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The Influence of International Experience of Green Technology Innovation Policy on Regional Residents' Income Difference

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Abstract: *Since the reform and opening up, China has witnessed rapid economic development, and now it has become the largest economy in the world. But with the development of economy, extensive development mode and rapid growth of population, the contradiction between economic development and natural environment has become more and more prominent. With the continuous deterioration of the environment, people around the world pay more and more attention to the environment, and there are more and more voices calling for national green and sustainable development. In this context, green technology innovation policy was born and developed rapidly, changing the mode of economic growth, reducing energy consumption and pollutant emissions, which has important strategic significance for the sustainable development of economy. However, at present, the system of green technology innovation policy in China is not perfect enough. We need to learn from the experience of international green technology innovation and design a green technology innovation system in line with China's national conditions. This paper uses the international experience of green technology innovation for reference, designs regional green technology innovation policies in line with China's national conditions, and analyzes the impact of green technology innovation policies on regional residents' income differences.*

Keywords: *Sustainable Development, Green Technology Innovation, International Experience.*

1. Introduction

After the reform and opening up, China's economy began to develop rapidly from 1979 to 2011, but the growth rate began to slow down since 2012. Since the reform and opening up, China has created huge social wealth at an unprecedented speed, and formed a traditional economic development mode of "resources, products and pollution emissions" that simply pursues economic growth [1-3]. In a certain period of history, this development model has played a great role in promoting the development of China's economy within the scope of environmental carrying capacity. But with the development of the population and the material consumption demand and the science and technology, which emphasizes the demand for natural resources, human activities have changed greatly in degree, scale and quantity. The defects of the traditional economic development model are exposed. It can be seen that the rapid growth of China's economy has brought about resource shortage, environmental pollution, ecological damage and other problems, resulting in the lack of economic development potential and even more difficult [4-6]. How to ensure the sustainable development of economy is an urgent problem. The report of the 18th National Congress of the Communist Party of China proposes to vigorously promote The goal of ecological civilization construction adhere to the basic national policy of saving resources and protecting the environment, strive to promote green development, circular development and low-carbon development and form the spatial pattern, industrial structure, production mode and life style of saving resources and protecting the environment. To achieve this goal, we must rely on green technology innovation [7-9], promote the optimization and upgrading of economic structure, reduce the consumption of resources and energy, reduce the damage of ecological environment, improve the quality and efficiency of economic development, and take the road of green development.

"Green technology" is relative to the "black technology" which seriously damages the ecological environment [10, 11]. Green technology is a new term that appeared in the West in 1970s. People have different understanding of green technology. E. brawn and D. wield first put forward the concept of

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green technology in 1994, which refers to the general term of "pollution-free" technology, technology and products that follow the laws and principles of ecological economy, save resources and energy, eliminate, reduce or avoid environmental pollution and damage, and minimize the negative ecological effect [12-14]. The scope of green technology is relatively wide. The existing researchers' various understandings of green technology contain some correct understandings and reflect some aspects of green tech. In a word, the so-called green technology refers to the general term of various modern technologies, processes and products that can reduce the marginal internal and external costs of production of an enterprise and minimize the sum of internal and external costs for the ultimate purpose of maximizing the economic and environmental "win-win" while giving full play to its functions. According to the above definition, green technology is mainly divided into the following three aspects: green products [15, 16], green process [17-19], end treatment technology [20]. First, green process (or process technology) refers to the process flow of improving the utilization rate of resources, reducing the emission of waste gas and reducing the harm to the environment and human body in the process of product design and manufacturing. It mainly includes green design [21] and green packaging [22]; second, green products (or source technology) refer to pollution-free, energy-saving and human friendly products. It mainly includes green food, green lighting, green materials, green buildings, etc.; third, the end treatment technology or disposal technology refers to the technology for the treatment of environmental pollution caused by production and consumption. Among them, green process can reduce the negative effects of environmental pollution, and energy-saving end treatment technology can bring competitive advantages to the country, and both of them can reduce the green cost, and green cost can increase the value of green products while reducing environmental pollution, so as to obtain higher profits than similar products and bring greater benefits to the country. Only those countries that carry out green technology innovation have market advantages.

