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# *New Path of Upgrading Construction Machinery Industry Relying on Green and Sustainable Development*

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***Keywords:*** Green Sustainable Development, Construction Machinery, Industrial Upgrading, New Path

***Abstract:*** China is in the process of industrialization and informatization. A lot of new technologies have emerged in the industrial field, and great changes have taken place in technology, management and other aspects. These new industries and industrial upgrading promote the sustainable development of social economy. In order to avoid the depression of the traditional construction machinery industry, this paper intends to explore the new path of green development of the industry. This paper mainly uses the methods of investigation and comparison to study the green development of construction machinery. This paper also analyzes the path of green development by building the DEA Metallier model. The survey results show that although the efficiency of green technology innovation is different between ecological and non-ecological cities, the gap is gradually narrowing, only 0.06. This shows that in order to upgrade the industry, construction machinery needs to focus on its green technology investment.

## 1. Introduction

At present, China's green sustainable development has made great progress. But there are still many problems in practical application. The upgrading of the construction machinery industry is to improve the quality of the enterprise's products and achieve win-win economic and social benefits through the transformation of the existing production technology and management methods. In the future, China will move towards high quality, high efficiency and intensification. This requires the construction machinery industry to pay attention to the scientific and technological content and improve energy conservation and emission reduction.

There are many theoretical achievements on the exploration of the new path of green sustainable development and construction machinery industry upgrading. For example, some scholars hope to

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improve the emission, noise and other indicators of stock construction machinery by means of data opening, technical transformation and other means, and provide high-quality green cycle products to the urban market [1-2]. Some scholars believe that China's construction machinery industry is facing upgrading and transformation. Under the dual effects of slowing economic growth and increasing environmental protection pressure, the whole industry is undergoing the transformation of sustainable development mode [3-4]. In addition, some scholars put forward that it is an inevitable choice to take the road of green design and manufacturing in the development of construction machinery [5-6]. This is an important measure to promote industrial upgrading and sustainable development. Therefore, there are still a lot of research to provide theoretical support for the construction machinery to take the green development path.

This paper first describes the theory of green sustainable development, and puts forward the green sustainable development of construction machinery. Secondly, this paper briefly discusses the development of China's mechanical engineering industry. After that, the paper discusses the upgrading path of construction machinery industry in different points and puts forward corresponding ways. Finally, through investigation and model construction, the important role of innovative technology in the industry is analyzed.

## 2. Upgrade of Sustainable Construction Machinery Industry

### 2.1. Sustainable Development

The combination of green technology and traditional industrial production is a new form of advanced science and efficient energy conservation and emission reduction. At present, China is in the process of transition from industrialization to intelligent development, with "three low" as the characteristic, requiring high precision and sophisticated manufacturing as the leading direction. At the same time, we should fundamentally change the current extensive growth model. Therefore, under this general background, we should vigorously promote the optimization and upgrading of industrial structure, improve the technical level and resource utilization efficiency and other innovative reforms, so as to achieve the concept of green sustainable development. Green sustainable development is people-oriented, fundamentally changing the traditional mode of economic growth, and achieving coordination, balance and mutual promotion between resources and the environment. Establish the enterprise's awareness of environmental protection, and create a production activity under the premise of respecting the natural ecological environment and protecting ecological resources in the society. Establish an industrial chain that meets the overall interests and long-term needs of society and can fully utilize existing natural resources to develop. We will improve laws and regulations to constrain people's behavior and improve the public's awareness of green sustainability [7-8].

The upgrading of green and sustainable construction machinery industry is in line with the requirements of China's current rapid economic and social development, and can meet the growing material and cultural needs of people. Therefore, the existing construction machinery needs to be optimized. In the new era, environmental problems are prominent and have certain technical difficulties, so in order to achieve green and sustainable development, we must vigorously promote the transformation and upgrading of enterprises and accelerate the pace of the construction of innovative talent training system to improve the entire socio-economic structure [9-10].

## 2.2. Development of China's Construction Machinery Industry

With the restructuring of state-owned enterprises and the increase of private capital, a number of powerful enterprises have emerged in China's construction machinery industry. The main customers of concrete machinery are large construction companies. The development of urbanization provides broad space for the development of concrete machinery. Consignment is the highest sub industry in China. Due to its design mode, the excavator has higher performance and efficiency than the loader, partially replacing the functions of the loader, especially the small excavator has great market potential. Construction cranes in China mainly include truck cranes and crawler cranes. Engineering cranes are widely used in power plant construction, municipal construction, bridge construction, water conservancy and hydropower and other fields. There is a large demand for bulldozers, national highway construction, railway construction, large-scale water-saving infrastructure construction, etc.

