian Federation and the European Community on Cooperation in Science and Technology	2011	Strengthening cooperation between Russia and the European Union in the fields of biotechnology, aviation and space research, new materials, etc., stimulating innovation and technological transfer	Member States of the European Union
Agreement between the Government of the Russian Federation and the Government of the United States of America on	2013	Development of high-tech industries, strengthening the exchange of scientific and technical personnel, stimulating commercialization and technological achievements	European Union

cooperation in nuclear and energy research and development			
Agreement between the Government of the Russian Federation and the Government of Japan on scientific and technical cooperation	2018	Strengthening cooperation between Russia and Japan in the fields of energy, medicine, ecology, etc., promoting commercialization and technological achievements	USA

Source: Compiled by the author.

Over the past decades, Russia has been a country of great scientific and technological power, leading the world in aviation, space and nuclear technology. However, in recent years there has been a downward trend in Russia's cooperation with other countries in the field of innovation due to geopolitical tensions, economic recession and Russia's possible preference to develop and master technologies on its own. With increasing international competition and the trend towards globalization, Russia should seek cooperation with other countries to maintain its dominant position in international competition in science and technology.

The Russian Science Foundation (RSF) is a fund established by the Russian government to finance scientific research. Its main purpose is to provide financial support to university professors and researchers, and to promote scientific and technological progress and development. The Russian Science Foundation can be used to support a variety of scientific projects, including basic research, applied research and technological innovation. These projects involve a wide range of fields, including natural sciences, engineering technologies, social sciences and humanities, etc. By supporting these projects, the fund can provide broader research opportunities for Russia's innovative professionals and encourage their achievements in their respective fields. Table 30 shows the information about the investment of the state of Russia in scientific and technological research over the last seven years. It can be seen that the amount of the fund's investment has been increasing every year recently. This shows that the Russian government highly values scientific and technological progress and strives to provide sufficient funding for its scientists and researchers in order to attract highly qualified specialists.

Table 30 - RNF expenditures on scientific and scientific-technical programs and projects

Year	Expenditures of the Russian Science Foundation on scientific and scientific-technical programs and projects (RUB bln)
2014	7.99
2015	14.56
2016	17.9
2017	18.5

2018	21.4
2019	21.7
2020	21
2021	22.1

Source: Compiled by the author on the basis of [85].

The effectiveness of Russia's talent support policy can be assessed by the share of GDP spent on education, the number of researchers, the number of Russian students studying abroad, the number of students returning to Russia and the number of foreign experts working in China.

Investment in education is a fundamental and strategically important investment that ensures the long-term development of the country, is an important material basis for the development of education and a priority area of government financial support. The state should prioritize the development of education, pay high attention to increasing financial investment in education and take policy measures to increase financial investment in education. This table shows Russia's investment in education from 2000 to 2021, divided by the budget systems of different levels in Russia. From Table 31, it can be seen that the Russian government's investment in education increased from 214.7 billion rubles in 2000 to 4690.7 billion rubles in 2021, which shows that the government's investment in education is constantly increasing. Over this period, the federal budget for education has also increased year on year, from R38.1 billion in 2000 to R1,064.4 billion in 2021. This may be due to the fact that the government has realized the importance of education for the development of the country and has increased its investment in this area. In general, this table shows that the Russian government is constantly investing in education, which contributes to increasing the level of educated population and the development of the economy and society as a whole.

Table 31 - Government Expenditures on Education by Level of the Budget System, 2000-2021 (billions of RUR)

Year	2000	2005	2010	2015	2018	2019	2020	2021
Consolidated budget of the Russian Federation and budgets of state off-budget funds	214,7	801,8	1893,9	3034,6	3668,6	4050,7	4324,0	4690,7
Federal budget	38,1	162,1	422,8	610,6	722,6	826,5	956,9	1064,4

Source: Compiled by the author on the basis of [87].

Public investment in innovation can contribute to the creation of a platform in the form of key laboratories and centers of technological innovation. These can be research institutes, technoparks, innovation centers and other organizations that are engaged in the development and commercialization of new technologies. Such investments can take various forms, such as providing financial support for innovators, etc. These investments can stimulate the research and development work of innovators, improve their efficiency and the quality of their results. This will further stimulate the continuous reform and modernization of technologies and products, enhancing the competitiveness and innovation capacity of enterprises and the country. According to the data in Table 32, we can say that there is an increase in investment in the field of innovation in Russia from 2015 to 2020. In general, investments in this area have increased from 1,211.29 billion rubles in 2015 to 2,134.04 billion rubles in 2020, with these investments continuing to grow each year. Specifically, in current prices, investment in innovation in Russia amounted to RUB 1,211.29 billion in 2015 and increased to RUB 2,134.04 billion in 2020. After adjusting for inflation, investments in the field of innovation amounted to 790.82 billion rubles in 2015 and increased to 1124.77 billion rubles in 2020. In addition, it can be noted that the investment growth rates in 2019 and 2020 are significantly higher than in previous years. This shows that Russia highly values the development of the field of innovation and seeks to encourage enterprises and innovators to increase investment in this area.

Table 32 - Costs of innovation activities

Year	2015	2016	2017	2018	2019	2020
Expenditures on innovation activities - total:						
in current prices, mln. rub.	1211294.4	1298444.5	1416922.8	1484901.1	1954133.3	2134038.4
in constant prices, mln. rub.	790817	824618.6	854546	814135.1	1039211.5	1124766.5
as a percentage of 2010	192.4	200.6	207.9	198.1	252.8	273.7

Source: Compiled by the author on the basis of [87].

State support for the digital economy can have a positive impact on innovation. The future development of economy, society and political systems is primarily associated with the development of innovative and digital technologies [33]. The development of the digital economy requires support for various innovative technologies such as artificial intelligence, big data, cloud computing, etc. If the government provides support and encourages enterprises and innovators to invest in these fields, it can stimulate their research and development potential, promoting the rapid development of the digital economy. The success of digital economic innovation can not only enhance the economic strength and competitiveness of the country, but also bring more employment opportunities and economic development in the society. According to Table 33, we can conclude that from 2017 to 2021, Russia's investment in the digital economy has increased year by year. Overall, Russia invested from 3324 billion rubles in 2017 to 4848 billion rubles in 2021 in the development of the digital economy. At the same time, a significant share of investments is the contribution of enterprises to the creation, distribution and use of digital technologies and related products and services. In 2017, enterprises invested 1,739 billion rubles in this area, and by 2021 - already 2,947 billion rubles. In addition, household investment in the use of digital technologies and connected products and services is also growing every year. In 2017, investments in this area amounted to 1,210 billion rubles, and by 2021, already 1,901 billion rubles.

This shows that the Russian government is taking the development of the digital economy seriously and is keen to encourage businesses and households to invest in digital technologies. The development of the digital economy is extremely important for Russia's economic development.

Table 33 - Gross Domestic Costs of Digital Economy Development (billions of rubles)

Year	2017	2018	2019	2020	2021
total	3324	3795	4094	4063	4848
Internal costs for organizations to create, disseminate and use digital technologies and related products and services	1739	1953	2453	2262	2947
Household expenditures on the use of digital technologies and related products and services	1210	1397	1641	1801	1901

Source: Compiled by the author on the basis of [87].

Public investment in research and development (R&D) can contribute to the development of high-tech industries and increase their competitiveness. High-tech industry is usually dependent on innovative technologies and intellectual property and requires high R&D expenditures. If the government provides sufficient funding and policy support to encourage investment and innovation in this area among enterprises and innovators, it will spur their active research efforts, contributing to the development of high-tech industries. These investments can help enterprises create new products, improve production efficiency, reduce costs, improve product quality and increase international competitiveness. At the same time, these investments can also contribute to employment and economic growth in the high-tech industry, stimulating the development of related industries and forming a more powerful and innovative economic system.

Table 34 shows Russia's investment in domestic R&D from 2010 to 2020. Russia's investment in R&D shows a constant growth trend from 523.4 billion rubles in 2010 to 1174.5 billion rubles in 2020. However, Russia's R&D spending seems to have declined in 2018 and 2019, but there is a significant increase in 2020. Russia's domestic R&D spending grew between 2010 and 2014, but fluctuated in 2015 and 2016, then began to grow steadily again from 2017 to 2020. These data exclude the impact of inflation on Russia's domestic R&D expenditures. The shares of Russia's domestic R&D expenditure in total domestic product show that this share was around 1.13% in 2010, then declined between 2013 and 2014, and then started to rise again, reaching 1.1% in 2020. This indicates that the share of Russia's R&D investment in the economy is quite stable, but there is no clear upward trend.

Table 34 - Internal research and development costs

Year	2010	2013	2014	2015	2016	2017	2018	2019	2020
Internal research and development costs, ths. rub:									
in current prices	52337723 3.9	74979763 8.8	84752699 2.9	91466905 7.2	94381521 9.6	1019152437	1028247645	1134786665	1174534297
in constant prices 2010	52337723 3.9	56413937 1.6	59317398 7.2	59715940 2.8	599399987	61465076 7.2	56376316 9.5	60348152 7.7	61905565 6.6
Internal expenditures on research and development as a percentage of gross domestic product	1.13	1.03	1.07	1.1	1.1	1.11	0.99	1.04	1.1

Source: Compiled by the author on the basis of [87].

Improving the state protection of intellectual property can provide a more favorable legal environment and institutional support for independent innovation development and innovation investment, stimulating the creative power of enterprises, promoting technological progress and modernization of industries. First, improving intellectual property protection can increase the willingness of enterprises to invest in intellectual property, stimulating the development of independent innovation. Second, improving intellectual property protection can attract more investment in innovation, promoting technological progress and modernization of industries. Innovation requires significant financial inputs, and improving intellectual property protection can increase the return and risk-return ratio of innovation investment, attracting more investment funds into innovation and thus promoting technological innovation and modernization. From Table 35, it can be seen that Russia has seen significant progress in intellectual property protection. For more than twenty years, from 2000 to 2020, the number of patent applications filed in Russia has been steadily increasing, especially since 2010. At the same time, the number of domestic patent applications has always been higher than the number of foreign patent applications. In addition, Russia has made some progress in granting patents. The number of granted patents in Russia has been steadily increasing since 2000, and the growth rate has increased since 2010. It should be noted that the number of domestic patents granted is still significantly higher than the number of foreign patents. Finally, there are still many active patents in Russia. Since 2010, the number of active patents in Russia has been continuously increasing, especially since 2018. This shows that the system of intellectual property protection in Russia continues to improve.

Table 35 - Receipt of patent applications and granting of patents for inventions

Year	2000	2010	2018	2019	2020
Patent applications filed in the Russian Federation	28688	42500	37957	35511	34984

Including applicants:					
domestic	23377	28722	24926	23337	23759
foreign	5311	13778	13031	12174	11225
Patents granted in the Russian Federation	17592	30322	35774	34008	28788
Including applicants:					
domestic	14444	21627	20526	20113	17181
foreign	3148	8695	15248	13895	11607
Valid patents of the Russian Federation	144325	181904	256419	263688	266189

Source: Compiled by the author on the basis of [87].

Government expansion of the domestic market can increase demand for companies' products and stimulate their innovation activity. When market demand increases, companies are more active in research and development of new products to meet market needs and increase their market share. In addition, expanding the domestic market can reduce firms' production costs and increase their competitiveness. By reducing production costs, companies can focus more on technological innovation and product development, which promotes technological advancement and production modernization. In addition, expanding the domestic market can also attract more investment in innovation, providing firms with sufficient funding to advance science and technology. According to the data in Table 36, it can be concluded that in 2014 to 2016, the fortunes of companies were severely affected, which led to a decrease in innovation investment and slowed down innovation activities, hindering the development of innovation. In addition, although Russia's GDP per capita grew significantly in 2017 and 2018, the growth rate started to slow down in 2019 and 2020, which may also have a negative impact on the development of innovation in Russia. In general, stability and growth of the economy play a crucial role in the development of innovation.

