

The construction of science and technology innovation policy design framework—take Shandong Province as an example

Yongfei Jia

*Qilu University of Technology, Shandong Academy of Sciences,
Institute of Science and Technology for Development of Shandong, Jinan, China*

Chang Liu

Taishan University, Tai'an, China, and

Chong Yin and Qing Zhu

*Qilu University of Technology, Shandong Academy of Sciences,
Institute of Science and Technology for Development of Shandong, Jinan, China*

Abstract

Purpose – Under the background of economic and technological globalization, all countries will pay attention to science and technology innovation policies. At this time, the era of innovation policy plays an important role. In order to thoroughly implement the spirit of the 19th National Congress of the Communist Party of China, earnestly innovate development concepts and strengthen the key supporting role of scientific and technological innovation for social development.

Design/methodology/approach – The research will make an in-depth study on the policy of scientific and technological innovation, take the change trend of the number of laws and regulations and the analysis of the basic content as the entry point, and classify it from five different aspects, such as the policy of scientific and technological system and mechanism, the policy of financial guidance, the policy of technological innovation of enterprises, the policy of scientific and technological talents, and the policy of intellectual property.

Findings – Through the comparison of the development history of science and technology policies at home and abroad, the development history of science and technology innovation policies under the special national conditions of China is obtained. Combining with the relevant basic theories of science and technology innovation system, designing from the publishing department, main content, and implementation subject, constructing a synergistic science and technology innovation system of “government, industry, university and research,” and forming an “integration of supply and demand” technology innovation framework will guide the development of China’s science and technology innovation in the future.

Originality/value – The authors construct the policy framework of science and technology collaborative innovation based on the concept of science and technology innovation policies. The framework has realistic significance for its future development.

Keywords Science and technology innovation policy, Policy framework design, Collaborative science and technology innovation policy system

Paper type Research paper



1. Introduction

The Central Committee attaches great importance to the driving effect of scientific and technological innovation activities on social progress and economic development and proceeds from the overall layout and development strategy of the country. The 13th Five-Year Plan puts forward corresponding requirements to improve China's science and technology innovation capacity and contribution rate of science and technology progress and strive to achieve the goal of an innovative country. In the report of the 19th National Congress of the Communist Party of China (CPC), Xi Jin-ping explicitly proposed that innovation is the primary engine of development and the strategic support for the construction of a modern economic system. Research on the role of policies dates back to political economists such as Smith (1950) and List (2016). Ball believed that science and technology policies were "centralized measures taken by the government to promote the development of scientific and technological research and to achieve political goals" (Ball, 1993). Until the twenty-first century, Lundwar and Borrás formally put forward the concept of systematic science and technology innovation policies (Fagerberg *et al.*, 2004) and defined it as "Public policies that the government has implemented to promote the production, diffusion and application of scientific and technological knowledge to achieve national goals" (Lundvall and Borrás, 2005). Wang *et al.* proposed that science and technology innovation policies have certain value. For example, China's science and technology innovation policies have basic values such as political function, science and technology progress, economic benefit, social development, and ecological evolution (Wang *et al.*, 2017). At the same time, Kang *et al.* believed that technology innovation plays an important role in the process of social development. Therefore, research on the evaluation of science and technology innovation policies has been increasing in recent years (Kang *et al.*, 2018). GAO used the content analysis to conduct an in-depth analysis of the evolution of science and technology policy (GAO, 1989). Li *et al.* analyzed the evolution path of international science and technology policy over the past 42 years. The scope of research has changed from early sporadic distribution to recent key research, and the research perspective has also changed from macro to micro. Their study provides a more comprehensive understanding of the changing trends and hotspots of international research and provides a reference basis for future development and research (Li *et al.*, 2018). Fu proposed corresponding suggestions for expanding the supply of grassroots industry development policies based on the perspective of policy demand subjects through the analysis of the evolution trend of local government science and technology policies (Fu, 2010). Similarly, Wang *et al.* adopted the combination of qualitative and quantitative methods to explore the formulation and implementation of research policies from the perspectives of policy demand and supply and provided differentiated policies to support different innovation entities (Wang *et al.*, 2018). Song *et al.* revealed the internal response mechanism of regional science and technology innovation policies by constructing a "policy-enterprise" combination model (Song *et al.*, 2018). Chen *et al.* analyzed from different perspectives of macro, meso, and micro. They believed that the design of innovation policy should focus on multidimensionality and effectiveness, and the same policies should focus on diversity and combination effects (Chen, 2016). In short, all these provided reference and enlightenment for the optimization and design of China's science and technology innovation policies system framework.

In addition, there are many problems about the construction, evaluation, implementation effect and existing problems of scientific and technological innovation policies are deeply explored in different regions and provinces. For example, Hu *et al.* take Nanjing as a case to conduct a policy evaluation process from the aspects of policy content assessment, policy implementation evaluation, and policy effectiveness evaluation (Hu *et al.*, 2018). Gong *et al.* set up a regional innovation policies system framework from the main body of innovation activities, the stage of innovation activities, and the dimension of innovation policy tools and

established a “1 + 10” innovation policies system with Chengdu as an example (Gong and Liu, 2015). Combining the fuzzy comprehensive evaluation method, Yan comprehensively evaluated and compares the implementation effects of science and technology innovation policies in Hebei Province from the perspective of government and enterprises (Tong, 2018). With the help of network resources, Yan *et al.* made an econometric analysis of the policy documents on science and technology innovation issued in Shandong Province from 2000 to 2012 and tried to construct a regional framework of science and technology innovation policies (Xi *et al.*, 2014). In summary, many scholars have made a comparative study of the science and technology innovation from different research perspectives and research methods. However, the formulation of science and technology innovation policies requires the combination of theory and practice. There is a lack of theoretical research on science and technology innovation policies. Therefore, based on the previous research, this study explores the evolution process of the science and technology innovation policies and the characteristics of the policy system. Furthermore, we construct the policy framework of science and technology collaborative innovation based on the concept of science and technology innovation policies. The framework has realistic significance for its future development.