In the sustainable development of construction machinery industry, we should actively promote green sustainability and whole process management, and fundamentally solve the problems in enterprise production. First, start from the enterprise itself. On the one hand, we should strengthen the quality training of employees to make them realize the two goals of "innovation, coordination" and "improvement". The second is to improve product quality standards and environmental protection level through technology research and development. On the other hand, after introducing advanced technologies from developed countries, digestion and absorption will be carried out [11-12].

In promoting the upgrading of the construction machinery industry with green and sustainable development, the government should take the lead and give full play to the role of the urban market in allocating resources, integrating enterprise advantages and improving efficiency. The first is to improve the policy and regulation system. The government departments should formulate relevant laws and regulations according to the national conditions of our country to constrain enterprise behavior norms. At the same time, it can also play its due role in the coordination, management and supervision of the relationship between various departments through the establishment and improvement of industry associations, as well as in guiding the industrialization process and solving measures, so as to promote green sustainable development. The improvement of technology level, product quality and urban competitiveness of construction machinery industry can better improve the sustainable development of enterprises [13-14].

Talents, knowledge, technology, system and management have gradually been put into production as production factors, and their roles are becoming more and more important, occupying a more and more important position in production operation. There are two main forms of technological innovation, one is to transform and improve the original technology, and the other is to produce new technology. The source of development cannot be separated from innovation, and technological innovation plays an important role in driving industrial upgrading. The political environment of any industry is extremely important for the transformation and upgrading of the industry. The national support policies for the industry often play a decisive role in the process of industrial development. Different enterprises have their own purposes and different corporate cultures, of course, their own advantages are often different, which requires managers to develop innovation systems according to their own conditions. Management innovation means that the managers of enterprises use new management elements, management methods, or management models to complete the organizational activities of a certain goal. Enterprises can constantly innovate their management methods according to their own development needs and the changes in

the political, economic and cultural environment in which they are currently located. With the development of science and technology, the arrival of the age of big data, the birth of high-tech information and communication products, and the continuous innovation of enterprise business models, in the context of this information age, different industries have achieved cross-border integration. Big data can dig deeper into the subtle needs of customers, so as to accurately locate their real needs, provide customized services for customers, and create more value for enterprises [15-16].

### 2.3. Upgrading Path of Construction Machinery Industry

The upgrading within the industry mainly includes: process upgrading, which mainly improves the core competitiveness of enterprises, reduces costs and improves profits by introducing new processes, new technologies and restructuring of enterprise production processes. Product upgrading, which mainly forms new products by making up the deficiencies of the original products, or develops new products, so as to improve the added value of products. Function upgrading: by extending the value chain of products, the value that the industry can bring to the enterprise can be increased in all aspects of production, processing and sales as much as possible. Cross industry upgrading, leaping from low value-added industry to high value-added industry in different industrial levels [17-18].

The machinery industry should strengthen its own construction, improve product quality and reduce production costs. Minimize environmental pollution while ensuring the safety and reliability of construction machinery. The government needs to increase policy support, guide relevant industries to upgrade and transform, optimize structural adjustment, etc. to promote green sustainable development.

To increase the intermediate investment of the construction machinery industry in strategic emerging industries, it is essential to fundamentally transform the production mode of strategic emerging industries, open the service city market, and guide the construction machinery industry to make various changes and innovations in the direction of the actual needs of strategic emerging industries. It is necessary to promote the professional, scientific and evolutionary development of the construction machinery industry, that is, to realize the service driven manufacturing development mode of developing strategic emerging industries driven by the construction machinery industry, and to provide resources and products for strategic emerging industries with the goal of technological innovation and the means of follow-up services.

Guide the construction machinery industry to change from a demand oriented model to a demand creation model, so as to meet the professional needs of strategic emerging industries. China's construction machinery industry is still dominated by the demand oriented model, that is, driven by strategic emerging industries and driven by the spread of demand to create products and technologies in the construction machinery industry. The service products provided by the construction machinery industry often lag behind the needs of strategic emerging industries. The government should provide substantial production subsidies to producer service enterprises providing services for strategic emerging industries through policy guidance and tax relief, and can also adopt qualification evaluation, incentive certificates and other methods to transfer such industries to strategic emerging industries.