Table 36 - GDP per capita, PPP (in current international dollars) - Russian Federation

years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Significance	20490.12695	22798.67383	24303.47266	26073.875	25761.64844	24085.32422	24128.08594	25926.44336	28821.26172	30067.74023	29936.92969	32966.35938

Source: Compiled by the author on the basis of [87].

State support for the commercialization of innovative scientific and technological achievements contributes to the creation of an environment for independent innovative development. The commercialization of innovative scientific and technological achievements requires financial, resource and market support. But many start-up companies and scientific groups face the problem of obtaining financing, market maturity and insufficient government support, resulting in many high-quality innovative scientific and technological achievements cannot be fully commercialized, which is an inefficient use of innovative resources and professionals. Therefore, government support for the commercialization of innovative scientific and technological achievements is necessary, it will help to unlock the commercial potential of innovative scientific and technological achievements, promote economic development and social progress. In addition, the state support for the commercialization of innovative scientific and technological achievements will have a positive impact on the innovation environment. Firstly, it promotes the commercialization process of innovative scientific and technological achievements and ensures economic and social development. Secondly, the funding encourages more professionals and companies to participate in the research and commercialization of S&T innovation, which promotes the development and improvement of the innovation ecosystem. Finally, funding provides the necessary support and protection for start-ups and research teams, and reduces the risks and costs of commercialization, which helps attract more innovators and entrepreneurs into research and entrepreneurship.

We end up with Figure 34, which illustrates the main areas of government support and incentives for innovation in Russia. Clarifying the main directions of state support and stimulation of innovation activity in Russia is multifaceted. First, it provides guidance and direction for innovators and increases the efficiency of innovation activities. Second, by concentrating resources on strengthening R&D in promising areas, the country's innovation potential and competitiveness can be enhanced. Third, a clear direction of support can promote the development of new industries and economic growth points, and contribute to the economic development of the country. In addition, a clear direction of support can improve the innovation ecosystem, promote cooperation and interaction between the government, enterprises and research institutes, and attract more investment and talents to participate in innovation.

The conditions of the post-industrial society model are characterized by the use of new tools to promote scientific and technological progress [31]. To improve the national system, we consider the use of many tools of innovation platforms: technopark, technology transfer center, special economic zones (SEZ), science cities, entrepreneurship support centers, engineering centers, centers for collective use of scientific equipment, centers for cluster development, centers for scientific and technical information, science and technology centers, science cities, etc.

In our opinion, the most promising tool for the development of innovation structures in Russia in recent years should be recognized as the creation of innovative scientific and technological centers, which act as specialized organizations that unite scientists, engineers, entrepreneurs and other specialists to conduct scientific research, develop new technologies and innovative products. It is these structural forms that play an important role in the creation of the innovation ecosystem, contribute to the development of competitive industries and increase the level of scientific achievements in the country.

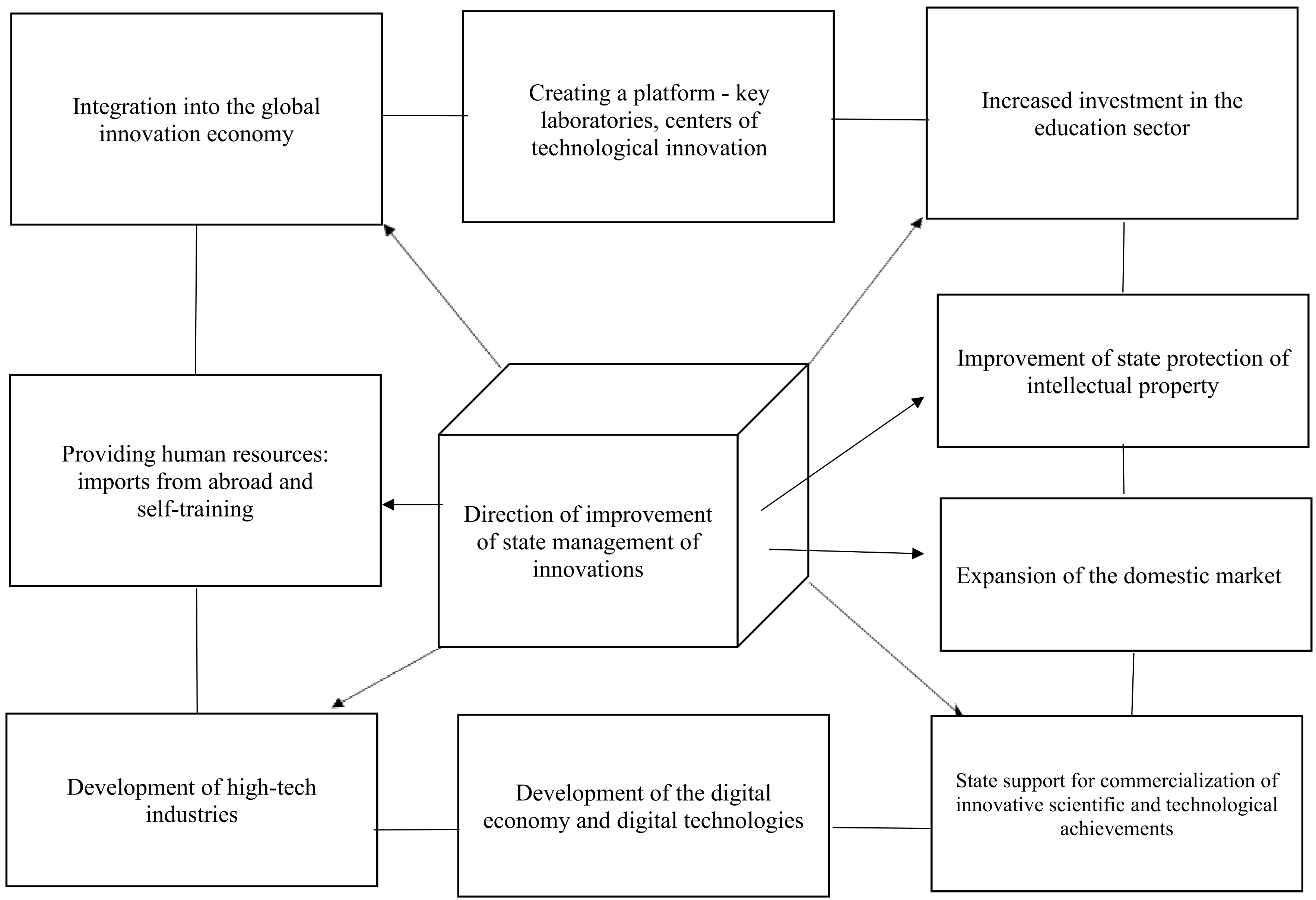


Figure 34. Direction of improvement of state management of innovations

Source: Compiled by the author.

3.2 Innovative scientific and technological center as a form of implementation of state innovation management

According to the Federal Law of 04.06.2018 N 131-FZ, innovation science and technology centers is a set of organizations, including research, educational and technological institutions, as well as other participants, whose activities are aimed at carrying out scientific and technological activities in a certain territory for the purpose of innovation and technology development (Fig. 35). The main purpose of Innovative scientific and technological center is to create favorable conditions for scientific and technological progress and innovative development.

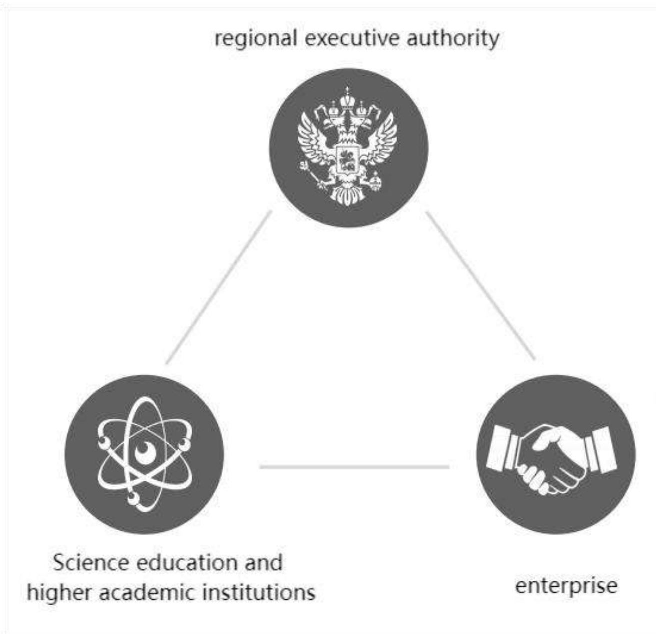


Figure. 35. Scheme of interconnection of innovation science and technology centers subjects
Source: Compiled by the author on the basis of [78].

Innovative scientific and technological centers are one of the forms of implementation of state support for innovative development. They are created and supported by the state in order to stimulate innovation, scientific research and technological progress. The state provides financial support, infrastructure, tax benefits and other advantages to Innovative scientific and technological centers so that they can effectively develop and commercialize innovations, cooperate with businesses and contribute to the growth of the national economy. Innovative scientific and technological centers also play an important role in shaping and improving the national innovation system.

In the period 2019-2022, 10 centers were established on the basis of draft decisions of the Government of the Russian Federation prepared by the Ministry of Economic Development of Russia in accordance with the law No. 216-FZ on innovation science and technology centers [24].

Table 37 - Innovative Science and Technology Centers in the Russian Federation

Name Innovative scientific and technological center	Date
Innovative scientific and technological center MSU Vorobyovy Gory (Moscow)	March 28, 2019.
Innovative scientific and technological center "Sirius" (Sochi)	November 8, 2019.
Innovative scientific and technological center "Mendeleev Valley" (Moscow)	December 24, 2019.
Innovative scientific and technological center "Russky" (Russky Island, Primorsky Krai)	November 18, 2020.
Innovative scientific and technological center "Composite Valley" (Tula region)	January 21, 2021.
Innovative scientific and technological center "Intellectual Electronics - Valdai" (Novgorod region)	September 30, 2021.
Innovative scientific and technological center "Park of Nuclear and Medical Technologies" (Kaluga Region)	October 20, 2021.
Innovative scientific and technological center "Quantum Valley" (Nizhny Novgorod region)	November 30, 2021.
Innovative scientific and technological center "Baltic Valley - HUMANTECH" (Kaliningrad Oblast)	February 17, 2022.
Innovative scientific and technological center "Aerospace Innovation Valley" (Ryazan region)	April 22, 2022.

Source: Compiled by the author on the basis of [78].

Based on the description of the process of creating the Innovative scientific and technological center "Intellectual Electronics - Valdai" and Figure 36, it can be concluded that this example is an illustration of the process of forming an Innovative scientific and technological center as a whole. It emphasizes the importance of the following key stages:

1.Infrastructure formation. This stage includes the initial establishment of the necessary infrastructure that provides the basis for the Innovative scientific and technological center. It may include the construction of buildings, engineering systems, laboratories, technical equipment, and other components necessary for the operation of the center.

2.Attracting residents. Once the infrastructure is in place, the Innovative scientific and technological center begins to attract residents - organizations and companies that will actively participate in the innovation and development of the center. This process may include attracting innovative start-ups, university research centers, industrial enterprises and other interested businesses.

3.Increase in total income. With the gradual attraction of residents and the development of their activities, the total income of the Innovative scientific and technological center begins to increase. This may be due to commercialization of innovations, receipt of investments, sales of products or services, and other sources of income related to innovation activities.

