



The Effect Path of Guiding Role of Science and Technology Award: A Case Study of UHV Technology

Wen-hui Qi^{1,2}, Dan Wang³, Bao-guang Xu^{1,2}(✉), Jian-fei Lu³, Yan-yan Shao⁴, Wei Zhu³, and Xin Li³

¹ Institutes of Science and Development, Chinese Academy of Sciences, Beijing 100190, China
xbg@casisd.cn

² School of Public Policy and Management, University of Chinese Academy of Sciences, Beijing 100049, China

³ State Grid Energy Research Institute Co., Ltd, Beijing 102209, China
{wangdan, lujianfei, zhuwei, lixin}@sgeri.sgcc.com.cn

⁴ School of Emergency Management Science and Engineering, University of Chinese Academy of Sciences, Beijing 100049, China
shaoyanyan21@mails.ucas.ac.cn

Abstract. The science and technology award is an important component of China's science and technology policy, which has been playing an important guiding role in guiding the direction of innovation, optimizing resource allocation and enhancing innovation capacity. In order to research the effect path of the guiding role of science and technology award, the implementation path of the national development plan was sorted out, the affect objects and ways of science and technology award in this path was analyzed, and the theoretical model of the effect path of guiding role of science and technology award was proposed finally. Taking the field of UHV technology as an example, the theoretical model was verified. The research results showed that the guiding role of science and technology award is reflected in its positive moderating effect in the formulation of the development plan of innovation subjects and the development of innovative activities of researchers, thus promoting the implementation of the national development plan.

Keywords: Science and technology award · Guiding role · Effect path · UHV technology

1 Introduction

The science and technology award is an important component of China's science and technology policy, which is an institutional arrangement to recognize the contributions of researchers [1]. After decades of continuous exploration and improvement, China's science and technology award system has become increasingly perfect and has embarked on the road of legalization, scientization and institutionalization. It has been playing an important guiding role in guiding the direction of innovation, optimizing resource allocation and enhancing innovation capacity.

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In the related researches on the guiding role of science and technology award, Zhang [2] first proposed that when science and technology award was used to achieve the management intention of upper level, it played the role of communication. Through further analysis, Wang et al. [3] and Liu et al. [4] defined this communication role as the guiding role of science and technology award. In terms of the specific effect path for the guidance role of science and technology award, Liu [5] argued that the development of key industries can be guided by increasing the number of awards and creating additional award programs, and the development of some industries that do not meet the needs of current social development can be inhibited by reducing the number of awards and eliminating award programs. Shao and Lei [6] also found that only when science and technology award is compatible with the development of science and technology, it can play a positive guiding role and promote the progress of science and technology in the direction of social and economic development. On the contrary, there will be a negative guiding role, such as weak awareness of joint research, low efficiency of results transformation and so on. Wang et al. [7] analyzed the trends in the number of programs, regional distribution and composition of the main bodies in the field of surveying and mapping that had received the Science and Technology Progress Award since the 11th Five-Year Plan. The reform measures were put forward to guide the R&D focus of surveying and mapping geographic information technology, promote the development of regional coordinated innovation ability, and encourage important innovation subjects by means of the science and technology award system. Mao et al. [8] pointed out that the policy development of science and technology award and the demonstration effect of award winners can be used to guide researchers to carry out innovative activities and solve major technical problems in the development of important industries, thus promoting technological upgrading and industrial development. Zheng [9] suggested that science and technology award plays the guiding role through two channels, one is to guide the direction of science and technology development by controlling the allocation of science and technology production resources, and the other is to directly regulate the innovation direction of researchers.

In existing researches, scholars have explained the guiding role of science and technology award in terms of guiding the development of key industries and motivating researchers to carry out innovation activities, but the explanation of its specific effect path is not complete. This paper tries to analyze the effect mechanism of the guiding role of science and technology award, and clarifies the specific effect paths of guiding the development of key industries and promoting the innovation activities of researchers. The conclusion can provide a theoretical basis for the policy formulation and implementation of science and technology award.

2 Theoretical Model Construction

The guiding role of science and technology award guides scientific researchers to carry out innovative activities with national needs as the orientation and with the purpose of solving hot spots, difficulties and key issues concerning economic construction, social development and national security [7].