2. Quantity and content of science and technology innovation policies

2.1 The changes in quantity about science and technology innovation policies

As can be seen from the number of science and technology innovation policies documents issued by Shandong Province in recent years (Figure 1), the overall trend is that the number of documents is rising, but it is volatile in different periods and can be roughly divided into three stages. In the early stage of development (2000–2005), the number of documents related to the science and technology innovation policies in this stage is small, but it has a rising trend in general. In the mid-term volatility stage (2006–2009), the number of documents fluctuated obviously. Among them, the number in 2009 was as high as 26, which formed a strong contrast in 2008. The number of documents issued in 2008 was only 30.7 percent of that in 2009, which fluctuated considerably during that period. In the later stage of growth (2010–2016), the number of this stage has shown a steady and continuous growth, forming a relatively stable trend. In short, it also reflects the government’s attention to science and technology innovation from the side and to form a corresponding legal document of science and technology innovation.

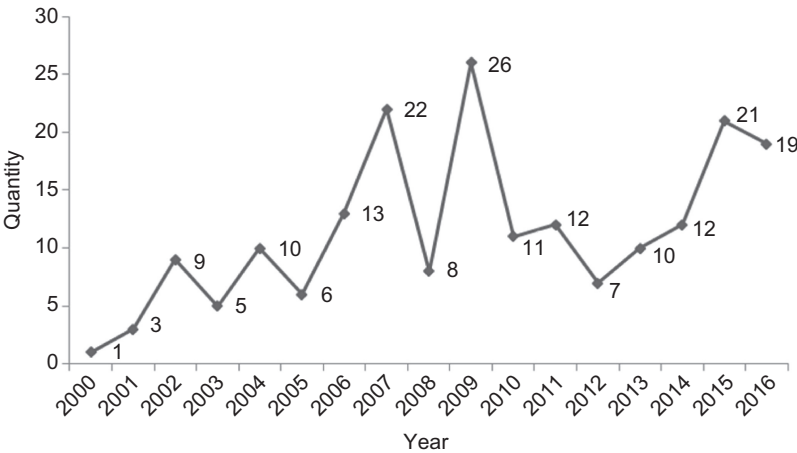


Figure 1.
Changes in the number
of policy documents in
Shandong Province
over the years

2.2 Science and technology policy documents distribution

2.2.1 Basic information of science and technology innovation policy documents. According to the science and technology innovation policies documents issued by Shandong Province, its main contents are divided into six categories (Figure 2), the use of science and technology investment (46.57 percent), tax incentives (10.77 percent), financial support (11.28 percent) and government procurement (3.01 percent), intellectual property (13.28 percent), and technology platform (15.09 percent). Firstly, it can be seen that the current focus of the government is still in the science and technology investment. The related science and technology innovation policies and regulations document is the highest, close to half the quantity, which can reflect the focus of the government's science and technology policies more intuitively. Secondly, the higher proportion is the science and technology platform documents. In recent years, the construction and application of various forms of platform have accelerated the promulgation of the relevant policies by the government departments, but there is still a big gap compared to technology investment. The proportion of intellectual property rights, financial support, and tax incentives is similar. This is also an important manifestation of support policies and protective measures for technological innovation. Government procurement content accounts for the least proportion. Government procurement plays a very important role for small and medium-sized enterprises in the early stage of research and development. Therefore, we should pay attention to it and invest in it.

2.2.2 Different types of science and technology innovation policy documents. From the perspective of the current policies documents on science and technology innovation, they are divided into five types of policies: the policy of the system and mechanism of science and technology, the policy of financial guidance, the policy of technological innovation of enterprises, the policy of talents in science and technology, and the policy of intellectual property rights (Table I). At the same time, it is a necessary stage in the process of scientific and technological research and development and the transformation of scientific and technological achievements. The clear regulations and constraints on relevant laws and policies in these areas are conducive to the development and progress of scientific and technological innovation in our country.

Specifically, the content of policies documents promulgated in recent years is focused on (1) the science and technology system and mechanism. Deepening the reform of the system and mechanism and implementing the innovation-driven strategy are aimed at achieving the goal of "two hundred-years plan." The government should regulate the transformation of scientific and technological achievements, speed up the transfer of technology such as