Emphasize the technical creativity of the construction machinery industry, so as to support the reform of its demand creation mode, and realize the technical support and knowledge diffusion of strategic emerging industries. The government should take stronger measures for technology

introduction and development to improve the conversion rate and absorption rate of scientific and technological achievements in the construction machinery industry.

Establish the industrial standards for the construction machinery industry, set up exemplary enterprises, and form a sound elimination mechanism. The government should gather scientific researchers and policy makers to formulate standard industry norms for the construction machinery industry. Give the industry professional enforcement rules, improve the elimination mechanism, establish exemplary enterprises, and guide enterprises to conduct standardized, positive and clear responsibility production and service activities.

## 3. Investigation on New Path of Construction Machinery Industry Upgrading

### 3.1. Construction of Two-Stage Network DEA Metallier Model

Based on the value chain theory of green technology innovation, this paper uses the model DEA model to measure the efficiency of the two stages of technology research and development and technology transformation in stages. And at the same time brings environmental factors into the analysis framework of technology innovation process. Input orientation is to reduce all inputs as much as possible when the output is certain; Output orientation is to increase all outputs as much as possible under certain input. Non oriented measures take two aspects into consideration at the same time. The focus of this analysis is to measure the efficiency value of each stage.

### 3.2. Indicator System and Data Processing

According to the innovation value chain, the "black box" of green technology innovation can be opened, and the process of green technology innovation can be divided into two stages: green technology research and development and green achievements transformation. See Figure 1 for details:

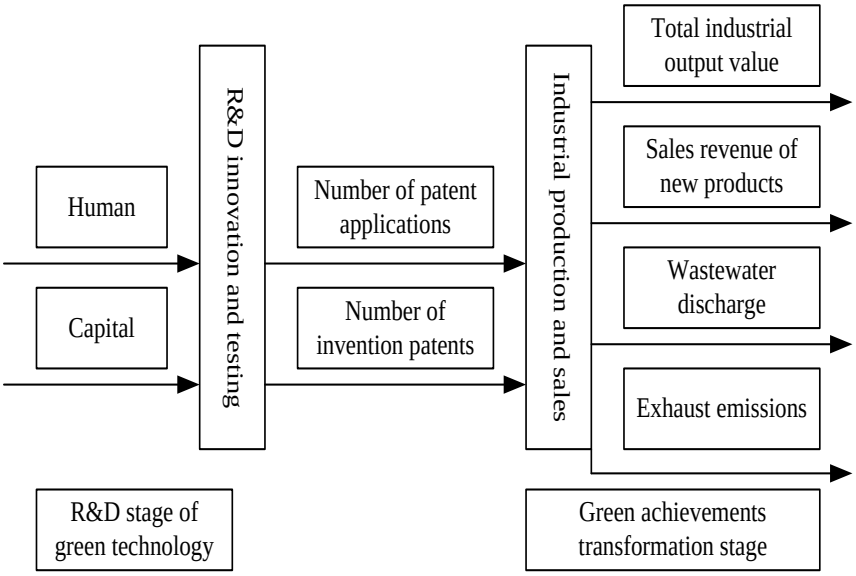


*Figure 1. The process of industrial technology innovation from the perspective of innovation value chain*

According to the availability and integrity of data, combined with the innovation value chain, the specific input and output indicators of industrial green technology R&D and green achievement transformation are as follows. The R&D investment of industrial enterprises mainly includes two aspects: human investment and capital investment. The perpetual inventory method is used to calculate the stock index:

$$Z_{mn} = (1-\lambda)Z_{m(n-1)} + M_{mn} \tag{1}$$

Wherein, $Z_{mn}$ and $Z_{m(n-1)}$ represent the R&D capital stock of industrial enterprises in year n and n-1 in region m, and $\lambda$ are capital depreciation rates. The formula for calculating the base period of R&D funds is:

$$Z_{m100} = \frac{M_{m100}}{h_m + \lambda} \tag{2}$$

Among them, $h_m$ indicates the average growth rate of actual R&D expenditure of industrial enterprises. The intermediate output is expressed by the number of patent applications and the number of invention patents owned. The number of patent applications can reflect the activity of technological innovation activities of industrial enterprises. The output of achievement transformation is mainly divided into expected output and unexpected output. The expected output mainly represents the economic effect of the technological innovation process of industrial enterprises. This paper selects the gross industrial output value and the sales revenue of new products to measure.