The country clarifies the key development fields, main goals and major programs in the future by formulating development plans (e.g., the 14th Five-Year Plan for National

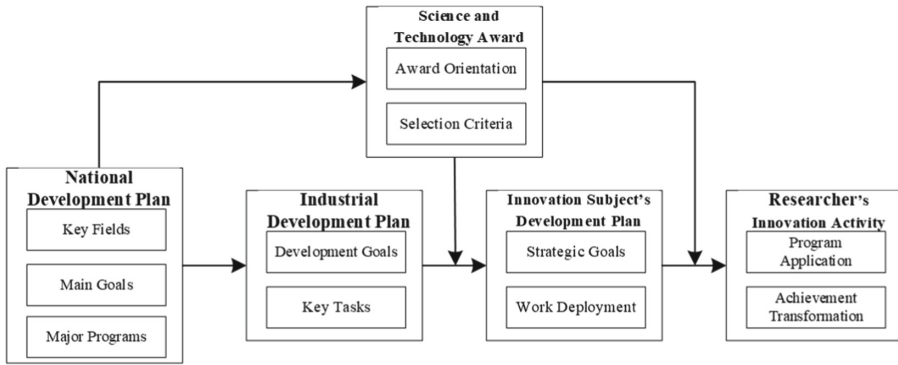


Fig. 1. The theoretical model of the effect path of guiding role of science and technology award

Economic and Social Development of the People’s Republic of China, the National Medium and Long-Term Development Plan for Science and Technology (2021–2035)). Based on this, all industries and innovation subjects will formulate their development plans based on their own development status, and clarify the development objectives and key task deployment for some time to come. Researchers will carry out corresponding innovation activities according to the development plans of country, industry and innovation subject, including applying for new research programs and reasonably selecting research programs for achievements transformation.

The guiding role of science and technology award is a moderating effect in essence. After the introduction of national development plan, the orientation and selection criteria of science and technology award will be consistent with its key fields and main objectives. In the process that innovation subjects make their own development plans according to national development plans and industrial development plans, and in the process that researchers carry out innovation activities according to the development plans of the country, industry and innovation subjects, science and technology award plays a positive moderating effect.

To sum up, the theoretical model of the effect path of guiding role of science and technology award is shown in Fig. 1.

2.1 The Implementation of National Development Plan

Based on the current intricate international environment and the basic national conditions of the primary stage of socialism in China, and in accordance with the strategic arrangement of building a modern socialist country comprehensively, central government formulates national economic and social development plans, scientific and technological innovation development plans, so as to clarify the main targets in the coming time and break them down into various development areas. According to the urgency degree of the development of various fields, the key fields and non-key fields are distinguished, and major construction programs are arranged in the key areas. Based on the position of the industry in the national development plan and its own development status, combined with the main goals of the national development plan and the layout of major engineering

construction, the industrial development plan is formulated to define the development goals and the key tasks deployment of the industry in the coming time.

As the main entities of scientific and technological innovation activities, enterprises and research institutions are the implementation units of the national development plan and the industrial development plan. Their development goals and work deployment are more granular refinement of national and industrial development plans. Researchers need to obtain research funds, improve their research levels and expand their research teams by applying for scientific and technological programs and promoting the application of scientific and technological achievements. The development plans of country, industry and innovation subjects are the beacons of program application and scientific and technological achievement transformation for researchers. Only the programs and achievements which conform to the work deployment and are conducive to achieving the development goals can be easily approved and transformed.

Therefore, the national development plan will affect the formulation of industrial development plan and innovation subject's development plan, and ultimately affect the innovation activities of researchers.

2.2 The Guiding Role of Science and Technology Award

Science and technology award should be closely integrated with the national development plan. According to the price theory [10], prices for goods are determined by the relationship between supply and demand of goods. When demand exceeds supply, the demand for goods is larger and the supply is insufficient, leading to the rise of prices. When supply exceeds demand, the demand for goods is smaller and the supply is excessive, the prices will go down. What's more, the relationship between supply and demand is determined by the stage of social and economic development. In different stages, the demand for goods is different, which leads to fluctuations in prices. Similarly, in different stages of social and economic development, the demand and supply of different industries and technologies are also different. Therefore, the industries and technology fields with large demand and insufficient supply will become key fields. Based on the analysis of the current level of national economic and technological development, the national development plan defines the key industries and technological fields in the future, leading the direction of national economic development and scientific and technological innovation.