In general, these key stages help to achieve the goals of developing the innovation sphere, creating a favorable environment for scientific and technological progress and stimulating economic growth. The process of establishing an Innovative scientific and technological center requires a systematic approach, gradual development and the participation of various stakeholders.

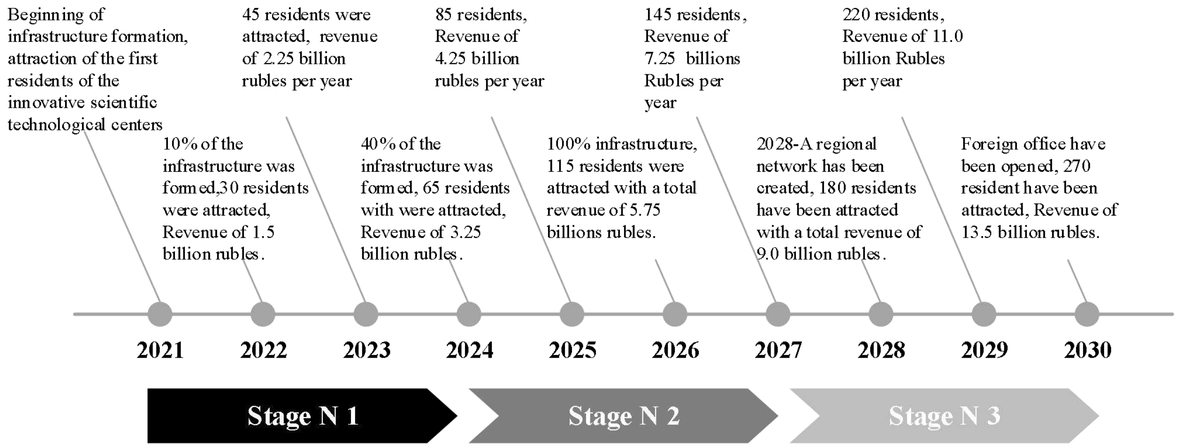


Figure 36. Roadmap for the creation of Innovative scientific and technological center "Intelligent electronics - Valdai"

Source: Compiled by the author on the basis of[79].

At present, there is no single model of Innovative scientific and technological center, so we plan to research several models and find out the shortcomings in the design and development of Innovative scientific and technological center. Our goal is to propose an ideal model of Innovative scientific and technological center, taking into account the experience of China, which successfully develops innovation centers and applies them for scientific and technological achievements, economic growth and social development.

Table 38 - Specialization of innovative science and technology centers in the Russian Fede ration

Innovative scientific and technological center	**Specialization**
Innovative scientific and technological center "Baltic Valley - Humantech"	- Biomedical Cellular Products - Assistive devices and technologies - High Performance Agro- and Aquaculture, Functional Nutrition - Clean energy and design technologies
Innovative scientific and technological center "Intellectual Electronics - Valdai"	- Development and creation of high-tech electronic component base, professional and consumer electronics - Development and creation of new, including portable, energy sources - Development and creation of the 5th generation mobile communication network - Development and creation of quantum sensors, devices using quantum technologies - Development of biomedical cell technologies - Development and creation of the Internet of Things (devices, appliances, systems, software platforms)
Innovative scientific and technological center "Mendeleev Valley"	- Agrochemistry, agrobiotechnology and biotechnology - High-Tech Chemistry and High-Purity Substances - Medical and pharmaceutical chemistry and chemical technology - Special purpose chemical technologies, high-energy substances - Processes and apparatuses of chemical technology, including digital ones

Innovative scientific and technological center "Quantum Valley"	- Advanced digital (including quantum) technologies - Innovative production, components and materials - Ecology and elimination of accumulated environmental damage - Intelligent transportation systems - High-tech personalized medicine and medical device engineering
Innovative scientific and technological center "Vorobyovy Gory" MSU	- Biomedicine, pharmaceuticals, biomedical research and testing - Nanotechnology, research of new materials and nanomachining - Information technologies and mathematical modeling - Robotics, special-purpose and machine engineering technologies, energy conservation and efficient energy storage - Space Research and Astronautics - Interdisciplinary Humanities and Cognitive Sciences - Sports, innovative sports technologies - Artificial Intelligence Technologies - Geonomy and ecology
Innovative scientific and technological center "Park of atomic and medical technologies"	- Nuclear research and development - Nuclear medicine and pharmaceuticals - Diagnostic and therapeutic systems - Information and communication technologies - Additive technologies, new materials, laser technologies
Innovative scientific and technological center "Composite-	- Multifunctional materials, chemical components and technologies of their production - Modeling, designing and production of products from composite materials - New ecologically oriented technologies of closed cycle for low-tonnage chemical productions - Catalytic materials and chemical production technologies for agrarian and petrochemical industries
valley	- Aerospace systems and technologies - Radio engineering, electrical engineering, electronics - Information systems and technologies - Biomedical technologies and medical devices - Additive technologies, new materials, laser technologies
Innovative scientific and technological center "Aerospace Innovation Valley"	- Information technology - Artificial Intelligence - Genetics and life sciences - Interdisciplinary research, including research in pedagogical and cognitive sciences
Innovative scientific and technological center "Sirius"	- Oceans - Biotechnology - Information and communication technologies

Source: Compiled by the author.

Table 38 shows the specialization of innovative scientific and technological centers in the Russian Federation. The following main directions of Innovative scientific and technological center activities can be distinguished:

- Integration of science and technology. In many Innovative scientific and technological centers there is intensive interaction between different scientific and technological fields. For example, the Innovative scientific and technological center "Vorobyovy Gory" integrates biomedicine, nanotechnology, information technology and space research. Such integration promotes synergy and mutual reinforcement of different areas.

- Attention to high-tech industries. Many Innovative scientific and technological centers specialize in the development and creation of high-tech products and technologies. For example, Innovative scientific and technological center "Baltic Valley - Humantech" deals with biomedical cellular products, and INTC "Intellectual Electronics - Valdai" develops high-tech electronic component bases and new energy sources.

- Application and commercialization orientation. Many Innovative scientific and technological centers are actively engaged in translating scientific developments into practice and creating innovative products. For example, Innovative scientific and technological center "Quantum Valley" is working on advanced digital and quantum technologies that can be widely used in various fields.

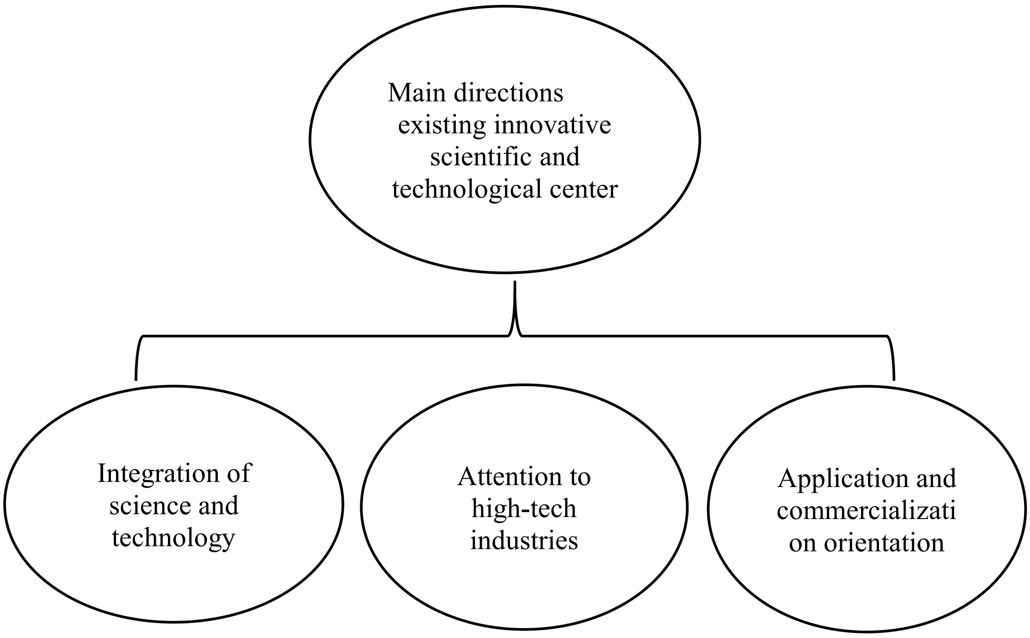


Figure 37. Main activities of the existing Innovative scientific and technological center
Source: Compiled by the author.

Figure 37 shows the main activities of the existing Innovative scientific and technological center. It can be seen that the experience of innovation development in China shows that there are many areas in which this experience can be useful, such as international cooperation, talent attraction, intellectual property protection and understanding market needs.

3.3 Recommendations for the improvement of innovative science and technology centers in Russia

Based on the Chinese experience and the strategic approach to STCI development, we offer the following specific recommendations for improving innovative science and technology centers.

1. Using the strategy of "pre-incubation abroad + startup acceleration in the local market" to create an incubator. Despite the sanctions restrictions, Russia remains a deeply integrated economy in the system of international division of labor. Pre-incubation abroad refers to the formation of an innovation center abroad for research, development and innovation activities. Usually, the purpose of establishing a pre-incubation center abroad is to take advantage of the advantages and resources of other countries, such as technology, research personnel, market opportunities, and others. Companies or organizations can conduct research and development of new products or technologies in a pre-incubation center abroad and then apply them to the domestic or global market. Local startup acceleration is the provision of support and services to startups domestically to help them accelerate their growth and development. This typically includes providing funding, mentoring, market access support, networking and partnership opportunities, and other resources to help startups succeed in the domestic or global marketplace. These resources and services help accelerate startup development, spur innovation and job growth. Innovative science and technology centers, building on existing international cooperation channels, promote the establishment of bilateral science and technology innovation centers inside and outside the country, forming an integrated incubation chain of "pre-incubation abroad - incubation in the local market - acceleration in the local market - industrialization in the local market".

The strategy of "pre-incubation abroad + startup acceleration in the local market" is a new type of sustainable innovation entrepreneurship, aiming to promote interaction and cooperation between domestic companies and innovation projects and foreign technology and market resources. Some key provisions of the strategy are summarized below.

(1) Foreign innovation incubation. This model starts with the establishment of technology transfer centers abroad, which are usually located in regions with high innovation potential. The main objective of these centers is to facilitate cooperation between foreign innovators and technology resources and domestic companies.

- Mission. Promotion of international innovation cooperation, attraction of foreign innovations and expertise to strengthen the market position.
- Complex strategy. Development of a network of partnerships with foreign innovation centers and universities, organization of international conferences and events, exchange of experts and research projects.
- Strategic objectives. Increasing the number of international innovation projects, expanding global participation and attracting foreign innovators and investors.
- Specific strategic directions and ways to achieve them. Establishment of cooperation agreements

with leading foreign innovation centers, organization of internships for young scientists, participation in global exhibitions and forums.

- Analyzing the effectiveness of the strategy. Evaluation of the number of signed agreements, the volume of international innovation projects and attracted foreign capital.

(2) Acceleration of domestic transformation. In parallel with the establishment of foreign technology transfer centers, incubation gas pedals and industrial bases are also being developed domestically. The aim of these institutions is to integrate foreign projects into the country and actively develop and industrialize them in the domestic market.

- Mission. Maximizing operational efficiency and strengthening internal processes to achieve competitive advantage.
- Complex strategy. Optimization of business processes, implementation of modern management systems, development of innovation culture.
- Strategic objectives. Reducing costs, increasing productivity, improving the quality of products and services.
- Specific strategic directions and ways to achieve them. Audit of internal processes, automation of tasks, training of employees in new methods of work.
- Analyzing the effectiveness of the strategy. Evaluation of cost reduction, productivity increase and employee satisfaction.