### 3.3. Measurement and Decomposition of Industrial Green Technology Innovation Efficiency

Statistical description of input variables, intermediate outputs and final outputs. Specifically, the technical innovation manpower and capital input of industrial enterprises lags far behind the ecological civilization demonstration cities, which may be related to the fact that most of the ecological civilization demonstration cities are economically underdeveloped cities. And the investment of industrial enterprises in technical innovation is limited. On the other hand, the talent reserve of ecological civilization demonstration cities lags far behind that of non-ecological civilization demonstration cities. The lack of funds and human resources restricts the implementation of green technology innovation in ecological civilization demonstration cities. The large gap between the maximum and minimum values of the two regions reflects the significant regional heterogeneity of regional technological innovation in terms of "quantity".

## 4. Analysis of Relevant Investigation Results

### 4.1. Efficiency of Regional Green Technology Innovation

In order to judge the overall technological innovation process of ecological civilization demonstration cities, this paper analyzes the efficiency of green technological innovation of industrial enterprises in ecological civilization demonstration cities from 2016 to 2021 based on DEA model. As shown in Table 1, the green technology innovation efficiency of industrial enterprises in ecological civilization demonstration cities is relatively low on the whole, and there is much room for improvement.

*Table 1. Regional green technology innovation efficiency*

| | Demonstration cities for ecological civilization | Non-demonstration cities for ecological civilization | Nationwide |
|---|---|---|---|
| 2016 | 0.28 | 0.42 | 0.35 |
| 2017 | 0.31 | 0.43 | 0.37 |
| 2018 | 0.35 | 0.45 | 0.4 |
| 2019 | 0.34 | 0.44 | 0.39 |
| 2020 | 0.4 | 0.46 | 0.43 |
| 2021 | 0.44 | 0.5 | 0.47 |

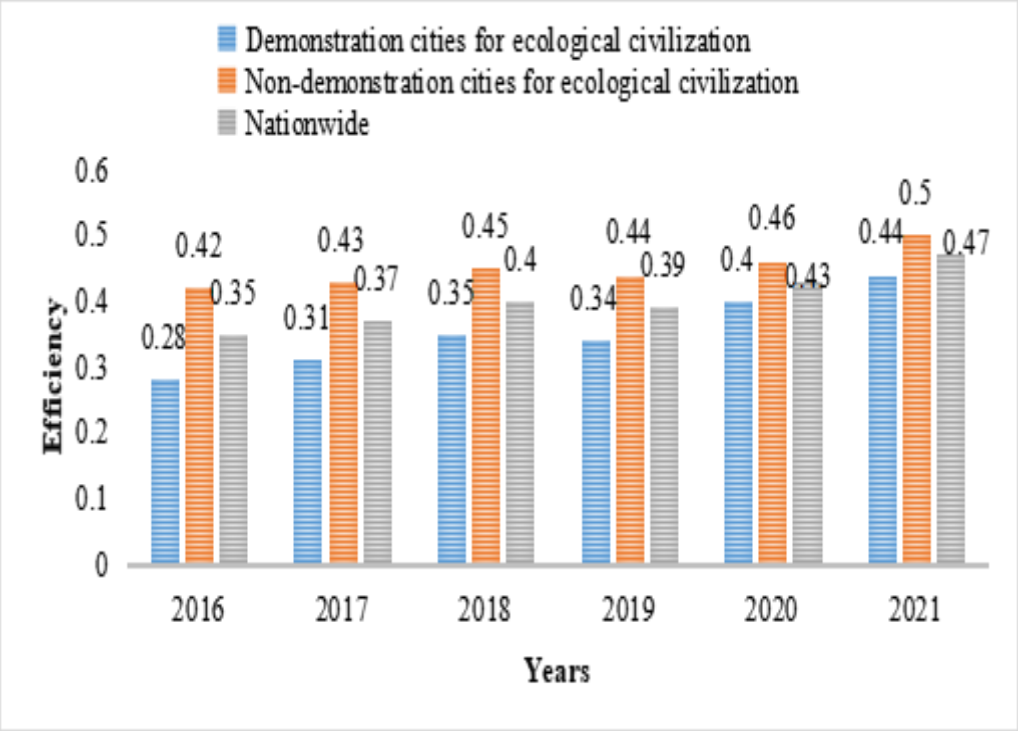


*Figure 2. Regional green technology innovation efficiency*

As shown in Figure 2, we can see that the fluctuation trend of ecological civilization demonstration cities and non-ecological civilization demonstration cities tends to converge. And the green technology innovation efficiency of non-ecological civilization demonstration cities has always been higher than that of ecological cities. The economic effect of industrial green technology innovation in ecological civilization demonstration cities lags behind that in non-ecological civilization demonstration cities, while the environmental effect of green technology innovation is not much different from that in non-ecological civilization demonstration cities.