In terms of science and technology award, The Regulation on National Science and Technology Awards clearly stipulates that the award orientation and selection criteria should be closely combined with the national major strategic needs and medium-term and long-term science and technology development plans, can guide innovation resources and talents to gather in key fields and promote the rapid development of Chinese society and economy. Several measures can be taken to guide the concentration of superior scientific and technological resources on key scientific and technological fields and new strategic industries, such as setting up new awards, increasing the number of awards for key industries and key technological fields, and emphasizing the outstanding contribution of scientific and technological innovation achievements to social and economic development. For non-key industries and backward technological fields, negative effects can be suppressed by reducing the number of awards and other ways. Through the above

means to achieve a good interaction between technological innovation and social and economic development. Therefore, the orientation of science and technology award is consistent with the national development plan.

Science and technology award can promote the formulation of innovation subject's development plan and the development of researcher's innovation activities. Reputation theory [11] holds that organization has the need to pursue good reputation, win social recognition, obtain resources, opportunities and support, and then complete value creation. According to Maslow's Hierarchy of Needs Theory [12], human needs can be divided into five levels from low to high like a ladder, namely, physiological needs, safety needs, social needs, respect needs and self-actualization needs. Only when the lower-level needs are satisfied, will the higher-level needs be pursued. As high-level talents, on the basis of meeting their physiological needs, safety needs, social needs and respect needs, researchers have a strong need to pursue self-realization. The science and technology awards are consistent with the national and industrial development plan. And as an institutional arrangement for the recognition of the innovation achievements of researchers, science and technology awards can meet the pursuit of organizational reputation of innovation subjects and the self-realization needs of researchers. Therefore, whether in order to implement the national and industrial development plan or pursue the organizational reputation, the innovation subject will actively formulate the development plan, clarify the strategic target and work deployment in the future period, and make them consistent with the national and industrial development goals, as well as the orientation of science and technology award. No matter in order to obtain research funds, improve research level, or apply for scientific and technological awards and pursue value realization, researchers will actively adjust their direction of innovation and carry out innovation activities. They will apply for research programs in the key fields designated by the national development plan, in accordance with the scientific and technological innovation tasks laid out in the industrial development plan and the innovation subject's development plan. Additionally, they select programs for achievements transformation reasonably, strive to obtain significant social and economic benefits to meet the criteria of science and technology award.

To sum up, the orientation of science and technology award is consistent with the development goals of the national development plan. Scientific and technological innovation in key fields is more in line with the development needs of the social economy at the present stage, easier to achieve significant economic or social benefits, and meet the selection criteria of science and technology award. Therefore, the guiding role of science and technology award is reflected in that it can promote the formulation of the development plan of innovation subjects, promote the adjustment of innovation direction of researchers, so as to make the advantageous science and technology resources and talents gather in key technological fields and industries.

3 Case Analysis

The power industry is the basic industry supporting economic and social development, which is an important part of the energy industry. It is not only related to the lifeline of the economy and social stability, but also an important foundation for building a

harmonious society. Power grid is an important field in the power industry, including six major technical fields of power system operation and control, power grid protection and control, new energy grid connection and consumption, power distribution, electrical equipment manufacturing, and power grid disaster prevention and mitigation. In the field of electrical equipment manufacturing technology, since the construction of the 500 kV Pingwu UHV (ultra-high voltage) transmission project in 1979, the outgoing line devices had been relying on imports, which seriously restricted the interconnection development of Chinese energy and the upgrading of the equipment industry. It was urgent to conquer the key technologies of UHV and EHV (extra-high voltage) outgoing line devices to achieve full autonomy of transformers. Since the 12th Five Year Plan, Chinese UHV AC (alternating current) transmission project has achieved the development of 1000 kV, 1000 MW · A single power transformer, which is the first in the world. The rated capacity of a single high-voltage shunt reactor is 320000 kW, which is the largest equipment among similar products in the world. The insulation level, loss value, noise level and other technical performance indicators of the UHV transformer successfully developed in China have surpassed the products of Japan. The insulation structure design without partial discharge has been realized, reaching the international leading level in general. China has gradually built the world's largest UHV DC (direct current) transmission system, built several world first flexible DC transmission demonstration projects, and took the lead in mastering the control and protection technology for ± 800 kV and ± 100 kV UHV DC transmission, and the control and protection technology for ± 500 kV and ± 800 kV flexible DC transmission. From "following" to "parallel", China has finally become "leading". Therefore, this paper takes the UHV technology as an example to analyze the effect path of guiding role of science and technology award.