(3) Direct communication with enterprises and capital. Overseas technology transfer centers and innovative science and technology centers establish direct communication with enterprises and capital. This facilitates technology exchange, cooperation and capital flow, which helps to overcome international barriers and promotes innovation cooperation at the global level.

- Mission. To establish direct relationships with businesses and investors to ensure financial sustainability and development.
- Complex strategy. Development of customer and investor relations department, participation in investment events.
- Strategic objectives. Attract investment, expand client base, develop new markets.
- Specific strategic directions and ways to achieve them. Making presentations to investors, improving customer service, developing marketing campaigns.
- Analyzing the effectiveness of the strategy. Evaluation of the volume of investments attracted, growth of the client base and market reaction.

(4) Development in the local market. Providing sufficient space, including incubation gas pedals and industrial bases, to help foreign projects quickly adapt to the domestic market and ensure sustainable development.

- Mission. Adapting products and services to local needs and strengthening market positions.
- Comprehensive strategy. Marketing research, adaptation of products and services, strengthening partnerships with local companies.
- Strategic objectives Increase market share, satisfy local customers, strengthen brand.
- Specific strategic directions and how to achieve them. Analyzing local needs, creating product lines for the local market, establishing strategic partnerships.
- Analyzing the effectiveness of the strategy. Evaluate market share growth, customer satisfaction and profitability from the local market.

In sum, this strategy promotes the interconnection of the national and global innovation ecosystems, facilitates the transfer of technology, knowledge and capital, and helps stimulate sustainable innovation.

2. Classify and attract innovative specialists of different levels. Specialists can be divided into cadres - leaders and specialists of classes A, B, C and D. Different categories of personnel have corresponding conditions, funding and benefits. The types of personnel in the table, such as cadre-leader, specialist of A, B, C and D classes have specific requirements for qualifications and benefits.

Table 39 - Example of introduction of levels, conditions for personnel

Personnel type
Leader cadres: academically competent, who have achieved profound knowledge in their fields and made systematic and creative achievements and contributions, being recognized by colleagues both at home and abroad, possessing the ability to lead at the national and world level, able to lead a scientific group with famous scientists from different countries in joint work. Have great potential for innovative development, achieving outstanding scientific results and being recognized by peers, have the ability to help their field of science to be at or ahead of the cutting edge both at home and abroad, renowned scientists from different countries
A Specialist Class: Bachelor's, Master's and Doctor of Science qualifications are similar or close, graduated from leading universities in Russia and abroad; or Doctor with qualifications defined by the Institute for National Technological Research of the Central Research Institute. Conduct research work on government projects and publish articles in SSCI, SCI, and EI journals as first authors. Their research and educational achievements are rated by experts in the field as being at the world-class level in the discipline
B class-specialist: qualifications of Bachelor, Master and Doctor are similar or close, graduated from leading universities in Russia and abroad; or Doctor with a qualification recognized by the educational institution as in demand. They conduct research work on government projects and publish articles in SSCI, SCI, EI journals as first authors. Their scientific and educational achievements are evaluated by experts in the field as a priority in Russia
C class-specialist: specialty or meets the development needs of the educational institution in the relevant field and specialty. They participate in research work on state or regional projects and publish articles in highly rated Russian scientific journals as first authors. Their scientific and educational achievements are assessed by experts in the field as being at the cutting edge in Russia. Doctors are educated abroad
D grade-specialist: They have some teaching and research skills, are involved in research work on teaching and research projects and have published scientific articles in their area of expertise

Source: Compiled by the author.

Table 39 is based on China's experience in this area; the relevant Chinese experience can be found in Appendix 8. Table 39 shows that talent attraction strategies used in innovative science and technology centers have the following characteristics:

(1)Diversification of talent types: the strategy focuses on different types of qualifications, including cadre leader, specialist of different levels, etc. This reflects the need for specialists of different levels and experience.

(2)Conditions are situation-specific: the strategy emphasizes the principle of "one person, one plan" by defining specific engagement conditions according to different types of professionals and their achievements in a particular field. This individualized approach facilitates the attraction of different types of professionals.

(3)Age requirements: the strategy sets different age requirements for professors, associate professors and doctors, which can help attract young professionals and encourage their outstanding achievements at an early age.

(4)Housing and scientific start-up capital: the strategy provides housing and scientific start-up capital to help new professionals successfully adapt to the new environment and start scientific work.

(5)Individualized negotiation: for some professionals, the strategy enables individualized negotiation according to their specific needs and development situation, which promotes better adaptation to individual characteristics.

3. Building a comprehensive system for assessing the innovativeness of organizations. At present, many enterprises seek to join the system of innovative science and technology centers and obtain the status of innovative science and technology centers. We establish certain criteria and provide modern methods for determining whether these enterprises are truly innovative (the scheme of innovativeness in Appendix 12). Thus, this is the first step in the process of formation and development of the status of innovative science and technology centers. The establishment of a comprehensive system for assessing the innovativeness of organizations is intended to address the following objectives: identifying truly innovative companies, increasing transparency and trust, stimulating true innovation potential and improving the accuracy of public policies for science and technology development. This contributes to the development of scientific and technological achievements in the country's economy.

Innovative science and technology centers should take a number of specific measures to identify and support technology companies, including:

(1)Clear standards. Innovative science and technology centers set clear standards for determining the status of a technology company, including the company's operating history, intellectual property, compliance with technology and industry standards, proportion of employees engaged in research and development, ratio of research and development expenditures to total revenue, share of high-tech products in total revenue, and others.

(2)Peer Review. Companies must undergo expert evaluation including intellectual property evaluation, commercialization of R&D results, quality of organization and management, and evaluation of company growth.

(3)Specialized Agencies. Specialized accreditation agencies have been established to carry out peer review.

These specific measures are aimed at promoting and supporting technological innovation, reducing the tax burden on innovative enterprises, and encouraging additional investment in research and development.

4. Securing intellectual property through blockchain technology. Blockchain technology provides safer, more efficient and transparent solutions for managing intellectual property, which helps protect intellectual rights, reduce infringement and foster innovation and the digital economy. It enables intellectual property owners, companies and governments to better address the challenges of intellectual property management and ensure the legitimacy and credibility of intellectual property. Blockchain technology has important implications in intellectual property management, as shown in the following aspects:

(1) Security and tamperability: Blockchain uses strong encryption techniques to store intellectual property information in a distributed registry, which ensures the security and integrity of the data. Once information is registered, it is virtually impossible to tamper with or delete it, which helps prevent intellectual property infringement and fraud.

(2) Transparency and traceability: The blockchain registry is publicly accessible and anyone can view the information in it, increasing transparency in intellectual property management. Every transaction is recorded and can be traced back to its source, which helps ensure the authenticity and provenance of intellectual property.

(3) Decentralization and reduced intermediary costs: Blockchain technology allows intellectual property owners to interact directly with users without the need for intermediaries, reducing transaction costs and time. This reduces the complexity of intellectual property management and increases efficiency.

(4) Automation and smart contracts: Blockchain supports smart contracts that are automatically executed under certain conditions, such as payment of license fees. This increases the efficiency of intellectual property trading and reduces errors and disputes.

(5) Countering infringement and counterfeit goods: Blockchain can be used to track and verify product supply chains, ensuring the authenticity and legality of goods. This helps reduce intellectual property infringement and the appearance of counterfeit goods.

(6) Globalization and interoperability: Blockchain is a technology with global reach that enables intellectual property management to operate on the world stage. This facilitates international intellectual property trade and collaboration.

With the increasing use of blockchain technology in intellectual property management, here are 5 of the most important methods, along with their tasks, workflow and evaluation metrics:

(1) Registration of intellectual property on blockchain

- Description: Create a blockchain-based intellectual property registration system where authors can upload information about their intellectual property. Blockchain records provide an immutable timestamp and source, which helps to protect intellectual property and prevent infringement. This measure guarantees the authenticity and ownership of intellectual property.
- Challenge: Create a blockchain-based intellectual property registration system that allows authors to upload their intellectual property information to the blockchain and provide a time and source record.
- Workflow: Authors upload their intellectual property information to the registration system on the blockchain and each piece of intellectual property is assigned a unique identifier and then the linked data is recorded on the blockchain.
- Evaluation indicators: Number of registered intellectual property items, accuracy of information, efficiency of the registration process.

(2) Tracking and utilization of offchain data

- Description: Create an intellectual property tracking system using blockchain technology where records of intellectual property owners can be traced. Support for off-blockchain data, such as court decisions and license agreements, provides more complete information and supports evidence and management of intellectual property.
- Challenge: Create a tracking system for intellectual property that provides transparent tracking and management of the entire product lifecycle.
- Workflow: Intellectual property information is linked to off-chain data such as court judgments and license agreements, creating a complete chain of information.
- Evaluation metrics: Number of successfully traced intellectual property, integrity of the ownership chain, reliability of data sources.

(3) Smart Contracts

- Description: Using smart contracts to automatically execute license agreements and intellectual property transactions. These contracts are capable of automatically handling various intellectual property management tasks, such as collecting and distributing royalties, which reduces human error and increases trust in contracts.

- Challenge: Use smart contracts to automate licensing and intellectual property transactions, enabling more efficient management.
- Workflow: Create rules for smart contracts that enable automatic enforcement of terms and conditions, such as automatic collection of license fees.
- Evaluation metrics: Number of smart contracts successfully executed, accuracy of execution, reduction in transaction costs.

(4) Market and platforms for intellectual property on blockchain

- Description: Using smart contracts to automatically execute license agreements and intellectual property transactions. These contracts are capable of automatically handling various intellectual property management tasks, such as collecting and distributing license fees, which reduces human error and increases trust in contracts.
- Challenge: Create a blockchain-based marketplace and platform for intellectual property that facilitates interaction between creators and potential partners.
- Workflow: Create a marketplace and platform that allows creators to upload intellectual property information and interact with potential buyers and licensees.
- Evaluation indicators: Transaction security, transparency, number of users and volume of transactions on the platform.

(5) Development and updating of legislation and standards

- Description: Developing and updating legislation to adapt to the use of blockchain technology in intellectual property management. Actively participate in the creation of standards to ensure consistency and interoperability of blockchain technology in intellectual property management. Legislative improvements and standard setting play an important role in providing legitimacy and credibility to intellectual property.
- Challenge: Developing and updating legislation that takes into account the application of blockchain technology to intellectual property and actively participating in standard setting.
- Workflow: Collaboration between legal departments and blockchain experts to develop applicable legislation and standards.
- Scorecard: Number of laws and standards created, their effectiveness and impact.

5. Development of innovative science and technology centers should be based on the strategic priorities set out in the Concept of Technological Development of Russia until 2030, the Priority-2030 Program and other strategic documents (Annex 13). The development of innovative science and technology centers should be carried out in strict compliance with the fulfillment of strategic goals and objectives set out in these documents. The following priority strategic directions in the innovation sphere can be identified from the provided materials:

(1)Artificial Intelligence. The Concept of Technological Development of Russia until 2030 mentions the development of artificial intelligence as one of the "cross-cutting technological" areas. Artificial intelligence is considered important for technological development and innovation in many industries.

(2)Quantum computing and quantum communications. These areas are also included in the list of "cross-cutting technology" areas. Quantum technologies can revolutionize computing capabilities and enable secure data communication.

(3)Hydrogen energy. The Concept of Technological Development of Russia until 2030 mentions hydrogen energy as a technological area with potential for development and creation of new energy solutions.

(4)Promising materials and substances. In the list of "cross-cutting technologies" there is a mention of technologies of new materials and substances. The development of new materials can lead to innovations in various sectors, including transportation, construction and medicine.