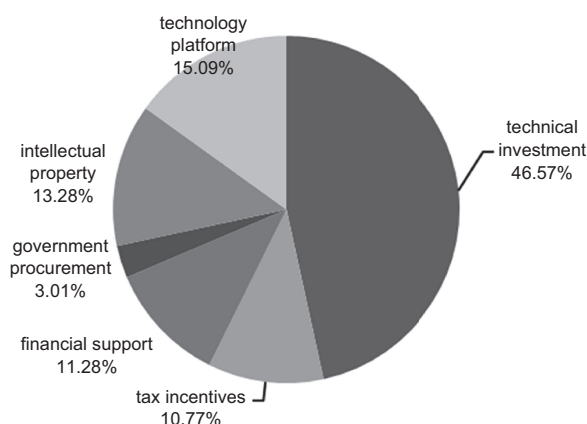


Figure 2.
Basic information on
Shandong policy
documents

Table I.
Different types of
science and technology
innovation policies

Classification	Nationwide	Shandong province
Science and technology system, mechanism, and policy	The reform of scientific research institution, the management of technology plan, the transformation of scientific and technological achievements, innovation demonstration zone (demonstration province) pilot, etc.	The reform of scientific research institution, the reform of science and technology reward system, independent innovation demonstration zone, the development of agricultural high-tech industry and seed industry technology, etc.
Financial guidance policy	Technology funding and finance, technology finance and taxation, special fund supervision of science and technology plan, responsibility system of subject, etc.	Key research and development expenses plus deductions, financial subsidies for research and development funds, management of subsidies for service agencies, etc.
Enterprise technology innovation policy	High-tech enterprises, R&D subsidies, mass entrepreneurship, support for the innovation platform, and the creation of space development services, etc.	Innovation and development of small and micro enterprises in science and technology, promotion of innovation coupons, promotion of development of innovative industrial clusters, etc.
Science and technology talent policy	Science and technology talents and talent development, science and technology leading talents, talent classification evaluation, support for the transformation of scientific research results, etc.	Implementation opinions on talent development system, Taishan scholar project, youth science and technology talent innovation, science and technology leading talent innovation studio, top talents “one case one discussion” implementation, etc.
Intellectual property policy	The IP Office strongly supports and announces the patent award method, etc.	Implementation of the Intellectual Property Strategic Behavior Plan and the Shandong Patent Awards, etc.

research and development institutions, colleges, and universities, promote the innovation and entrepreneurship of high-tech personnel, and create a good transfer environment as far as possible. The government should carry out pilot experiments in independent innovation demonstration zones (demonstration provinces) to create a number of replicable and replicable practical models of sustainable development. Shandong Province has issued a series of relevant regulations in deepening the reform of the scientific and technological system, building and developing the national independent innovation demonstration zone, planning scientific and technological innovation, promoting agricultural scientific and technological innovation, and reforming the transfer of scientific research achievements in scientific research institutes of provincial colleges and universities, and agricultural high-tech industry and international scientific and technological cooperation. (2) Financial guidance policy. The central government supervises the special fund for science and technology planning, implements the responsibility system of the supervisory body, and records the behavior of dishonesty. Similarly, the Shandong Provincial Government has provided guidance for the development of the provincial technology market, the transformation of scientific and technological achievements, the operation of intellectual property rights in key industries, the management of subsidized funds by service institutions, the management of pilot funds for scientific and technological achievements transformation, and provincial natural science fund reform and other related policies and measures. (3) Enterprise technology innovation policy. At present, the technological innovation policy of enterprises in China involves research and development (R&D) investment, high-tech enterprises, national and provincial innovation platform construction, mass innovation incubator, strategic alliance of industrial technology innovation and

innovation vouchers, and so on. Shandong Province has also issued relevant opinions on accelerating the development of science and technology service industry, innovating and developing small and micro enterprises, and promoting the development of innovative industrial clusters. (4) Science and technology talent policy. It accelerates the support and implementation of talent development and scientific research achievements and promotes fair, just, and open results transfer transactions. Similarly, Shandong Province has issued a notice on the implementation of the talent development system and issued a series of relevant opinions on the leading talent projects of Taishan scholars. In addition, a series of implementation rules on industrial leading talent projects, modern service industries, and social and civilian production industries have been issued. (5) Intellectual property policy. With the progress of society, people's awareness of intellectual property rights has generally increased. Construction of intellectual property rights plays a vital role in economic and social development, which is the key to building a strong country in science and technology. In this regard, the State Council has issued opinions on accelerating the construction of a strong intellectual property country under the new situation as well as an in-depth implementation of the National IP Strategy Action Plan. At the same time, the patent award method was announced. In order to implement the aforementioned documents, Shandong Province has accordingly formulated an in-depth implementation of the IP Strategic Action Plan and the Shandong Provincial Patent Incentive Measures Notice.

3. Transmutation of science and technology innovation policies

3.1 *Development of science and technology innovation policies in the world*

The science and technology innovation policy is comprehensive, inclusive, and historically inherited. Therefore, the development process of science and technology innovation policy goes through the following three stages (Figure 3)

The first stage: from the Second World War to the late 1960s, under the influence of the development of science and culture at that time, it was believed that scientific and technological innovation activities should be carried out in accordance with the “research-development-commercialization” model. The focus of government investment should be on basic research, and science and technology innovation policy should also been focused on the front end of basic research. This is the initial stage of the science and technology innovation policy, which is of fundamental importance to its future development.

The second stage: in the 1970s and 1990s, the economic development and social progress of Western countries were rapid. Get some enlightenment from the basic innovation activities to derive interaction model represented by the “chain-loop model.” It is believed that innovation activities and production activities are not necessarily one-way. In fact, they can be developed as “circular” cycles. The products of the basic research in the previous stage are the inputs for recirculation research and development. The government needs to increase investment in procurement and technology development before tax to promote the development of circular chain.

The third stage: since the 1990s, Freeman first proposed the “National Innovation System” and gradually developed into the “National Innovation System Theory.” The theory holds that innovation activities are systematic behaviors of multisubject interaction formed by specific subjects in a specific environment. This theory has pioneered the systematic analysis of scientific and technological innovation policies, greatly expanded the horizons, and laid the direction for the mutual integration of the subjects and the integration of the subject and the environment.