As a developing country, the biggest restriction of China's economic transformation from the traditional development mode to the green technology innovation development mode is that the overall level of science and technology is backward and the ability of technology research and development is limited. The success of technological innovation depends largely on the strength of R & D capability. China's green technology R & D ability is always at a low level due to many factors. Among them, green technology innovation talent resources are scarce, including entrepreneurs with long-term vision and good quality, core technical R & D personnel and excellent technical operators. Green technology innovation needs people-oriented talents with innovation ability and awareness, so that theory can be transformed into practical productivity results through innovation. Therefore, the key to green technology innovation is to make full use of human resources. In addition, the green technology innovation lacks the corresponding management and incentive mechanism, and the lack of motivation makes it difficult to achieve a major breakthrough in technology innovation. On the one hand, the enterprise may only see the short-term profit goal without paying attention to the long-term, which makes it difficult to give up the current interests to invest in the long-term development. The current economic development model and technology form a low efficiency balance. If we want to develop green economy, we should first break the original industrial interest chain, invest sufficient funds in research and development, purchase supporting facilities, change the original marketing concept and profit model. This series of changes will inevitably produce huge additional costs. For enterprises with short-term profit goals, it is difficult to realize the huge cost of investment in technological innovation. What kind of technological innovation strategy should Chinese enterprises adopt? They should make appropriate choices according to their environment and their own green technological innovation ability. But in fact, many enterprises often lack of understanding of the economic environment and their own strength, which leads to the failure of enterprises to choose the right innovation strategy. For example, some powerful enterprises simply carry out terminal treatment, but this treatment cannot fundamentally solve the problem of environmental pollution, so in the long run, its green technology cost is high and efficiency is low. On the contrary, some weak enterprises invest a lot of manpower and capital in the high-level green technology innovation. Although they pay a high cost, they do not achieve the expected effect, but make the enterprises in trouble. In view of a series of problems existing in China's economic transformation, it is necessary to draw on the experience of international green technology innovation, put forward green technology innovation policies in line with China's national conditions, and promote China's economic transformation and rapid development.

Based on the above background, China's economic achievements since the reform and opening up have attracted the world's attention and become the world's largest economy. But at the same time of economic development, the environmental problems are more and more prominent. The continuous deterioration of the environment and the large consumption of resources have become the biggest

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constraints of China's economic development. With the continuous consumption of resources in China, people pay more and more attention to the environment. The voice of calling for the national green and sustainable development is more and more high. The country also gradually attaches importance to sustainable development, and begins to adjust China's economic development mode. In the process of economic transformation, the implementation of the key green technology innovation policy in China is not perfect, the system is not perfect, and has not achieved much effect. Green technology is an important technology for national transformation and sustainable economic development. At present, there are many application cases in the world, which have achieved good results. Therefore, it is necessary to solve the experience of international green technology innovation, design regional green technology innovation policies in line with China's national conditions, analyze the impact of green technology innovation policies on regional residents' income differences, and promote the transformation and rapid development of China's economy.

2. Green Technology Innovation and its International Experience

2.1. The Concept of Green Technology Innovation

At present, with the development of science and technology in our country, the disadvantages of traditional technology innovation have gradually emerged. On the way to seek new economic model, the emergence of green technology has gradually been accepted by people, becoming a new model to replace the traditional technology model, and green technology innovation has also become one of the focuses of academic circles. Green technology is a technical system that can reduce pollution, reduce consumption and improve ecology. Green technology is the general term of "pollution-free" or "less pollution-free" technologies, processes and products that follow the ecological principles and ecological economic laws, save resources and energy, avoid, eliminate or reduce the pollution and damage of ecological environment, and have the least negative ecological effects. Green technology has changed the single economic model of traditional technology. It takes the development of economy and environmental protection as its purpose, and overcomes the traditional technology's emphasis on economic development and neglect of the protection of ecological environment. It is in line with the road of sustainable development in China.

Green technology innovation promotes the coordinated development of economy and environment. It takes sustainable development as the value, green technology innovation promotes the coordinated development of economy and environment, takes sustainable development as the value measurement standard, and takes technology and management innovation as the motivation and incentive mechanism. The concept of green technology innovation is elaborated from different perspectives in the academic circles. Generally speaking, management innovation and technology innovation for environmental purposes are collectively called green technology innovation. It generally includes pollution control and prevention technology, investment saving and raw material substitution, waste recycling system, clean product technology, etc From the connotation point of view, green technology innovation is a kind of external non-economic technology innovation which can reduce people's production and consumption in the process and is transmitted by the ecological environment. At present, green technology innovation is recognized as the general term of green process innovation [23], green product innovation and green consciousness innovation, including sustainable development.