(5)Digital ecosystem in education. The Priority 2030 Program notes the importance of developing a digital ecosystem in education, including e-learning environments. This allows to integrate education with innovations and technologies, which is important for the formation of competent personnel in the innovation sphere.

(6)Development of new directions in science and technology. Research and development in nuclear and oil and gas engineering, aviation industry and other related fields are also recognized as important for innovation.

(7)Education and development of new specialties The Priority-2030 program is focused on the formation of universities capable of creating new scientific knowledge and technologies for implementation in the economy and social sphere. This includes the development of new educational programs and specialties that meet the needs of the market and innovation.

Innovative science and technology centers, combining Chinese experience in innovation management, are presented in Figure 38. Thus, innovative science and technology centers can become the best regional part of the national system of strategic scientific and technological forces of Russia.

The third chapter of the dissertation identifies areas in the field of innovation management that need to be developed in Russia and offers recommendations for improving Innovative science and technology centers in Russia. These recommendations can help to improve the performance of Innovative science and technology centers and promote innovation management and innovation development in Russia.

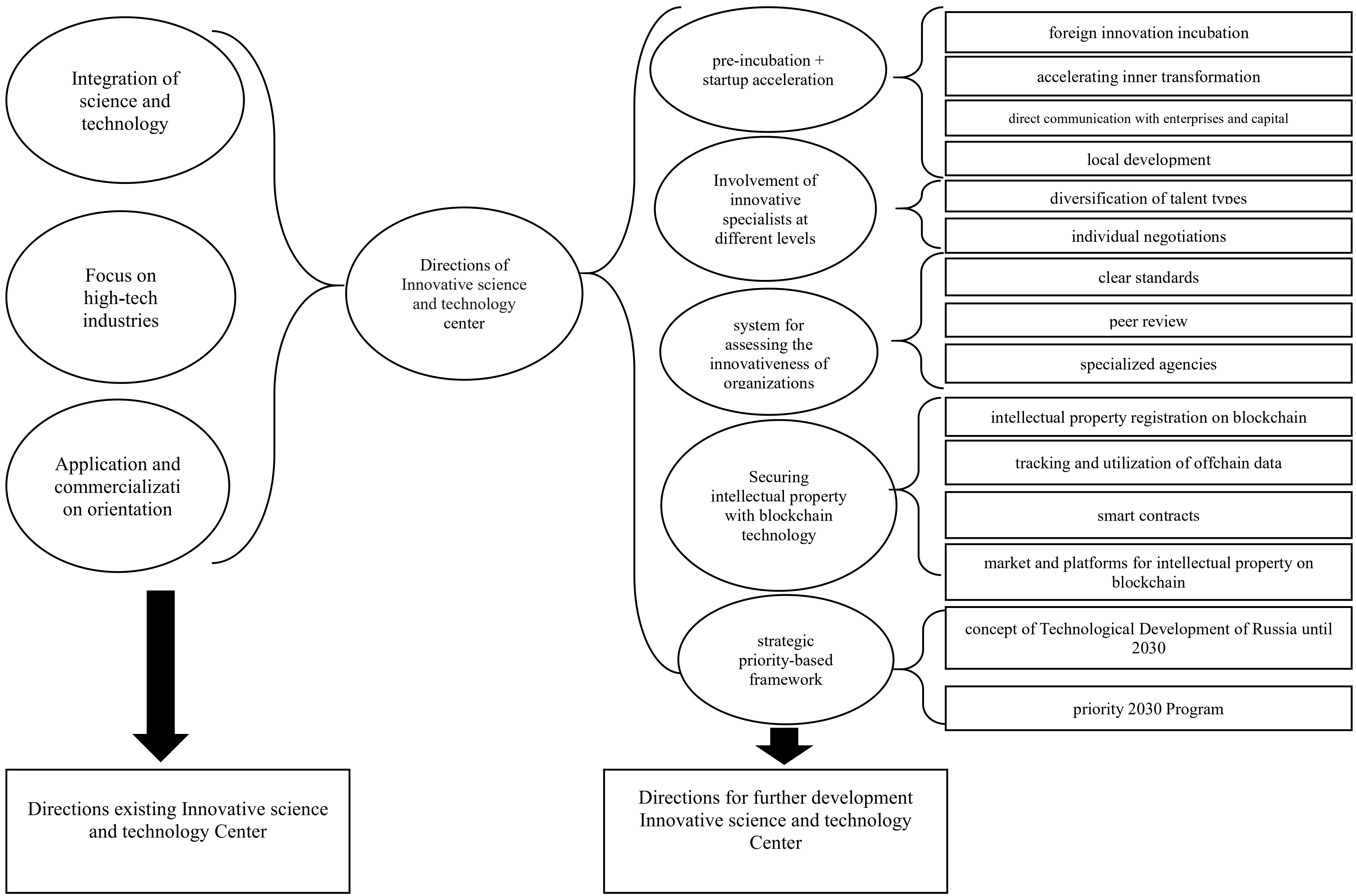


Figure 38. Strategic directions of Innovative science and technology center
Source: Compiled by the author.

CONCLUSION

Innovation is a process of creating and introducing new or improved products (services), techniques, technology, production organization and management, which brings various types of effect. The process of development of the theory of innovation is divided into three main stages, the first of which was presented by J. Schumpeter, who put forward the theory of innovation. Schumpeter, who put forward the theory of innovation. After J. Schumpeter, the theory of innovation was mainly studied in two directions: the school of technological innovation and the school of institutional innovation. The third stage is mainly related to the study of national innovation system. In recent years, the research topic of innovation management research has been continuously expanded, the research content has been deepened, and the research methods have been optimized. The research and development mainly focus on the following three aspects: innovation process and innovation management strategies, innovation ecosystem and its influence on innovation process, innovation capability and its measurement.

In this study, areas of national innovation systems that are at the forefront of innovation have been identified and examined in detail. These areas include the following aspects:

- A systems approach to analyze and investigate the relationship between technological innovation and its impact on economic development.

- The notion of a national innovation system, which takes into account that a national innovation system is a set of research institutions, universities, firms and governments that can either contribute individually to the development and diffusion of new technologies or interact constructively in a series of activities to improve innovation capacity and efficiency, thereby contributing to economic growth.

- Defining the organizational structure of the national innovation system.

- Current topics and trends in the development of national innovation systems in recent years, including public innovation governance, the creation of an enabling innovation environment, the development of an innovation ecosystem, the internationalization of national innovation systems and a comparative analysis of innovation systems in different countries.

- Priorities and public support measures for national innovation systems. The application of these directions and measures contributes to the development of national innovation systems, economic growth and social progress.

The study confirms the important role of innovation management in the development of the national innovation system. The role of state support in the development of the national innovation system is to create a favorable environment and stimulate innovation in the economy.

The structural form of innovation management includes scientific organizations, venture business, technology centers and science parks, technoparks, technopolises, incubators, founding centers and scientific and technological alliances, as well as innovative scientific and technological centers, which at the present stage, according to the author, play a key role in ensuring competitiveness and innovative development.

Methods of innovation management support are aimed at stimulating innovation, development of scientific research and technological progress in Russia. These methods include allocation of financial resources, information support, consulting assistance, educational development, assistance in foreign economic cooperation, infrastructure development and other support measures aimed at promoting and improving innovation management processes. These methods can be applied to the development of innovation and S&T activities in the Russian Federation in accordance with the legislation and the state S&T policy.

Chinese experience in the field of innovation management is presented in the "5T+1" model. In general, this model includes the following aspects: the capacity for technological introduction (t1), the capacity for technological innovation (including introduction of innovation, imitation innovation and complex innovation) (t2), the capacity for independent innovation (t3), the capacity for innovation in the domestic market (t4) and the capacity for innovation in the international market (t5), as well as training and development of human resources. The "5t+1" model describes the internal mechanism and laws of development of technologically backward countries from the initial stage of lagging behind to the level that brings them closer to developed countries.

Using econometric principal component analysis, the priority factors influencing the development of China's national innovation system were identified. The analysis of the factors influencing China's innovation development showed that international innovation cooperation, innovation investment, human resources policy and the creation of independent innovation environment jointly promote China's innovation development.

Based on the analysis of innovation management in China and Russia, including international innovation cooperation, human resources, innovation investment and the environment for independent innovation, recommendations for the application of Chinese experience in Russia were formulated.

1.Facilitate joint cooperation between government, enterprises and universities in the field of international innovation.

2.Creation of international innovation networks.

3.Prioritizing the involvement of foreign specialists.

4.Flexible and adaptive scientific personnel policy.

5.Attention to high-tech industries.

6.Creation of innovation demonstration zones and development of digital economy.

7.Protection of intellectual property.

8.Alignment with the country's development program and strategy.

This study focuses on innovation science and technology centers as an effective means of creating favorable conditions for scientific and technological progress and innovative development. This study proposes to consider innovation science and technology centers as a form of implementation of state support for innovative development, as they are created and supported by the state in order to stimulate innovation, scientific research and technological progress. The state provides financial support, infrastructure, tax benefits and other advantages to innovation science and technology centers so that they can effectively develop and commercialize innovations, cooperate with businesses and contribute to the growth of the national economy.

Russia has had innovation science and technology centers since 2017, and they are focused on directions:

First, there is close interaction between different scientific and technological fields, which has become the basis for the existing innovative science and technology centers.

Second, innovative science and technology centers specialize in the development and creation of high-tech products and technologies.

Third, innovative science and technology centers are actively engaged in the implementation of scientific developments in practice and the creation of innovative products.

The necessity to improve Innovative science and technology centers through the implementation of the following directions is substantiated:

1.Using the strategy of "pre-incubation abroad + accelerating startups in the local market" to create an incubator. This strategy allows to prepare startups in the global market and then actively introduce them in the local market.

2.Classification and involvement of innovative specialists of different levels. It is important to create a tiered system that attracts innovators and experts of all ages, facilitating the exchange of knowledge and experience.

3.Developing a comprehensive system to assess the innovativeness of organizations. Such a system will help to assess how effectively organizations innovate and promote scientific and technological development.

4.Securing intellectual property through blockchain technology. This will help provide more reliable and transparent protection of intellectual property and stimulate innovation.

5.Development of Innovative science and technology centers taking into account the strategic priorities outlined in the Concept of Technological Development of Russia until 2030, the Priority-2030 Program and other strategic documents. This will ensure consistency in the development of Innovative science and technology centers with national strategic goals.

These recommendations can help to improve the work of Innovative science and technology centers and promote innovation management and innovative development in Russia.

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APPENDIX 1

The definition of 'innovation' can be found in the section "1.1 Evolution of theories on innovation and innovative development"

Definition	Author
Innovation (innovation) usually refers to an object introduced into production as a result of research or discovery that is qualitatively different from its previous counterpart.	Utkin E.A., Morozova N.I, Morozova G.I.
The complete process from an idea to a finished product sold on the market.	Cook Y, Myers P.
A process including such activities as research, design, development and organization of production of a new product, technology or system.	Messi D., Quintas P, Wild D.
The development and implementation of new (improved) products, technologies, or processes.	Bezdudny F.F.
The result of the activity of updating, transforming the previous activity, leading to the replacement of some elements by others, or supplementing the existing ones with new ones.	Oksanich N.V.
Innovation in the field of engineering, technology, labor organization and management, based on the use of scientific achievements and best practices, as well as the use of innovations in a variety of fields and spheres of activity.	Kulagin A.S.
New or improved technologies, products or services created, as well as solutions of production, administrative, financial, legal, commercial or other nature, resulting in their introduction and subsequent practical application of a positive effect for the economic entities involved.	Stepanenko D.M.
Materialized result obtained from the investment of capital in a new technique or technology, in new forms of organization of production, labor, service and management, including new forms of control, accounting, planning methods, methods of analysis, etc. The process by which a scientific idea is developed and implemented.	Balabanov I.T.
The process in the course of which a scientific idea is brought to the stage of practical use and begins to produce an economic effect, i.e. acquires economic content.	Titov A.B.