In short, the development process of science and technology innovation policy has experienced a simple to complex, linear to multidevelopment model evolution process, which greatly enriched the formulation principles of our scientific and technological innovation and

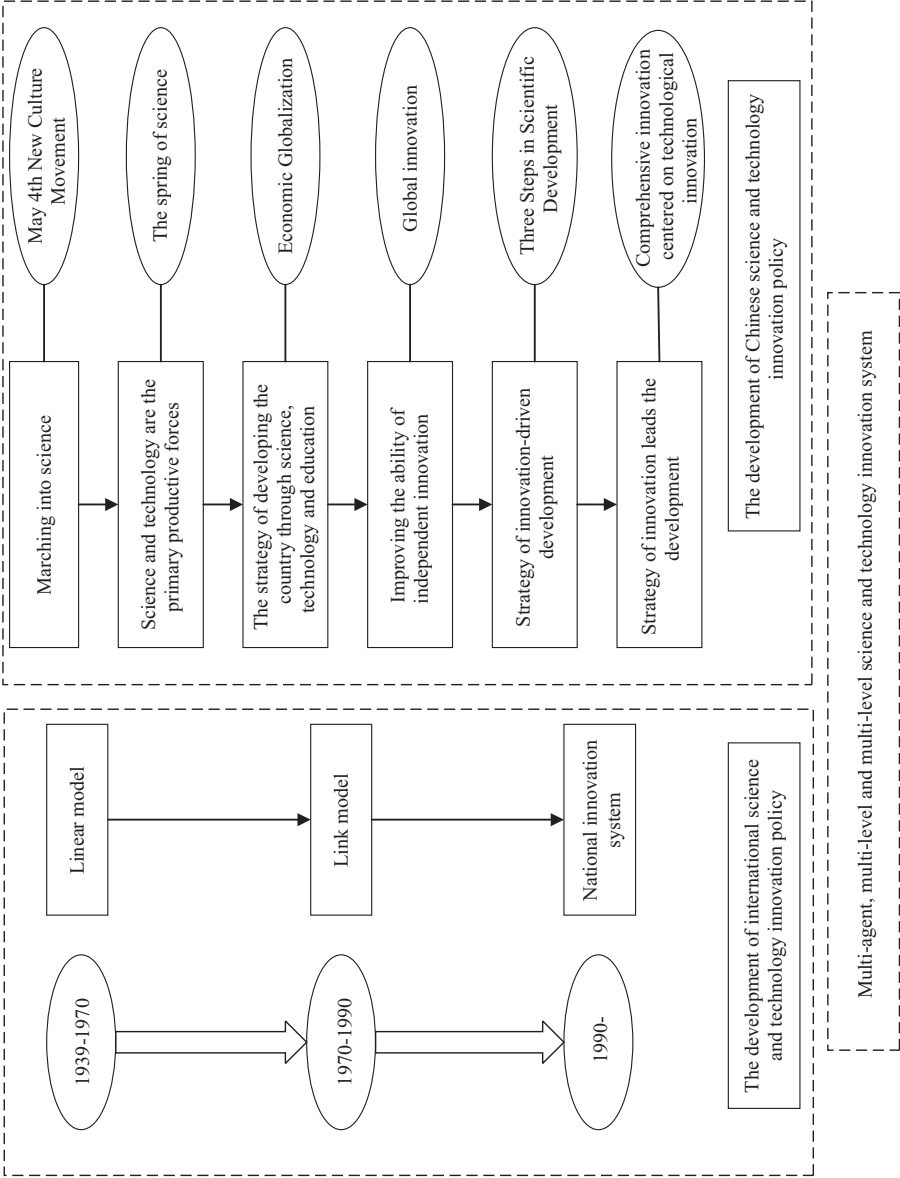


Figure 3.
The development of
science and technology
innovation policy

provided guiding and targeted suggestions for the implementation of science and technology innovation policies.

3.2 The development of Chinese science and technology innovation policies

The first stage: marching into science. Under the influence of international science and technology policies, China's policymaking philosophy is based on linear models. As mentioned in the book *Science – Never-Ending Frontier*, science and technology innovation is a one-way linear process, so, at that time, the formulation of science and technology policy in China was also concerned with basic research and other aspects. Before the founding of China, the "May 4th" New Culture Movement started the initial exploration of our country. A large number of patriotic intellectuals brought the scientific idea back to China for the first time and at the same time laid the foundation for the formulation of our country's system. After the founding of China, it was mentioned in the Common Program that "Make great efforts to develop natural science in order to serve the construction of industry, agriculture and national defense. Reward scientific discovery and invention, popularize scientific knowledge." Since then, the First National People's Congress and the Party Committee of the State Science and Technology Commission and the Party Group of the Chinese Academy of Sciences have proposed a series of policies on science and technology innovation. In short, the science and technology activities at that time were based on the basic research of government expenditure.

The second stage: science and technology are the primary productive forces. In March 1978, Deng Xiao-ping clearly stated at the National Science and Technology Conference that "science and technology are productivity." Since then, a series of policies have been issued to strengthen the development of science and technology and the economy and to play a combined role to achieve a significant increase in the production capacity of science and technology.

The third stage: the strategy of developing the country through science, technology, and education. With the development of economic globalization, different elements flow and merge with each other and further promote the interrelation and development of industry, so that people have a deeper understanding of innovation activities. Similarly, the government has issued corresponding policies to strengthen the support for scientific, technological, and innovation activities. From the national policy level, completing the development guidance and guidance for the science and technology innovation activity.