Based on the above concepts of green technology innovation, this paper holds that green technology innovation is a technology innovation system that integrates the development of economy and the protection of environment on the basis of green technology, which not only protects the ecological environment from damage, but also obtains economic benefits, aiming at sustainable development.

2.2. Characteristics of Green Technology Innovation

Before the industrial revolution, due to the impact of traditional technological innovation, people only pursue economic benefits, but ignore the protection of ecological environment, resulting in the imbalance between social development and ecological environment. Green technology is a technology opposite to the traditional technology of environmental pollution and ecological balance destruction. It requires the introduction of ecological ideas in the process of technological innovation, considering the impact and role of technology on the environment and ecology, not only to ensure the innovation and practicability of technology, but also to ensure environmental cleanliness and ecological balance. It takes the sustainable development as the goal, the ecological protection as the center, and introduces

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the ecological concept into the enterprise production system, so as to solve the problem of the balance between economic development and ecological environment to the maximum extent. Green technology innovation can be generally divided into two categories: one is green product innovation, that is to develop various energy-saving and raw material saving products, which do not harm or less harm to human health and ecological environment in the use process and after use, and are easy to recycle, reuse and regeneration. The other is green process innovation, including two aspects of clean process technology and end treatment technology, which mainly refers to the process technology that can reduce the generation and emission of waste gas pollutants, reduce the environmental pollution caused by industrial activities, and reduce the cost and material consumption. Compared with ordinary technological innovation, green technological innovation carries higher ecological and economic value pursuit.

Green technology innovation aims to improve the ecological environment, improve the quality of human life and other social benefits, and obtain potential economic benefits. It is not only an economic activity to commercialize green technology and products, but also a social activity to make green technology achievements public welfare. Therefore, the characteristics of green technology innovation are mainly manifested in the following aspects: first of all, green technology innovation has changed the traditional technology innovation, which only focuses on the pursuit of industrial output value and commercial profits, but ignores the healthy development of human life. Green technology innovation aims at sustainable development, integrates ecosystem with science and technology, promotes the harmonious development of nature and ecology, and unifies the three benefits of society, nature and ecology. It is consistent with the goal of sustainable development that industrial production can be better developed and environmental protection will not be affected. Secondly, green technology innovation has the characteristics of saving resources, protecting environment and recycling resources. Green technology innovation plays an important role in the development of circular economy [24, 25]. Circular economy is a social production and reproduction paradigm with the core of efficient utilization and recycling, the principle of "reduction, reuse and recycling", and the basic characteristics of low consumption, low emission and high efficiency. It is to reduce environmental pollution and consumption of resources as much as possible, so as to protect human beings from the threat of environmental pollution to life and health. Green technology innovation is the integration of ecosystem and science and technology, which makes human beings less affected by environmental pollution and saves resources.

2.3. International Experience of Green Technology Innovation

From the international experience of the green financial system, the UK GIB, established in October 2012, is the first investment bank dedicated to financing green and low-carbon projects in the world. Its function is to solve the problem of lack of market in infrastructure financing, encourage more social capital to invest in the field of green environmental protection projects with market failure, as the "catalyst" and supplement of green investment market, accelerate the transformation to green economy by mobilizing private capital. Since the establishment of the UK Green Investment Bank, it has developed rapidly. Through £1.8 billion direct investment, it has attracted a total of £6 billion of private funds to invest in the green economy. Different from general investment banks, green investment risk is one of the most important risks of GIB. It mainly measures whether the green environmental indicators of its investment conform to the sustainable green development principle, which also deserves our attention.

In order to achieve environmental sustainable development, the European Commission launched the global energy efficiency and renewable energy fund in 2008. GEEREF has a master fund structure, which provides equity investment to small and medium-sized project developers and enterprises. The fund adopts the form of PPP organizational structure, funded by the public sector, to promote the private sector to invest in sub funds and projects, including renewable energy and energy efficiency projects and green infrastructure projects in emerging markets, so as to effectively play the investment leverage effect of the master fund.

