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Research on the Coupling Mechanism of Technological Progress and Industrial Upgrade

—Based on the perspective of small and medium environmental protection enterprises

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***Abstract*—At present, China's economy has entered the "new normal" era. With the continuous upgrading of environmental governance, the environmental protection industry has reached the turning point of transformation and upgrading, and technological progress is an important promoter of industrial upgrading. Based on the characteristics of small and medium environmental protection enterprises, this paper uses the coupling concept in physics to study the coupling mechanism of technological progress and industrial upgrading of small and medium environmental protection enterprises from the three aspects of factor flow, adjustment of demand and supply structure, and environmental support. Explore how small and medium-sized environmental protection companies can complete industrial upgrading through technological progress in the current environment.**

Keywords—technological progress; industrial upgrading; coupling mechanism; environmental protection

I. INTRODUCTION

Industrial upgrading is the main factor affecting the adjustment of industrial structure, and technological progress is a necessary condition to promote industrial upgrading. Industrial upgrading includes two dimensions: advanced industrial structure and rationalized industrial structure. It is a dynamic accumulation process from quantitative change to qualitative change. That is, the process of shifting the center of gravity of the industrial structure from the primary industry to the secondary and tertiary industries is accompanied by an increase in coordination and correlation between industries. Technological progress affects changes in the industrial structure by affecting demand and supply. Technological progress reduces production costs and increases demand. Only high-tech industrial sectors can occupy market advantages, while outdated industrial sectors are gradually phased out. It will also increase the productivity of social labor, deepen the division of labor and cooperation between industries, increase the production level of the entire industrial chain, and gradually increase the proportion of technology (knowledge)-intensive industries in the industrial sector, further accelerating the advanced industrial structure Process. Industrial upgrading provides capital investment for technological innovation through the advantages of market competition, and the expansion of industrial boundaries also promotes the emergence of subsequent emerging technologies. The two are a two-way interactive relationship.

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II. RESEARCH BACKGROUND

As one of China's national strategic emerging industries, energy conservation and environmental protection is an important engine to promote stable economic growth. According to the "2017 China Environmental Protection Industry Development Status Report", there are 6,259 small and medium environmental protection enterprises, accounting for 95.8% of the total. And there are 4,457 companies with annual operating income below 20 million, accounting for 67.9% of the total. Although the number of small and medium environmental enterprises accounts for the majority of the entire environmental protection industry, most enterprises have small scales, weak technology R&D and achievement transformation capabilities, and a low contribution to the entire environmental protection industry.

For a long time, scholars have studied the technological progress and industrial upgrading. Rostow (1960) affirmes the prominent role played by technological progress in the process of alteration of leading industries, and believes that technological progress made the industrial structure more advanced and rationalized by creating new production functions [1]. Montobbio(2002)believes that industrial innovation will cause differences in the products of enterprises, thereby affecting the competitiveness of the industry, prompting internal adjustment of the industrial structure, and optimizing and upgrading the industrial structure [2]. Azadegan (2011) and others believe that industrial upgrading plays an

important role in innovation. Industrial upgrading allows enterprises to use existing knowledge more effectively, which in turn enables manufacturers to carry out developmental innovation. Industrial upgrading enables enterprises to accept new things, which in turn can promote exploratory innovation [3]. Sengupta(2014)believes that technological innovation creates new products and gradually forms new industrial sectors, which will change the original industrial structure [4]. Kamber(2016)and others believe that the impact of structural technological innovation policies on industrial structure and economic growth is asymmetric [5].

As China's economy entered the "new normal", domestic scholars also began to study the relationship between technological progress and industrial upgrading. Chuanzhong Du (2019) believes that breakthrough technological innovation is an important driving force to promote industrial transformation and upgrading [6]. Qing Zhao (2014) believes that the optimization of industrial structure can significantly promote the formation of technological innovation efficiency space spillover [7]. Zhang Qianqian(2019) believes that there is a synergy between technological innovation and industrial upgrading [8]. Decheng Fan(2020)believes that the rationalization of industrial structure and the development of high-level development are inconsistent in the short term, but the performance is consistent in the long term [9].