The fourth stage: improve the ability of independent innovation. Since the fortieth anniversary of reform and opening-up, China's economic development has made a leap forward. The development of information technology, such as the Internet and big data, has comprehensively changed economic, scientific, and technological activities. However, when the economic development reaches a certain level and scale, the traditional way of development is not suitable, so it is necessary to enter the era of innovation system, which pays more attention to coordination and cohesion. To improve the capacity of independent innovation through the initial formation of the science and technology innovation policy system, comprehensively promote the construction of the national innovation system and optimize the allocation of macro-scientific resources.

The fifth stage: strategy of innovation-driven development. In recent years, with the rapid development of the economy, a new round of scientific and technological revolution and industrial change is on the horizon. On the whole, innovation systems remain the mainstream of policy framework development. But at the same time, governance theory, sharing economy, inclusive innovation, and other theories play an increasingly important role in innovation policymaking. It is very important to realize the driving strategy of scientific and technological innovation, which is the starting point and key point of the development of scientific and technological innovation policy.

The sixth stage: strategy of innovation leads the development. General Secretary Xi Jinping pointed out in the report of the 19th National Congress that innovation is the first driving force for development, and it is also the strategic support for building a modern economic system. Since the implementation of the innovation-driven development strategy, many breakthroughs or even subversive achievements have been made in the development of science and technology in China, affecting all aspects of economic and social development, science and technology and economy, society, people's livelihood, and national security are more and more closely related. By perfecting the innovation policy system, we will better lead innovation in product innovation, industrial innovation, business model innovation, and so on with science and technology innovation and promote comprehensive innovation with science and technology innovation as the core.

In short, the process of technological innovation development in China is more comprehensive, systematic, coordinated, and more distinctive. Continuously improve China's science and technology innovation policy and form a theory of technological innovation with Chinese characteristics.

4. Science and technology innovation policy system and framework

4.1 Science and technology innovation policy system

4.1.1 The features of science and technology innovation policy system. Science and technology innovation policy system is not a simple superposition and reorganization of a variety of policies, but is a unified, complete, and systematic whole, which is formed by the interaction of each policy decision-making unit and the environmental elements interacting with each other. Therefore, science and technology innovation policy should be understood and its concept and characteristics from the whole are grasped, in order to better play its role and value. (1) Systematicness. On the one hand, considering that the main body of scientific and technological innovation covers universities, intermediaries, enterprises, scientific research institutions, financial institutions, and other types of main body, the diversity of the main body causes the complexity of scientific and technological innovation activities, On the other hand, scientific and technological innovation involves many processes, such as the discovery of scientific and technological activities, the development of technology, industrialization, and industrial transfer, which make the system of scientific and technological innovation more dynamic. Therefore, to realize the further development of science and technology, we should pay attention to the systematicness of scientific and technological innovation activities and strengthen the link and cooperation among each other. (2) Harmony. The science, technology, and innovation policy system needs to coordinate the problems that arise within science and technology activities, such as funding sources, talent training and science, technology and innovation policies, to strengthen coordination capabilities in various fields, to achieve common goals between different policies, and to avoid collision and conflict between different policies. (3) Effectiveness. Scientific and technological innovation policies tend to favor complex and comprehensive policies in the process of formulation because they involve a variety of subjects, fields, and levels. Therefore, it is easy to ignore the orientation of the policy objectives, so that the final policy designing deviates from the original objective and weakens the effectiveness of the policy. To deal with this easy-to-emerge problem, policymakers need to shift from comprehensive design to specialized policy. (4) Multi-level. The multi-level of science and technology innovation policy mainly includes two kinds of: vertical structure and horizontal structure. Firstly, from the perspective of the vertical structure, the policy can be divided into macro-policy, -meso-policy, and micro-policy, from the top to the bottom. In the macro-policy, scientific and technological innovation strategic objectives should be clear and the overall situation from the direction of development and the formulation of rules should be grasped. The meso-level is not only the foothold of the macro-

level but also the reference point of the micro-level, so this level is necessary to make a good connection between the macro-level and the micro-level. The microcosmic level pays more attention to the implementation object and the implementation effect. Secondly, from the perspective of horizontal structure, scientific, and technological innovation policy should be combined with supply strategy, environmental strategy, and demand policy. The supply strategy is to expand the supply by means of information, technology, and capital and to increase the breadth and depth of scientific and technological innovation. The environmental strategy is to create a favorable environment for the establishment of scientific and technological innovation system through government and enterprise regulation. The demand strategy is to promote the formulation of scientific and technological innovation policy by means of government procurement and so on. In conclusion, science and technology innovation policy needs to realize its social value through “push-pull” way.

4.1.2 Constructing the policy system of scientific and technological innovation. The scientific and technological innovation policy system should be constructed from the perspective of national innovation system. The policy should act on all aspects of the national innovation system. Based on the six categories of the national innovation system, the six major policies of the system of science and technology innovation policy respectively are: the element policy, the subject policy, the related policy, the industrial field innovation policy, the regional innovation policy, and the innovation environment policy. With the progress and development of science and technology in China, the policy system of science and technology innovation has been continuously improved and developed. The policy system has involved many main bodies such as colleges and universities, scientific research institutions, enterprises, intermediary institutions, and so on. Each link is linked and connected in the system. Therefore, a relatively perfect scientific and technological innovation system is formed with Chinese characteristics.