A complex process of creation, dissemination and use of a new practical means for a new (or for better satisfaction of an already known) social need.	Lapin N.I.
Practical implementation of qualitatively new solutions, the essence of strategy and the content of enterprise strategy.	B. Rappoport.
Targeted change in the functioning of the enterprise as a system.	L. Voldacek
The final result of innovation activity, realized in the form of a new or improved product sold on the market, a new or improved technological process used in practice.	"Concept of Innovation Policy of the Russian Federation for 1998-2000"

Source: Compiled by the author based on[14],[29],[35],[36],[50],[51],[55],[62],[63],[65],[71].

APPENDIX 2

An indicator of S&T capacity in China from 2000 to 2020. In the original sample is posted in section "2.2 Analyzing the factors affecting the development of innovation in China"

Year	Scientific and technological capacity		
	Number of experts coming to China (10 thousand)	Royalty payments for patented technologies ($ billion)	Amount of technology implementation contracts ($ billion)
2000	4.4	1.79	24.4
2001	4.9	2.07	23.1
2002	5.4	2.29	27.8
2003	6	2.57	32.9
2004	6.6	2.97	43.1
2005	6.8	3.5	49.8
2006	9.3	4.26	63
2007	13.5	5.05	72.2
2008	16	5.96	83
2009	16.5	6.73	73.9
2010	18	8.09	85.6
2011	18.5	9.98	92.2
2012	19.2	12.71	94.9
2013	19.6	15.2	95.5
2014	20	18.33	90.2
2015	20.8	22.37	94.5
2016	22.1	27.09	100.6
2017	23	31.35	120.5
2018	23.9	35.6	141.6
2019	24.5	39.66	149.2
2020	24.3	44.72	148.3

APPENDIX 3

A measure of China's self-reported innovation capacity from 2000 to 2020. In the original sample is posted in section "2.2 Analyzing the factors affecting the development of innovation in China"

Year	Stand-alone innovation				
	Expenditure on research and experimental development (RMB billion)	Number of science and technology industrial parks in China (number)	Number of authorizations to patent inventions (10,000)	Number of science and technology business incubators in China	Value of gross output of high-tech industries (trillion dollars)
2000	896	1038	1.5	25	1.04
2001	1042.5	1247	1.6	372	1.2
2002	1287.6	1589	2.1	421	1.5
2003	1539.6	1894	3.2	489	2.05
2004	1966.3	2053	4.9	506	2.70
2005	2450	2876	5.3	534	3.4
2006	3003.1	3256.0	5.7	548	4.1
2007	3710.2	3687	7.6	614	5.04
2008	4616	4432	9.4	782	5.70
2009	5791.9	5312	10.7	853	6.04
2010	7062.6	6647.0	13.5	924	7.47
2011	8687	8126	17.2	1023	8.84
2012	10298.4	9653.0	21.7	1311	10
2013	11846.6	11129	23.8	1432	11
2014	13015.6	12659	27.4	1748	12.8
2015	14169.9	14173	35.9	2533	14
2016	15676.7	15997	40.2	3255	15.24
2017	17606.1	18456	42	4063	15.9
2018	19677.9	21657	43.2	4849	16.1
2019	22143.6	24934	45.3	5206	16.7
2020	24426	27839	53	5843	17.5

APPENDIX 4

Indicator of domestic market development potential in China from 2000 to 2020. In the original sample, posted in section "2.2 Analyzing the factors affecting the development of innovation in China"

Year	Domestic market		
	Total income of Chinese enterprises (trillion yuan)	Number of SMEs in China (10,000 households)	China's GDP per capita (RMB million)
2000	15.99	162.7	0.79
2001	18.19	172.6	0.87
2002	21.41	184.1	0.95
2003	24.83	202.9	1.07
2004	30.10	224.2	1.25
2005	36.58	244.6	1.44
2006	44.71	262.3	1.67
2007	55.66	284.1	2.05
2008	67.70	296.4	2.41
2009	67.70	311.9	2.62
2010	92.72	340.0	3.08
2011	114.32	373.4	3.63
2012	135.38	406.9	3.98
2013	155.02	435.7	4.35
2014	170.88	471.7	4.69
2015	178.23	489.0	4.99
2016	188.84	508.6	5.38
2017	222.53	530.2	5.96
2018	247.65	555.2	6.55
2019	269.06	570.3	7.01
2020	281.69	1139.5	7.18

APPENDIX 5

An indicator of China's international market development potential from 2000 to 2020. In the original sample is placed in the section "2.2 Analyzing the factors affecting the development of innovation in China"

Year	International market		
	Total foreign direct investment (USD billion)	Number of enterprises with foreign financing	Volume of exported foreign direct investment (USD billion)
2000	40.79	198841	36
2001	42.8	213782	35
2002	52.74	225667	36
2003	53.51	234466	55
2004	60.63	262382	129
2005	60.6	284481	228
2006	69.5	318804	265
2007	82.66	344396	748
2008	92.39	372080	522
2009	95.01	374213	565
2010	1069.3	371786	688
2011	1160.7	372546	748
2012	1117.5	381534	878
2013	1178.5	395345	1010
2014	1199.6	405200	1232
2015	1361.6	409095	1217
2016	1348.6	410390	1701
2017	1369.5	431009	1583
2018	1387.7	452408	1298
2019	1414.6	476211	1430
2020	1448.9	498100	1329

APPENDIX 6

Talent development potential indicator in China from 2000 to 2020. In the original sample is posted in section "2.2 Analyzing factors affecting innovation development in China"

Year	Potential for talent formation				
	Education expenditure (RMB billion)	Number of college graduates in China (10,000)	Number of Chinese researchers (10 thousand people)	Number of international students in China	Number of students abroad
2000	3849.08	116.4	151.4	60000	60,000
2001	4637.66	143.6	158.8	71000	70,540
2002	5480.03	168.7	165.7	82000	82,000
2003	6208.27	194.2	171.4	100000	102,000
2004	7242.6	219.8	180.8	120838	109,100
2005	8418.84	255.6	191.2	134992	120,800
2006	9815.3	417.7	203.1	160054	135,000
2007	12148.07	462.5	220.2	180834	162,700
2008	14500.74	515.9	234.8	223499	189,800
2009	16502.71	615.9	256.6	238184	229,300
2010	19561.9	655.7	282.7	265090	285,000
2011	23869.29	683.6	305.1	292611	320,000
2012	27696.0	662.1	330.0	328330	399,600
2013	30364.72	699.6	355.9	328330	413,900
2014	32806.46	727.0	386.1	377054	459,800
2015	36129.19	725.7	414.6	397635	523,700
2016	38866	793.0	443.9	440000	572,400
2017	42557	795.0	468.7	489200	608,400
2018	46143	821.0	496.2	492185	662,100
2019	50178.12	874.0	526.4	492185	703,500
2020	53033.87	874.0	546.7	492185	500,900

APPENDIX 7

Technology centers in China, their regions and features.

Title	Region	Features
Jing-Jing-Ji	Beijing-Tianjin-High-	Means Beijin, Tianjin and Shijiazhuang
Zhongguancun, Beijing	Shijiazhuang High-Tech Industrial Belt	Renowned Chinese science and technology center
Chengdu, Sichuan	Haidian District, Beijing	Software specialization
Dalian, Liaoning	Tianfu Park, Chengdu, Sichuan	High-tech zone and software park
Shenyang	High-tech zone, Dalian	A new area for high-tech development
Shenzhen	Hongnan New Zone, Shenyang	One of China's leading hi-tech centers
Shanghai	Hi-tech Park, Shenzhen	Innovation-focused high-tech park

APPENDIX 8

China's Experience in Stimulating Human Resources: Conditions for Attracting Highly Qualified Personnel from China and Abroad to Hebei University of Agriculture

Admission level	Admission Requirements	Admission benefits
Leader cadre	Has significant academic influence in his/her field, has achieved important scientific results and is recognized as an outstanding scientist both at home and abroad	1. Reimbursement of relocation costs (3-5 million yuan); 2. Scientific research with funding of more than 10 million yuan; 3. Annual income of 1.5-2 million yuan
A Specialist class	Has significant academic influence in his/her field, has led national research projects and published more than 2 articles in leading journals such as Nature, Science, Cell.	1. Reimbursement of relocation costs (1-1.5 million yuan); 2. Scientific research with funding of 2 to 5 million yuan; 3. Annual income of 0.8-1.5 million yuan.
B Specialist class	Natural Sciences: published more than 4 articles with IF ≥ 15.0 (Engineering: IF ≥ 10.0) in tier 1 journals or more than 10 research articles; Humanities and Social Sciences: published more than 5 articles in leading AMI Comprehensive Evaluation Report journals or more than 8 articles in SSCI 1st quartile journals, or full papers published in China Social Science Digest, Xinhua Digest or journals rated by AMI Comprehensive Evaluation Report at a level above.	1. Relocation cost reimbursement (0.8-1 million yuan); 2. Scientific research with funding from 0.5 to 1.5 million yuan; 3. Annual income 0.4-0.8 million yuan.
C Specialist class	1. In rural medicine and medical sciences: published 1 article in top level journals such as Nature, Science, Cell, or more than 2 articles in high impact journals; 2. In engineering sciences: published 2 articles in high impact journals in engineering according to ESI or more than 5 articles in tier 1 journals; 3. In humanities and social sciences: published more than 8 articles in SSCI, A&HCI or CSSCI journals.	1. Reimbursement of relocation costs (0.4-0.6 million yuan); 2. Scientific research with funding from 0.5 to 1.5 million yuan; 3. Annual income 0.25-0.4 million yuan.
D Specialist class	1. In rural medicine and health sciences: published 1 article with IF ≥ 8.0 or more than 2 articles in tier 1 journals or more than 3 articles in tier 2 journals; 2. In engineering sciences: published 2 articles in tier 2 journals in engineering according to ESI data. 3. In Humanities and Social Sciences: published more than 3 articles in SSCI, A&HCI or CSSCI journals.	1. Relocation cost reimbursement (0.15-0.3 million yuan); 2. Research funding with start-up funding from 0.1 to 0.2 million yuan (humanities and social sciences: 0.05-0.1 million yuan); 3. Annual income 0.1-0.15 million yuan.

E specialist class	1. In Rural Medicine and Health Sciences: published 1 article in tier 2 or higher journals. 2. In engineering sciences: published 2 or more articles in engineering journals according to ESI and tier 1 national journals and EI (national journals). 3. In Humanities and Social Sciences: published 2 or more articles in SSCI, A&HCI, or CSSCI journals.	1. Reimbursement of relocation costs (0.05 million yuan); 2. Research funding when starting from 0.05 to 0.1 million yuan (humanities and social sciences: 0.03-0.05 million yuan).