As the national green guide fund of South Africa, the South Africa green fund is now managed by the South African Development Bank. It aims to help South Africa transition to a low-carbon, efficient resource utilization and climate change adaptation development path by supporting green initiatives. South Africa's green fund mainly provides funds for three financing windows: Green Town, low-carbon economy, environment and natural resource management. These three windows can reflect the national policy priorities of South Africa, promote ecosystem-based climate change adaptation interventions for rural development, help private enterprises reduce environmental pollution and

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resource consumption, and eliminate the impact of economic growth on natural resources, so as to achieve a low-carbon growth trajectory in line with the national climate change policy.

As a reliable option to meet the urgent investment needs of development finance and climate financing, governments have also established strategic investment funds to support domestic capital markets. Especially in emerging markets and developing economies, the strategic investment fund, as a private investor, is an investor in domestic projects such as the Asian infrastructure fund (2010) and the African Renewable Energy Fund (2014), as well as the SME fund. For example, strategic investment funds in Israel and Brazil can hold minority equity to invest in hybrid private equity and venture capital funds as limited partners to effectively solve the financing problem of innovative small and medium-sized enterprises.

From the perspective of fiscal and tax policies, different countries give preferential policies to enterprises applying for green development fund, for example, New York energy research and development agency arranges subsidies for enterprises applying for clean energy fund according to energy utilization performance; Thailand contract energy management fund provides low-cost equipment leasing and commercial bank loan guarantee for qualified small and medium-sized enterprises; In the green fund plan promoted by the Dutch government, only 1.2% of the capital income tax and 1.3% of the income tax are paid to green fund investors; the Korean government gives preferential policies such as tax exemption for dividend income to industrial investment funds that invest more than 60% of the green industry.

From the perspective of international experience, green bonds play an important role, such as the "Europe 2020 project bond" plan, which aims to finance the construction of energy, transportation, information and communication networks. The bonds in charge of the project are issued by the company in charge of the project, and are guaranteed by the European Union and the European investment bank to improve the credit level, so as to attract more institutional investors. In addition, in terms of financial product innovation and services, green banks can provide financial products such as credit enhancement, loan loss provision, loan guarantee and loan bundling. For long-term projects, direct investment or portfolio investment through high-level, mezzanine and secondary bonds is mainly adopted, and each transaction can meet the credit standard and investment standard required by green bank.

At present, some developed countries and developing countries have carried out green technology innovation economic model and practical work. The United States, Japan, Britain and other EU countries have made great achievements in the development of green technology innovation. This has a lot of experience for the development of green technology innovation in China.

3. Research on Regional Green Technology Innovation Policy

As a macro concept, the green technology innovation policy mainly emphasizes the role of institutional factors, market factors, R & D capabilities and R & D management capabilities and concepts of decision-making departments, involving enterprises and R & D management departments, environmental protection bureaus, educational institutions, R & D institutions and other subjects. All kinds of forces coordinate with each other to play a role in the development of green technology innovation, and subdivide or specify various factors. Among them, institutional factors include domestic environmental protection system and international environmental protection system concept factors, involving the concept of entrepreneurs, consumers, R & D personnel and other subjects, as well as the cultivation of green concept in education and training, including the R & D capabilities of enterprises themselves, other relevant institutions and their information links. R & D management mainly refers to the project approval, new product promotion, science and Technology Award and other relevant innovation management systems of the scientific research management department.

In order to better analyze the impact of innovation incentives and external support factors, it is necessary to study the main structure of regional green technology innovation policies, as shown in Figure 1.

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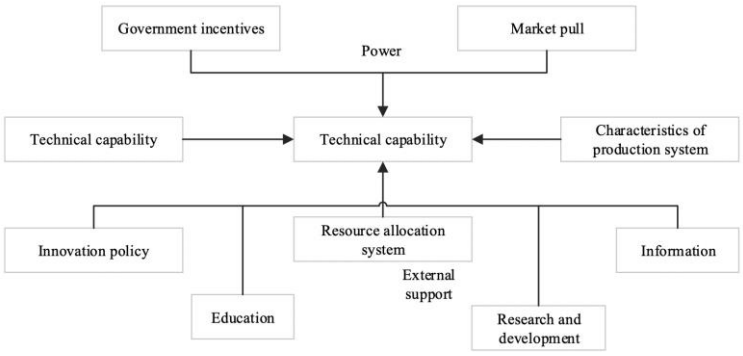

Figure. 1 Policy structure of green innovation technology.