Specifically, (1) elements policies. They refer to the elements of investments in scientific and technological activities, including science and technology investments, talents investments, and infrastructure investments. Science and technology investments are mainly divided into the national science and technology plan funds (special projects, funds, etc.), the National Natural Science Foundation of China, scientific research institutions operating expenses (the operation guarantee of basic research and social supply research), the basic scientific research operating expenses (self-selected topics research), the scientific research funds of public welfare industry, the funds of scientific research conditions construction, and so on. (2) Principal policies. The enterprise’s technological innovation policies aim to gain the benefit of the science and technology innovation through the enterprise and improve the subject position of the enterprise policy in the national innovation system. The policies of scientific research institutes and colleges and universities, as the backbone of our country’s national science and technology innovation policy system, provide multi-orientation support. The policies of innovative start-up service are mainly focused on the business incubator, the university science and Technology Park, the productivity promotion center, and so on. (3) Relevance policies. Industry-university-research policies refer to the incentive policy of scientific research cooperation among universities, research institutes, and enterprises. Military–civilian integration in the field of science and technology is an important part of the development of military–civilian integration in China. (4) Industry innovation policies. The policies mainly target at a number of specific industry policies. (5) Regional innovation policies. They are also innovation policies aimed at a particular region. (6) Innovative environmental policies. Policies aimed at some external environment, such as market environment, science and technology finance, cultural environment, and so on. In conclusion, the national science and technology innovation policies system with Chinese characteristics, as the focal point of government intervention in the operation and development of the national innovation system, involves various fields, levels, and various subjects and acts on all aspects of the national innovation system.

4.2 Science and technology innovation policy framework

The combination of scientific practice and theory, which supports each other and promotes common development, forms a complete system. Therefore, on the basis of the system of theory and practice, we should fully and profoundly understand and construct the regional scientific and technological innovation policy design framework. The design of scientific and technological innovation policy framework should be based on the relevant theoretical basis and complete the relevant design policy framework.

4.2.1 Theoretical basis. Until to now, there is a lot of research studies on science and technology innovation policies design that have obtained achievements. The theoretical basis of scientific and technological innovation policies design is the cornerstone of the whole scientific and technological innovation policy framework, and it should be explored from all aspects, multi-angle and multi-level, and should be dealt with flexibly according to the actual situation and special circumstances. The existing development and innovation policies should not be carried out blindly. The innovation policies should be improved, perfected, and innovated in the process of practical application. Therefore, the design of STI policies should be considered in the following aspects: (1) the purpose of science and technology innovation policies design framework should be clear. The starting point of all activities should be toward the design goal, and the policies design and promulgation should be carried out around the final implementation effect. The process of concrete construction design and implementation should be toward to the goal at all times, so as not to deviate from the final goal and ideal result. (2) Combine reality and proceed from reality. According to actual situation and development stage of Chinese, China is a developing country. Compared with the Western countries, the development of science and technology innovation in China starts relatively late. Hence, the design of science and technology innovation policy in China should be combined with its own development level and ability to make a reasonable plan for the design framework. (3) According to the characteristics of regional science and technology innovation policies, the framework design should also follow the comprehensive principle, the coordination principle, and the maneuverability principle. At the same time, strictly follow the formulation principles that are the premise and guarantee to complete the policy framework of science and technology innovation. (4) According to regional differences, science and technology innovation policies should be formulated and designed in line with local actual development. To facilitate implementation, research work should be carried out separately in three different types of regions: less developed areas, developing areas, and developed areas. (5) Based on the different research levels, we can not only explore the whole science and technology innovation achievements from the macro level, which can help to design the scientific and technological innovation policy, but also deeply study how the scientific research innovation environment affects the scientific research achievement from the micro-level. We can improve the construction of the new environment through financial means to improve regional science and technology innovation capacity.

In conclusion, the design of science and technology innovation policies must be handled flexibly on the basis of theory. The policies should flexibly be designed according to the actual situation, to form interrelationships and interactions between society and governments, to better serve the design of science and technology innovation policies, and to improve the quality and quantity of the output of scientific research and innovation, to successfully complete the objectives and requirements of the science and technology innovation policies in the course of China's economic and social development. We should adhere to the scientific and rational design concept of science and technology innovation policies, to form a good interaction of social science theory, government study, and policy practice.

4.2.2 The design framework. From the theoretical basis of science and technology innovation policy and the summary of practical experience in the past, based on the combination of the two, this paper constructs the theoretical framework of science and technology collaborative

innovation policy design. The theoretical framework of the design is mainly constructed from the publishing department, the main content, and the implementation subject. These aspects have interactions. In the different environment process, these aspects have different interrelationships from each other and the force and influence also have a significant gap (Figure 4). Specifically, (1) the issuing departments mainly are government general office, science and technology department, finance office, tax bureau, intellectual property office, and so on. These departments are mainly responsible for making policies according to the actual situation during that period and supervising the implementation of the main body. Its role lies in the ability to formulate a series of policies according to the new theory, so that scientific and technological innovation can be strongly supported by the central authorities and provincial governments. Hence, the implementation of science and technology innovation policies can be speeded up. Initially, the Committee of the Provincial People's Congress and the Science and Technology Department jointly deliberated and decided on the final implementation of the policy. In recent years, these policies have been mainly composed of provincial government, science and technology department, and finance office. (2) The main contents include to realize the organic integration of technology R&D, achievement transformation, talent training, enterprise cultivation, industry upgrading, and resource optimization and to promote the effective implementation and application of science and technology innovation policy. (3) The main body of implementation is "government, industry, university, research institutes, financial institutions," which are seven innovative and entrepreneurial communities, which are government, industry, universities, scientific research institutions, financial institutions, science and technology intermediary services, and target users, respectively. These communities form an innovative and entrepreneurial system, which accords with the development and has its own characteristics. The system provides strong support for the all-round development of the society in the new era. In addition, the background environment is not the same and the development of science and technology innovation is a continuous process, so the corresponding background environment is also in the continuous development. Over time, the innovation systems are differences in the environment in different periods, and there are no clear boundaries between the different environments. The development of the innovation systems has a circularity characteristic between each other. The formulation and implementation of science and technology innovation policies should be adjusted in accordance with the changes in the environment to ensure the scientific and reasonable behavior of science and technology policy and scientific research results. In short, when we design the science and technology policies, we should combine with the background conditions at that time to improve the science of science and technology policymaking.