APPENDIX 9

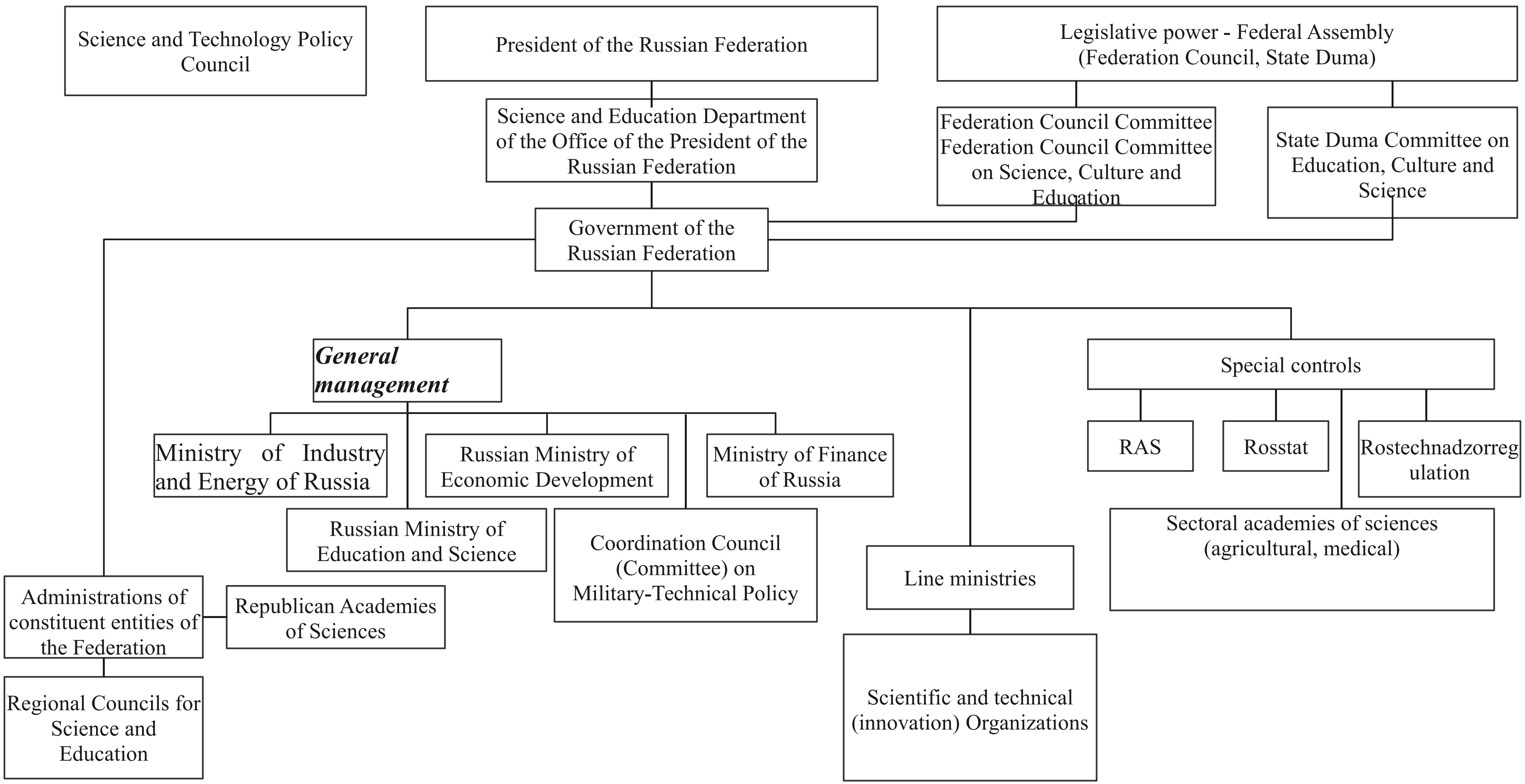

Figure: Scheme of organization of interconnection between the participants of innovation management in the Russian Federation

APPENDIX 10

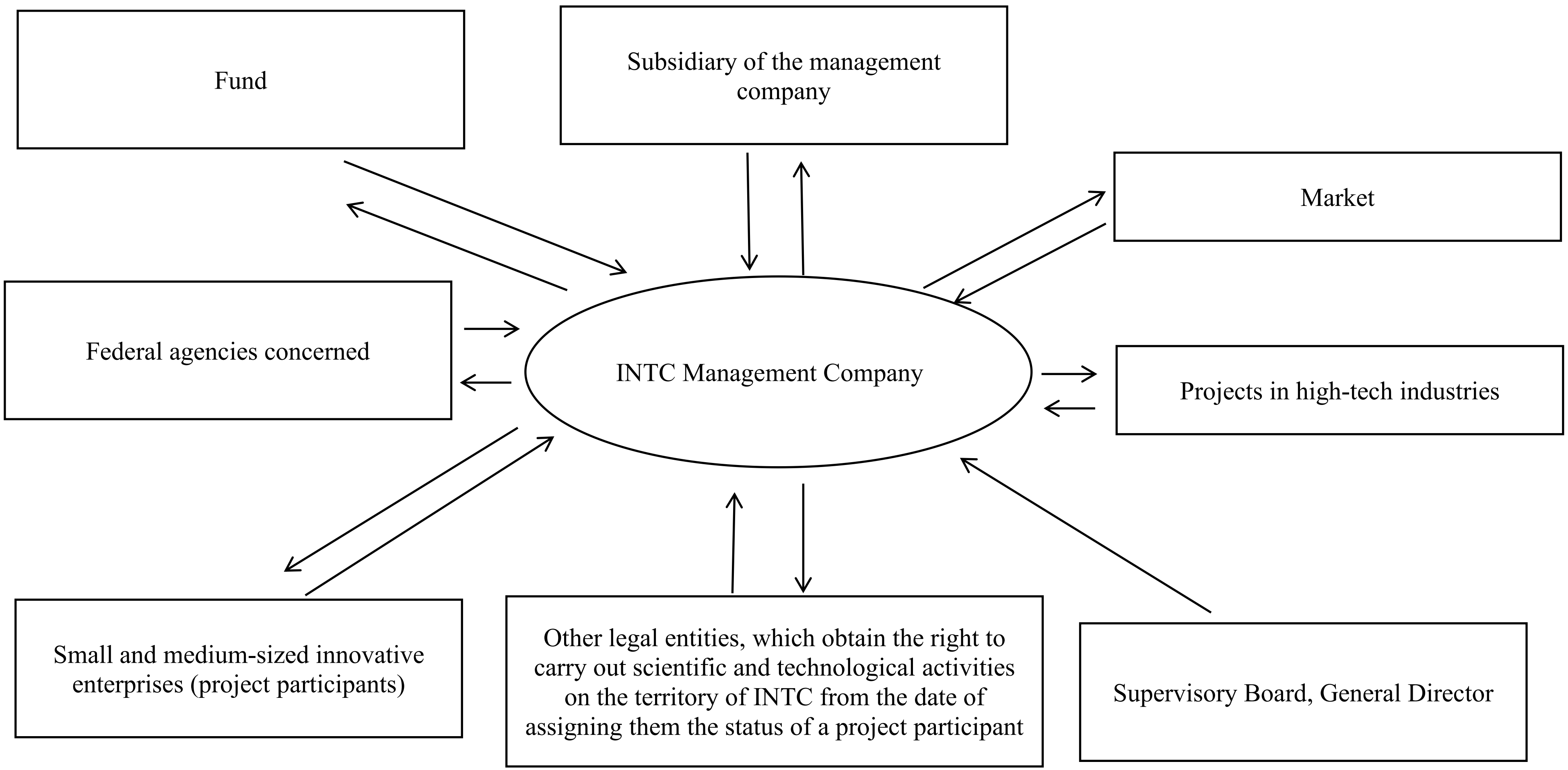

Figure: Scheme of organization of interconnection between participants of innovation management in STCI in Russia

APPENDIX 11

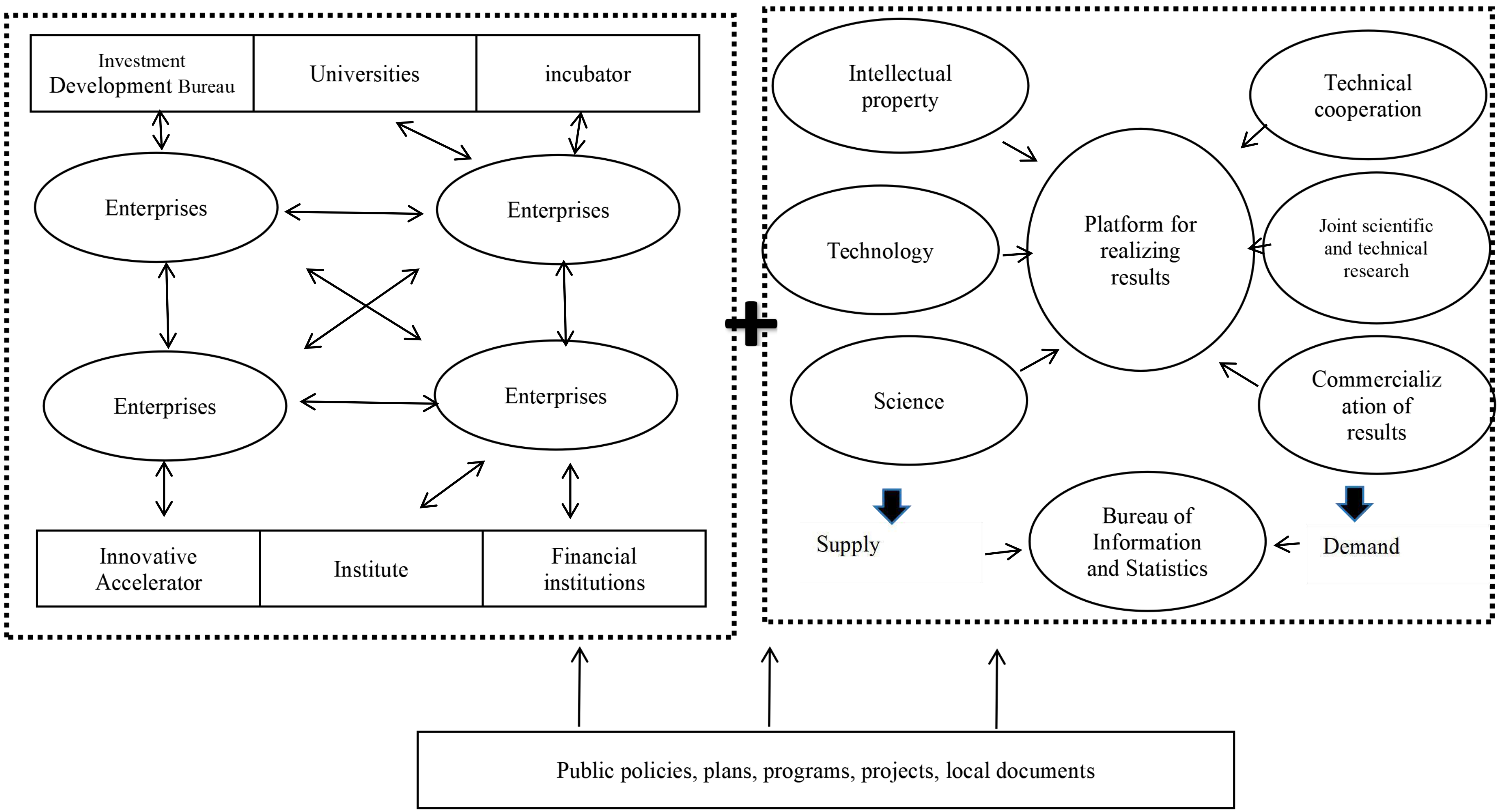

Figure: Scheme of organization of interconnection between participants of innovation management in innovation technology centers in China