3.1 The Implementation of National Development Plan

The national 12th Five-Year Plan, 13th Five-Year Plan and 14th Five-Year Plan clearly defined the main goals of economic development, innovation driven, people's well-being, green ecology, security and other aspects, and put forward the development direction of various industries and fields. In the field of UHV technology, the 12th Five-Year Plan proposed to further expand the scale of power transmission from west to east, develop high-capacity, high-efficiency and long-distance advanced transmission technologies, and enhance the power grids' ability to optimize power distribution and supply reliability. The 13th Five-Year Plan proposed to optimize the construction of the main grid frame and trans-regional transmission channels, focus on the construction of power transmission channels in the southwest, northwest, north and northeast. The 14th Five-Year Plan proposed to increase the utilization rate of UHV transmission channels and improve the power transmission and distribution capacity to remote areas.

The development plan of power industry is the extension and refinement of the national development plan in the power industry. According to the requirements of economic development and economic structure adjustment for the power industry development, the power development plan in the period of 12th Five-Year Plan proposed to ensure the power transmission and consumption of large energy bases, improve the safety and stability of the receiving-end grid, vigorously promote the application of advanced transmission technologies such as UHVDC, accelerate the construction

of large power transmission channels, and build a strong grid frame. The goals were to build Jinping-Jiangsu, Xiluodu-Zhejiang, Hami-Henan, Ningdong-Zhejiang AC/DC transmission projects, and to deliver power from large energy bases in the west and north to load centers in North China, East China and Central China. The Qinghai Tibet DC interconnection project was also required to complete to realize the interconnection between the Tibet power grid and the Northwest power grid and meet the power supply requirements of Tibet. The power development plan in the period of 13th Five-Year Plan proposed to plan outbound transmission channels, enhance resource allocation capacity, distribute outbound transmission in energy-rich areas rationally, build “west-east power transmission” transmission channels with UHV transmission and conventional transmission technology, and increase the scale by 130 million kw to about 270 million kW. The power development plan in the period of 14th Five-Year Plan proposed to promote the construction of UHVDC project for high-proportion new energy bases of “urban power transmission to the South”, build a strong and intelligent first-class modern distribution network initially, improve the power supply security capacity and information level significantly, and serve the construction of energy Internet efficiently.

In order to implement the national and industrial development plans and promote rapid and sound development in the power grid field, State Grid Corporation of China has formulated its own development plan. The development plan of State Grid Corporation of China in the period of 12th Five-Year Plan proposed to take the development of UHV as the top priority, build a “three vertical and three horizontal” UHV backbone grid connecting large energy bases and major load centers, build 13 DC transmission projects, and form a large-scale energy configuration pattern of “power transmission from west to east” and “power transmission from north to south”. The development plan of State Grid Corporation of China in the period of 13th Five-Year Plan proposed to continue to unswervingly promote the innovative development of UHV, so that it can play a greater role in maintaining growth, benefiting the people’s livelihood, adjusting the structure, and controlling smog. The projects of “five communications and eight direct communications”, “four communications and two direct communications”, and “three communications and continuous communications” also should be completed successively one after another. The development plan of State Grid Corporation of China in the period of 14th Five-Year Plan proposed the construction of key UHV projects such as Baihetan-Jiangsu and Jingmen-Wuhan, which would significantly improve the peak shaving and valley filling, frequency modulation and phase modulation capabilities of the power grids in Zhejiang and Jiangxi provinces, as well as East China and Central China, and play an important role in ensuring the security and stability of the power grid, enhancing the flexibility of system operation, and improving the renewable energy consumption capacity.

3.2 The Guiding Role of Science and Technology Award

According to the national 12th Five-Year Plan, 13th Five-Year Plan and 14th Five-Year Plan, as well as the power development plan during the above period, the research and engineering construction of UHV technology has gradually become the key field of social and economic development at the current stage.