Under the present requirements of social development, speeding up the construction of science and technology collaborative innovation policy systems is not only the requirement of the times, but also an important condition for the implementation of the spirit of the 19th CPC National Congress, the practical implementation of the development concept, and the realization of the development of science and technology innovation. The implementation main bodies that are science and technology innovation policy framework are inextricably related to each other. The publishing department should continue to study the theory and knowledge of scientific research to improve its decision-making ability and should combine work with theory to exert the maximum role between them. In addition, the department should take them as the basis for formulating scientific and technological innovation policies. In addition, the department should also revise the feedback from social practice, further enrich the existing theoretical knowledge, form a circular development model in practice, and continuously coordinate and improve the science and technology innovation system policies to guarantee the development of the whole circulation system. There are significant differences in the development level of each region, and the same set of policy theoretical system is not suitable for each region. Therefore, when developing the science and technology

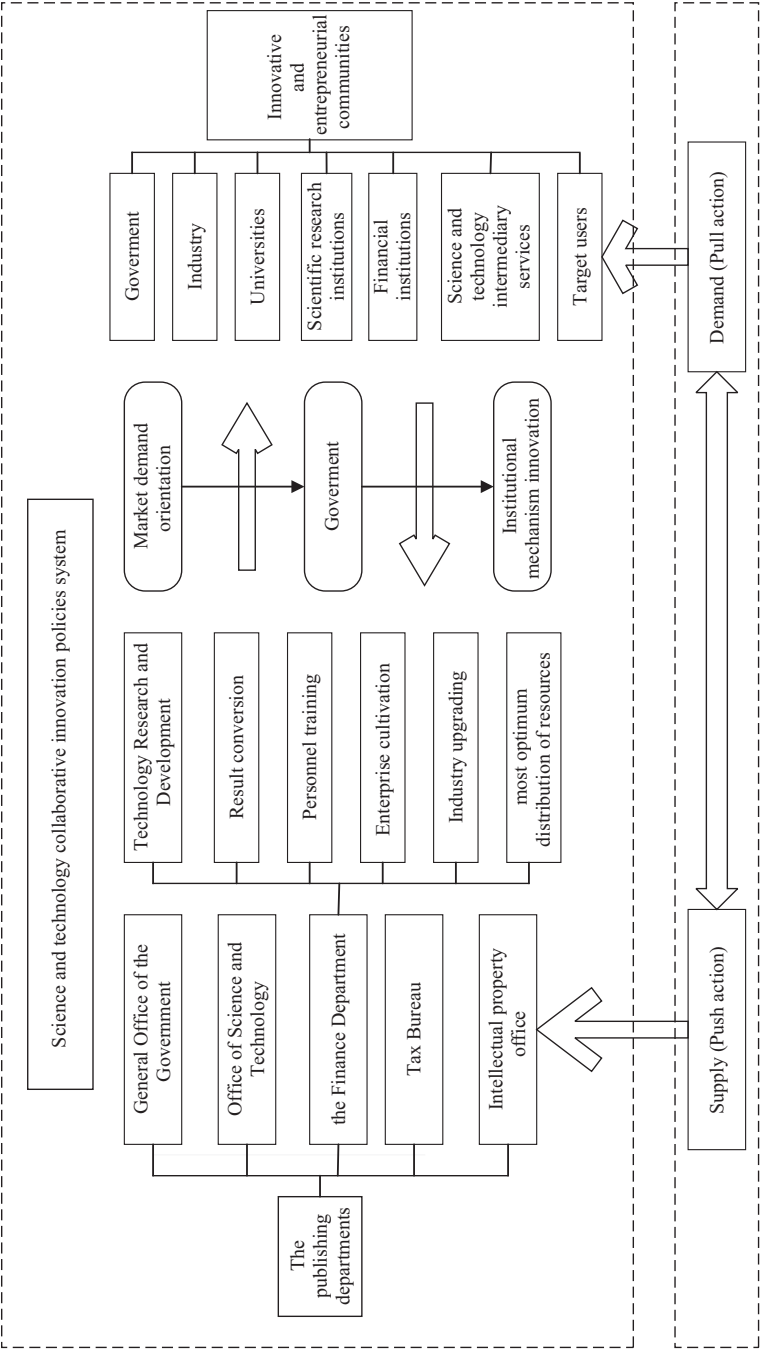


Figure 4.
The framework of
science and technology
collaborative
innovation policy

innovation policy, the department should consider comprehensively though combining the actual development situation of ourselves and the main body of “taking government-industry-university-research fund,” so that the department can formulate the relevant policy suitable for the development of our region and improve the implementation effect of the policy of science and technology innovation. The relevant policies are in accordance with the times in different periods. The publishing department should combine with the financial departments, science and technology departments, tax bureau, intellectual property office, and other multi-departments to judge the background environment, in order to complete accurate self-positioning and development planning and design. Finally, there are many types of social practice, so we should pay more attention to and invest in key projects, such as scientific and technological input, scientific and technological platform, intellectual property rights, and so on. In short, all departments should constantly improve and innovate the coordination and communication mechanism, improve the efficiency of work, strengthen the exchange and cooperation among the departments, and form a scientific and technological collaborative innovation policy system.