APPENDIX 12

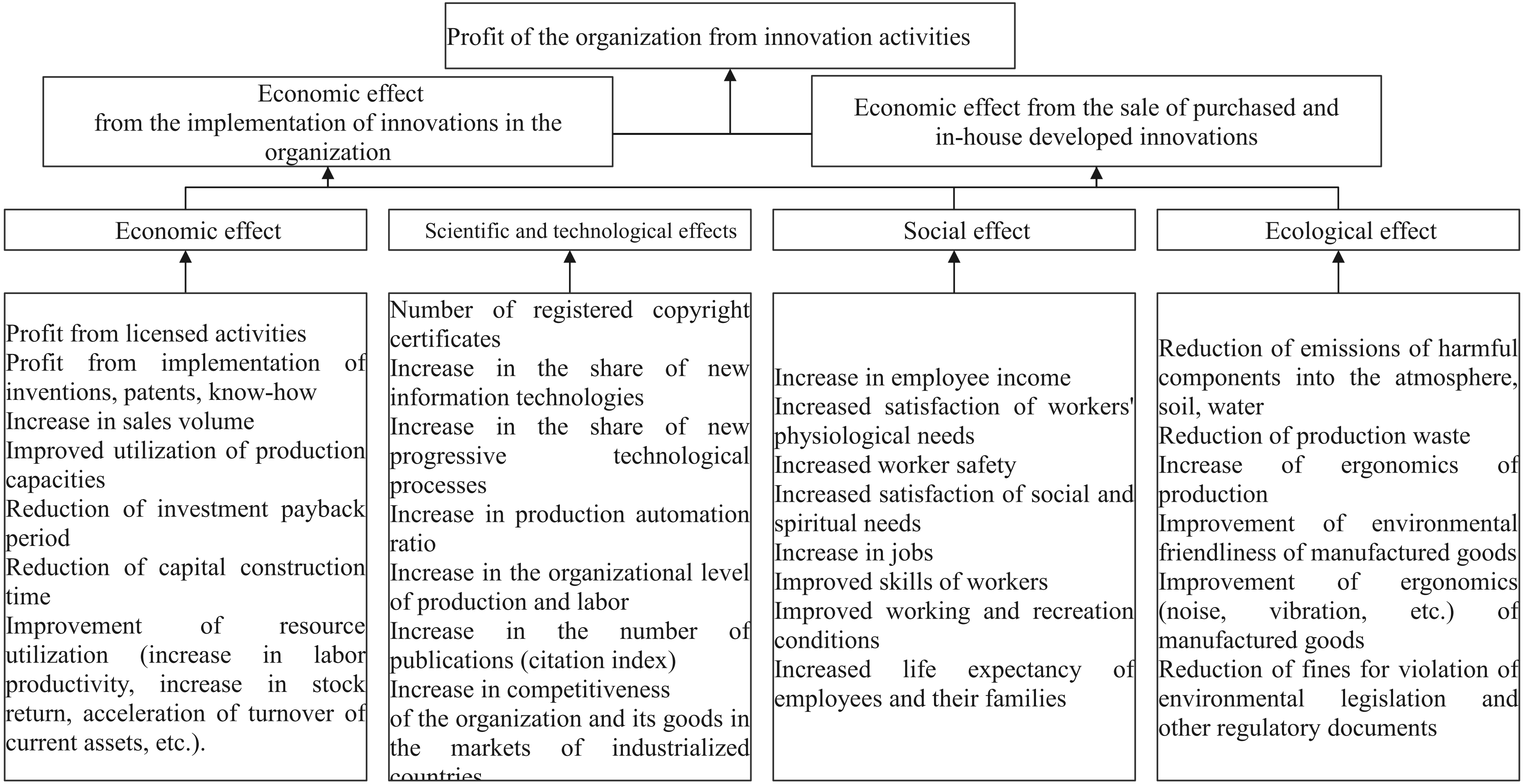

Figure: Scheme of the system for assessing the innovativeness of organizations.

APPENDIX 13

Innovation-related documents.

Administrative documents	Content in relation to innovation
Decree of the President of the Russian Federation of May 7, 2018, No. 204	Determination of strategic goals and directions of modernization and innovative development of the Russian economy.
The main directions of the Government's activities for the period until 2024, approved by the Government of the Russian Federation on September 29, 2018, No. 8028p-P13	Determination of goals and directions of the Government's activities in the context of innovation.
Strategy for Innovative Development of the Russian Federation, approved by Order of the Government of the Russian Federation No. 2227-r dated December 8, 2011	Approval of the strategy for innovative development of Russia.
Strategy for Scientific and Technological Development of the Russian Federation, approved by Decree of the President of the Russian Federation No. 642 dated December 1, 2016	Determination of the strategy for scientific and technological development of Russia.
Resolution of the Government of the Russian Federation No. 1172 of November 16, 2012	Establishing the powers of federal executive bodies for state support of innovation activities, including financial support and creation of infrastructure.
Resolution of the Government of the Russian Federation No. 773 of June 15, 2019	Determination of criteria for classifying goods, works and services as innovative products and high-tech products.
Updating of statistical observation forms for innovation activity in 2019	Ensuring actualization of information on innovation activities.
Preparation for updating the Strategy for Innovative Development of the Russian Federation in 2020	Starting work on updating the development strategy with a focus on innovation and preparing a factor model for achieving the national innovation goal.
Concept of Technological Development of Russia until 2030	Achievement of technological sovereignty, transition to innovation-oriented economic growth,

	technological support of sustainable development of production systems
Priority 2030 Program	Concentrate resources to ensure the contribution of Russian universities to the achievement of national development goals of the Russian Federation for the period until 2030, increase the scientific and educational potential of universities and scientific organizations, and ensure the participation of educational organizations of higher education in the socio-economic development of the constituent entities of the Russian Federation.

APPENDIX 14

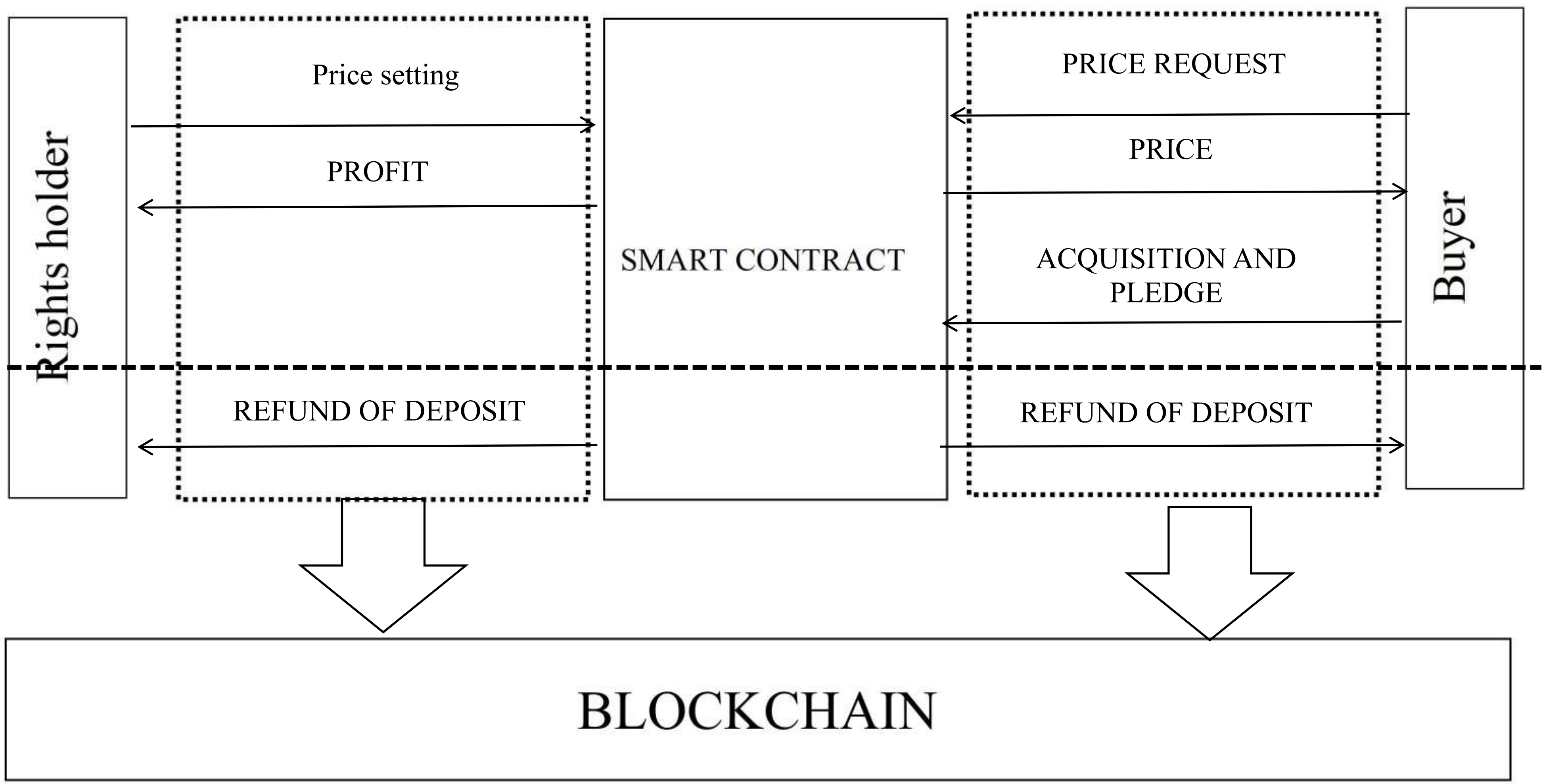

Figure: Blockchain-based transfer of exclusive rights.

APPENDIX 15

General characteristics of the dynamics of innovation activities

	Level of innovation activity of organisations	The share of organisations that carried out technological innovations, in the total number of organisations surveyed	Share of expenditures on innovation activities in the total volume of shipped goods, work performed, services	Volume of innovative goods, works, services (RUB million)	Share of innovative goods, works, services in the total volume of shipped goods, works, services performed	Expenditure on innovation activities of organisations (RUB million)	The share of small enterprises that carried out technological innovations in the reporting year in the total number of surveyed small enterprises	Expenditure on innovation activities of small enterprises (RUB million)	Special costs related to innovations aimed at improving the environment (RUB million)
2010	9.5	7.9	1.6	1,243,712.5	4.8	400,803.8	4.1	-	26,616.4
2011	10.4	8.9	2.2	2,106,740.7	6.3	733,816.0	5.1	9479.3	24,131.4
2012	10.3	9.1	2.5	2,872,905.1	8.0	904,560.8	-	-	27,768.7
2013	10.1	8.9	2.9	3,507,866.0	9.2	1,112,429.2	4.8	13510.5	15,098.2
2014	9.9	8.8	2.9	3,579,923.8	8.7	1,211,897.1	-	-	20,914.0
2015	9.3	8.3	2.6	3,843,428.7	8.4	1,203,638.1	4.5	12151.8	21,979.2
2016	8.4	7.3	2.5	4,364,321.7	8.5	1,284,590.3	-	-	12,338.0
2017	8.5 (according to the criteria of the 3rd edition	7.5 (according to the criteria of the 3rd edition					5.2	19220.4	
	14.6 (according to the criteria of the 4th edition of the Oslo Manual)	20.8 (according to the criteria of the 4th edition of the Oslo Manual)	2.4	4,166,998.7	7.2	1,404,985.3			27,073.0
2018	12.8	19.8	2.1	4,516,276.4	6.5	1,472,822.3	-	-	20,315.2
2019	9.1	21.6	2.1	4,863,381.9	5.3	1,954,133.3	5.9	27340.2	26,616.4
2020	10.8	23.0	2.3	5,189,046.2	5.7	2,134,038.4	-	-	24,131.4
2021	11.9	23.0	2.0	6,003,342.0	5.0	2,379,709.9	7.1	54441.8	27,768.7
2022	11.0	22.8	2.1	6,377,248.5	5.1	2,662,571.1			