### 4.2. Measurement Results of Green Technology Innovation, Ratio of Technological Gap between Two Stages and Technological Gap

The transformation level of green achievements in ecological civilization demonstration cities has deviated from the national best level year by year. The values of the three aspects of non-ecological civilization demonstration cities remain at the best level of 1, as shown in Table 2. The data on green innovation, technology R&D and achievements transformation of ecological

cities are far lower than those of non-ecological cities, so the gap is still large.

*Table 2. Green technology innovation and the two-stage technology gap ratio and technology gap*

| | Ecocity TGR | Non-eco-city TGR | Technological gap TGR | Mean value |
|---|---|---|---|---|
| Efficiency of green technology innovation | 0.37 | 1 | 0.63 | 0.62 |
| Technology research and development efficiency | 0.64 | 1 | 0.36 | 0.65 |
| Efficiency of achievement transformation | 0.57 | 1 | 0.43 | 0.64 |

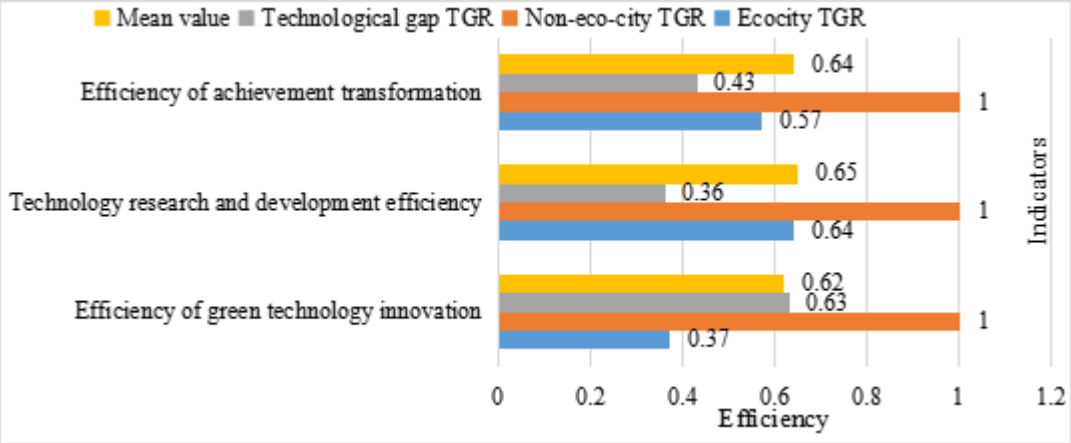


*Figure 3. Green technology innovation and the two-stage technology gap ratio and technology gap*

As shown in Figure 3, we can see that green technology innovation in ecological civilization demonstration cities has great development potential. According to the change of the mean value, we can find that in terms of green technology efficiency and technology R&D efficiency, the mean value is higher than one, both reaching more than 0.6. However, the achievement transformation rate is slightly lower than 0.2, so the economic effect and environmental benefit of the transformation of green achievements in ecological civilization demonstration cities have great room for improvement.

## 5. Conclusion

In the current green and sustainable development of construction machinery industry, enterprises lack of urban market demand and national policy support, resulting in a single product structure and low technology content. Therefore, we should accelerate the establishment of a sound green sustainable development system. First of all, the government should strengthen its guidance. Encourage relevant scientific research institutions to carry out innovation activities through financial subsidies or tax incentives. The second is to strengthen cooperation and exchange with foreign countries to learn advanced experience, and actively introduce new equipment and high-tech talents to research, develop and produce new construction machinery parts and accessories. Finally, the enterprise itself also needs to improve its independent research and development capabilities, constantly improve product technology, improve the nature of products, and reduce pollution at the source.

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## Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

## Conflict of Interest

The author states that this article has no conflict of interest.

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