5. Conclusion

This paper sorted out the science and technology innovation policy in an all-round way, analyzed the quantitative change trend of the documents on the scientific and technological innovation policy in Shandong Province in recent years, and calculated the proportion of the contents of science and technology innovation policy, which are science and technology input, tax incentive, financial support, government procurement, intellectual property rights, and technology platform. The policy documents issued by the government on science and technology innovation are classified and summarized from five different aspects: the policy of science and technology system and mechanism, the policy of financial guidance, the policy of technological innovation of enterprises, the policy of talents in science and technology, and the policy of intellectual property rights. This work enriches the contents of the research. It reflects the government’s support for science and technology innovation and the key items of science and technology policy design in different periods. According to the development axis of time, this paper conducted a comparative analysis of the overall evolution trend of international science and technology innovation policy and its unique development course in China. Because the development of science and technology innovation in our country starts late, the development course change has its own characteristics. The framework of science and technology innovation policy is designed from the issuing department, the main content, and the main body of implementation to form a “government-industry-university-research fund-taking” scientific and technological collaborative innovation system. They are closely combined with each other to form a complete and systematic overall framework, and the development process of adjusting and changing the design of science and technology innovation policy is described, in different background environments. In brief, through a series of related discussions, it is instructive for the government to make scientific and technological innovation policies.

However, this paper has still some shortcomings. First, we have some limitations in the collection of the science and technology innovation policy. Second, in the design of the overall scientific and technological innovation framework, a deeper comparative analysis should be conducted on the policies in different periods. Hence, these limitations should be further studied in future research.

References

- Ball, S.J. (1993), “What is policy texts, trajectories and toolboxes”, *Discourse*, Vol. 13 No. 2, pp. 10-17.
- Chen, J. (2016), “Theoretical Frontier and development trend of innovation policy”, *People’s Forum Academic Frontier*, No. 19, pp. 92-95.

- Fagerberg, J., Mowery, D.C. and Nelson, R.R. (2004), *The Oxford Handbook of Innovation*, Oxford University Press, London.
- Fu, J. (2010), "Needs of science and technology policies of enhancing the innovation ability of counties", *Forum on Science and Technology in China*, No. 10, pp. 81-85,106.
- Gong, Q.L. and Liu, C.Y. (2015), "Evaluation of regional innovation policy system based on three-dimensional analytical framework—A case of '1+10' innovation policy system in Chengdu", *Soft Science*, Vol. 29 No. 9, pp. 14-18.
- Hu, X.J., Luo, L., Wang, X. and Ma, P. (2018), "The case study of regional science and technology innovation policy in China by taking Zijin special community in Nanjing for example", *Scientific and Technological Management Research*, Vol. 38 No. 13, pp. 59-64.
- Kang, J., Yuan, Y. and Liao, X.D. (2018), "Research on abroad theory and practice of science and technology innovation policy evaluation", *Special Zone Economic*, No. 3, pp. 49-53.
- List, F. (2016), *The Natural System of Political Economy*, Routledge, London.
- Li, M.F., Wang, M.T., Qi, H.H. and Qi, Y.Y. (2018), "Evolution of international research on science and technology policy", *Studies in Science of Science*, Vol. 36 No. 9, pp. 1565-1574.
- Lundvall, B. and Borr  ss (2005), "Science, technology and innovation policy", in Fagerberg, J., Mowery, D.C. and Nelson, R. (Eds), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford, pp. 599-631.
- Song, C.C., Zhang, Y.A., Wang, Y.N. and Qi, Y. (2018), "Analysis and simulation for response mechanism of regional science and technology innovation policy", *Science and Technology Progress and Policy*, Vol. 35 No. 21, pp. 126-133.
- Smith, A. (1950), *An Inquiry into the Nature and Causes of the Wealth of Nations*, Methuen, New York.
- Tong, L.J. (2018), "Study on fuzzy comprehensive evaluation of implementation effect of science and technology innovation policy in Hebei province", *Chinese Collective Economy*, No. 31, pp. 100-101.
- U.S. Government Accountability Office (GAO) (1989), *Content Analysis: A Methodology for Structuring and Analysis Written Material*, Houghton Mifflin Company, Boston.
- Wang, Z., Xu, Z. and Tian, D. (2017), "The study of Chinese science, technology and innovation policy's value orientation and evaluation framework", *Forum on Science and Technology in China*, No. 3, pp. 27-32.
- Wang, J.F., Chen, Z. and Zhou, L. (2018), "The model and empirical study on the match between science and technology innovation policy supply and demand", *Science and Technology Progress and Policy*, Vol. 35 No. 16, pp. 121-128.
- Xi, Z.Y., Chi, K.X. and Yang, F.C. (2014), "Construction of the theoretical framework on regional scientific and technological innovation policy design: bibliometric analysis based on files of Shandong province (2000–2012)", *Science and Technology Progress and Policy*, Vol. 31 No. 5, pp. 39-44.

Corresponding author

Qing Zhu and can be contacted at: zhuqing0109@163.com

For instructions on how to order reprints of this article, please visit our website:

www.emeraldgroupublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com