In terms of science and technology award, the orientation of science and technology award is consistent with the national development plan. The UHV technology has been taken as the key field in the selection process, and the number of awards in this field has been increased. During the period of 12th Five-Year Plan, only one program in the UHV field won the national science and technology award. But this number increased to 4 during the period of 13th Five-Year Plan. In addition, the selection criteria of science and technology award emphasize that innovation achievements should not only have progressiveness technology, solve industry problems, but also obtain significant social or economic benefits. These are consistent with the development goals and major program deployment in key areas of the national development plan. For instance, the National Technological Invention Award requires that the achievements should be the first at home and abroad. It is also required that the technical ideas, principles or methods of the achievements should be innovative, have substantive characteristics and significant progress in technology, and be superior to similar technologies in terms of main performance, technical and economic indicators, scientific and technological level and its role and significance in promoting scientific and technological progress. In addition, it is required that the achievements should be implemented and applied for more than three years to achieve good application results. The National Science and Technology Progress Award requires that the achievements have important innovation in technology, especially independent innovation in the field of high and new technology, which has solved the hot spots, difficulties and key problems in the development of the industry. The overall technical level and technical and economic indicators have reached the leading level of the industry, forming the leading technology and brand products of the industry. The program is required to have a high degree of application, a strong demonstration, driving and diffusion capacity, which promotes the adjustment, optimization, upgrading of the industrial structure and the upgrading of products, and plays a great role in the development of the industry. In addition, after more than three years of large-scale implementation and application, the program is required to produce great economic or social benefits, realize the market value or social value of technological innovation, and make great contributions to economic construction, social development and national security.

The special requirements of the award orientation and selection criteria of science and technology award have promoted the State Grid Corporation of China to continuously strengthen the capital investment in the program layout of UHV technology research and the construction of UHV project, and promoted researchers to increase the program application and achievement transformation in the field of UHV technology. Since the period of 11th Five-Year Plan, the number of projects and research funds approved by State Grid Corporation of China in the field of UHV technology have increased year by year, and the number of engineering construction projects and project funds in the field of UHV technology have also increased. At the current stage of social and economic development, the UHV field belongs to the key technology field. Its research achievements are easier to be transformed, spread and applied on a large scale, and easier to meet the selection criteria of national science and technology awards. In 2012, the program of “Key Technology, Complete Equipment and Engineering Application of UHV AC Transmission” won the special prize of National Science and Technology Progress Award, marking a major breakthrough in the world’s high-voltage transmission technology and

establishing China's international leading position in the field of high-voltage transmission. Later, research programs in UHV fields have sprung up like mushrooms, and some with outstanding achievements have won national science and technology awards. For instance, the program "Key Technology and Application of $\pm 800\text{kV}$ UHVDC Converter Valve" won the second prize of National Technological Invention Award in 2016. The program of "UHV $\pm 800\text{kV}$ DC Transmission Project" won the special prize of National Science and Technology Progress Award in 2017. The program of "Key Technology and Engineering Application of EHV/UHV Transformer/Reactor Outgoing Device" won the second prize of National Science and Technology Progress Award in 2018. Latest, the program of "Development and Application of Ultra-low Loss Oriented Silicon Steel for UHV and High Energy Efficiency Power Transmission and Transformation Equipment" won the second prize of National Science and Technology Progress Award in 2020.

4 Conclusion

The national development plan can affect the formulation of the industrial development plan and the innovation subject's development plan, and ultimately affect the innovation activities of researchers. In this process, the orientation of science and technology award has always been consistent with the national development plan. The guiding role of science and technology award is reflected in the fact that it can promote the formulation of the development plan of the innovation subject and promote the adjustment of the innovation direction of researchers. On the one hand, the task layout of the innovation subject in key areas not only conforms to the requirements of the national and industrial development plans, but also meets the innovation subject's pursuit of organizational reputation. On the other hand, research activities carried out by researchers in key areas are not only the performance of implementing the development plan of the country, industry and innovation subject, but also easy to achieve significant economic or social benefits, meet the selection criteria of science and technology award, increase the probability of obtaining award, and promote self-realization.

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