The constituent elements of green technology innovation policy can be divided into dynamic factors and external supporting factors. There are four main factors that affect the innovation and diffusion of green technology. In addition to enterprise capability, enterprise capability is an internal factor, and other factors are power or external support. Even technological capability can be developed under the influence of green technological innovation policy. Therefore, how to coordinate the above factors, so as to eliminate the obstacles of green technology innovation and diffusion, and provide appropriate power and support are the key issues at present. The investigation and analysis found that the innovation and diffusion of green technology need to emphasize the role of the government to coordinate and promote green technology innovation policies, and provide technical, information, funding and policy support. The importance of supporting green technology innovation policy in the development of science and technology is being affirmed constantly, and the performance of green technology innovation policy in China depends on the coordination of education, finance, research and development, and government subsystem.

3.1 Educational System

According to the above, people's environmental awareness is an important factor in the innovation and diffusion of green technology. At the same time, the pressure of public opinion cannot be ignored. Both of them are inseparable from environmental protection education. But the environmental protection education in China is not optimistic. Even in Colleges and universities, there are few environmental protection courses, let alone primary and secondary schools.

3.2 Research and Development System

Most of the small and medium-sized enterprises in our country are lack of the technological capacity needed for green technology innovation and diffusion. At the same time, some green technologies need a lot of investment, which makes enterprises lack of innovation power. Therefore, the innovation and diffusion of green technology cannot be separated from the support and participation of the government and the cooperation between universities and scientific research institutes.

3.3 Financial System

The innovation and diffusion of green technology need the support of financial system. Lack of funds is a common problem facing developing countries. Because of the high risk and low return rate of green technology, it is very difficult to raise funds for green technology innovation and diffusion. In the period of economic transition, how to establish an effective allocation mechanism of funds and resources and promote the coordinated development of economy and environment has become an important issue that developing countries must solve.

3.4 Government Policies and Regulations

The government not only needs to formulate a series of environmental protection laws and regulations, but also needs to introduce policies conducive to green technology innovation and diffusion. As the government's policies not only directly affect the development of science and technology, but also affect other subsystems of the national innovation system, it is necessary for the

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government to formulate corresponding policies and regulations, so that the education, finance, research and development system will develop in the direction of green technology innovation and diffusion.

4. Results Analysis

In the analysis of the impact of green technology innovation policy on regional residents' income, four regions are adopted: eastern region, central region, western region and northeast region. The eastern region includes ten provinces and cities, including Beijing, Tianjin, Shanghai, Hebei, Jiangsu, Fujian, Zhejiang, Shandong, Guangdong and Hainan. The central region includes Henan, Shanxi, Anhui, Jiangxi, Hubei and Hunan. The western region includes 11 provinces and cities including Chongqing, Sichuan, Inner Mongolia, Guangxi, Guizhou, Shaanxi, Gansu, Yunnan, Qinghai, Ningxia and Xinjiang. Northeast China includes Jilin, Liaoning and Heilongjiang.

First of all, the high-tech industry is the main place to implement the green technology innovation policy, and the output of environmental pollutants is the unexpected output of the high-tech industry in the green technology innovation policy. But as long as the high-tech industry is running, the output of waste gas, waste water and solid waste will exist, and the waste discharge of high-tech industry is a relatively heavy part of the waste discharge of human society. Figure 2 shows the changes of three kinds of waste emissions in high-tech industry. It can be seen from Figure 2 that the emissions of three kinds of wastes are increasing from 2010 to 2016, of which the growth rate of waste water is the largest, while the growth rate of solid waste is relatively flat; with the proposal of green technology innovation policy, the introduction of green technology in high-tech industry led to the slow decline of three kinds of wastes after 2016. Although the emissions of the three wastes are decreasing after 2016, the annual emissions are still relatively large. It is necessary to learn from the international experience of green technology innovation policy to improve China's green technology innovation policy.

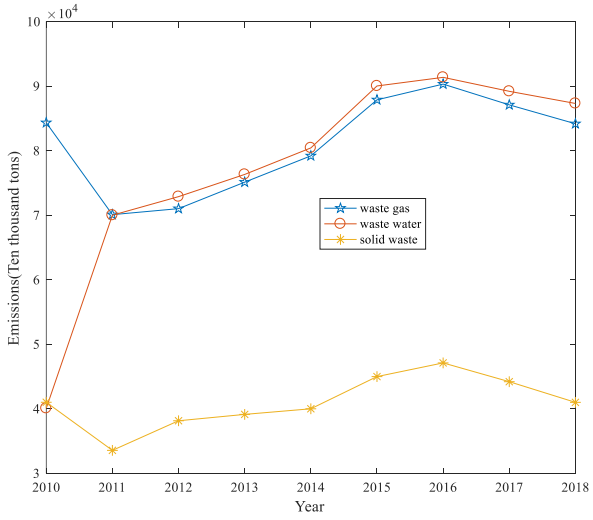

Figure. 2 Waste discharge of high-tech industry.

Further, this paper analyzes the environmental pollution index of four regions from 2010 to 2018, and the analysis results are shown in Figure 3. It can be seen from Figure 3 that: (1) The environmental pollution index of the eastern region in 2010 is the highest among the four regions, because most of the cities in the eastern region are developed provinces and cities. In 2010, they have made great use of environmental resources to achieve economic development, but also caused serious environmental pollution. (2) In 2010-2015, the environmental pollution index of the eastern region is on the rise. However, after 2015, the environmental pollution index began to decline. This is because the eastern region has developed to a certain extent, and the environmental pressure is too great, which seriously restricts the economic development. Therefore, the green technology innovation policy has been adopted for the economic system reform, and the environmental pollution has been reduced to a certain extent. (3) From 2010 to 2016, the environmental pollution index of the central region, the western region and the northeast region all showed an overall upward trend, because the three regions all vigorously developed their economy with the help of China's good economic development trend. This

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kind of development is based on the rapid consumption of environmental resources, so the environmental pollution index of the three regions rose sharply in this period. After 2016, the environmental pollution index of the three regions declined, because the green technology innovation policy has become the main trend of the development of the country, and the three regions began to use the green technology innovation policy for economic transformation. To sum up, we can see that after 2016, all four regions began to adapt to the policy and transform with the help of green technology innovation policy, which is also the inevitable trend of future development.

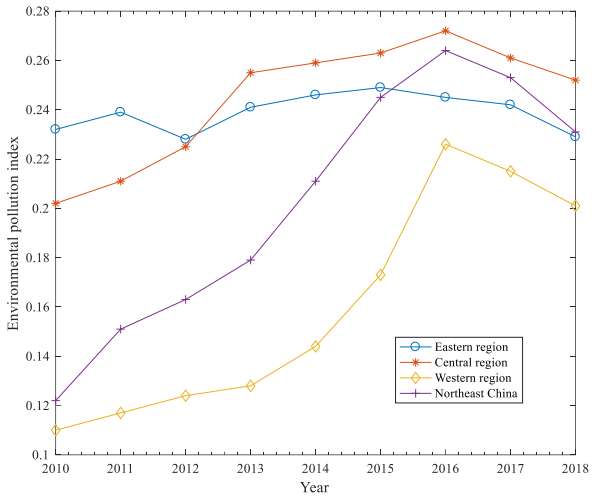

Figure. 3 Four regional environmental pollution indexes.

In addition, the overall analysis of China's green technology innovation efficiency from 2010 to 2018 is shown in Figure 4:

Green technology innovation efficiency=pure technical efficiency×Scale efficiency

Although the eastern region has a better economy, the other three regions still need to use environmental resources for economic development, so the growth of green technology innovation efficiency in this period is slow. With the rapid development of the economy, after 2015, the country began to attach importance to the policy of sustainable economic development, and the policy began to shift to the green technology innovation policy, so at this time, most of China began to transform its economy, which led to the rapid growth of the efficiency of green technology innovation after 2015. At present, by 2018, the efficiency of green technology innovation in China has just exceeded 0.7, which is far from the goal of green sustainable development. Therefore, the country still needs to vigorously promote the development and implementation of green technology innovation, and relying on the existing international successful experience is an important way to improve the efficiency of green technology innovation.

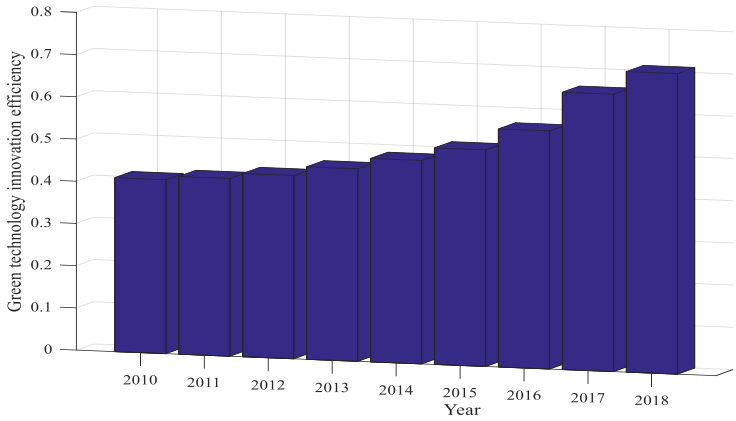

Figure. 4 Overall analysis chart of green technology innovation efficiency in China.

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In the implementation of green technology innovation policy, the impact on the economy is related to the strength of its investment. If the implementation of green technology innovation policy can well promote the income of regional residents, then the implementation of green technology innovation policy can be strengthened. Figure 5 shows the impact of green technology innovation policy on Residents' income, taking the central region as an example. It can be seen from the figure that before 2016, the economy of the central region was on the rise on the basis of sacrificing the environment. After the implementation of the green technology innovation policy in 2016 increased, between 2016 and 2017, because the green technology innovation needs capital investment, the per capita GDP of residents decreased because of the excessive capital investment, but with the green technology innovation policy starting to work, the economy recovered, and the per capita GDP continued to grow from 2017 to 2018. In conclusion, with the implementation of green technology innovation policy, residents' income will decline at the beginning, but with the benefit of green technology innovation policy, its impact on Residents' income will change from negative to positive.

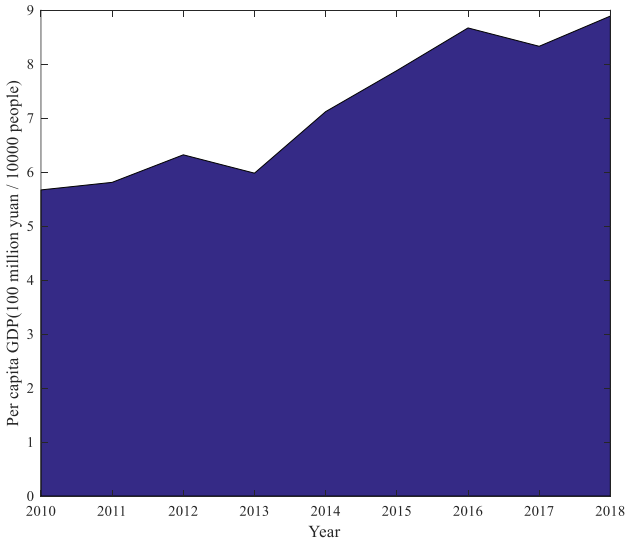

Figure. 5 Changes of residents' income in Central China with green technology innovation policy.

5. Conclusions

With the rapid development of China's economy, China's environmental problems have become more and more serious. It is urgent to change the existing economic model and improve the pressure of economic development on the environment. The concept of green innovation technology policy is an important means for China to change its economic model, to obtain greater economic benefits with less energy, to reduce energy consumption and pollutant emissions, and to achieve sustainable economic development. But at present, China's green technology innovation policy is not perfect, and the efficiency of green technology innovation is not good enough. It is necessary to introduce more successful international green technology innovation experience. Through data analysis, the environmental pollution index of the overall environmental pollutants in China is not enough in the green technology innovation policy. With the economic development, the environmental pollution index is on the rise, but with the increase of green technology innovation policy, the environmental pollution index begins to decline. Therefore, it is necessary to introduce more successful international green technology innovation experience, improve China's green technology innovation policy, and relieve the pressure of environmental pollution. However, with the implementation of green technology innovation policy intensified, the initial capital investment was large, and the GDP of residents' income decreased. However, with the recovery of benefits of green technology innovation policy, the GDP of residents' income increased. It can be seen that green technology innovation policy has a negative impact on Residents' income at the beginning of investment, but with the continuous implementation of green technology innovation policy, regional residents' income will change from negative impact to positive impact.

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