In summary, domestic and foreign research focuses more on the theoretical level of technological progress and industrial upgrading. This paper focuses on the perspective of small and medium environmental protection enterprises, based on the environmental protection industry, and uses the coupling concept in physics to build a technological progress and industrial upgrade coupling system from the three aspects of factor flow, demand and supply structure adjustment, and environmental support.

III. Coupling Mechanism of Technological Progress and Industrial Upgrading

A. *The Structure of the Coupling System of Technological Progress and Industrial Upgrading*

Coupling refers to the dynamic and associative relationship formed by the coordinated development of multiple systems. In the development of small and medium environmental protection enterprises, technological progress and industrial upgrading have formed a coupling system through the flow of factors under the adjustment of demand structure and supply structure and the role of environmental support. Factors are the core foundation between the two subsystems, and demand structure and supply structure are the key ways to influence the foundation of factors. Environmental support is an important factor affecting the coupling between the two subsystems of technological progress and industrial upgrading. With the development of small and medium environmental protection enterprises, the coupling relationship between the two subsystems has changed from low-level to high-level, and the coupling system has also transitioned from the budding stage to the mature stage. Through the role of this coupling system, the technical level of small and medium environmental protection enterprises has been improved, the factors are more abundant, the demand and supply structure are more reasonable, and the institutional environment is more perfect, thereby promoting the rationalization and advancement of the environmental protection industry structure, and thus achieving the entire environmental protection industry's Industrial upgrading. As shown in Fig.1

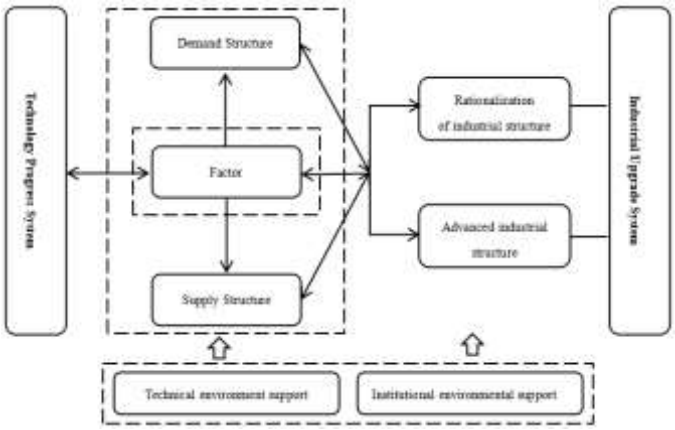

Fig. 1. Structure diagram of the coupling system of technological progress and industrial upgrading

B. *Coupling Mechanism Based on Factor Flow Level*

According to the principle of combination of production factors, in the process of industrial structure adjustment, the allocation proportion and combination relationship among labor, capital, technology and other production factors are one of the basic factors that determine the industrial structure. It affects the comparative cost between different types of production factors-intensive products to determine the future adjustment direction and adjustment method of the industrial structure. This section analyzes the coupling mechanism of technological progress and industrial upgrading in terms of talent, technology and capital. As shown in Fig.2

Fig. 2. Coupling mechanism based on factor flow

China's environmental protection industry currently has structural problems in terms of talents. One is the scarcity of high-end R&D talents, and the second is the lagging development of the environmental protection industry itself which restricts the introduction of talents. In particular, small and medium environmental protection companies are still in an awkward situation where it is difficult to recruit and retain people, High-quality talents are an important way for technological progress to promote industrial upgrading. With the introduction of high-quality talents, the talent structure has been continuously optimized, and labor productivity has been continuously improved. According to the fourth national

survey of basic environmental protection related industries in 2011, the number of companies with technological R&D capabilities in the national environmental protection industry is only one-tenth, which means that 90% of the other companies do not have technological R&D capabilities.

TABLE I. STATUS OF TECHNOLOGY RESEARCH OF ENVIRONMENTAL PROTECTION ENTERPRISES

project name	Number of enterprises	Number of companies with R&D activities	R&D investment (100 million yuan)	R&D personnel investment(10000)	Number of patent certificates obtained
total	23820	2385	342.72	17.04	30116

The improvement of technological level is an important part of technological progress and the main factor affecting the development level and industrial level of environmental protection industry. The improvement of the technical level has upgraded the original production equipment and updated the original technical process, which has raised the production efficiency of the entire department to a higher level. Through the transformation of technological achievements, the improvement of technology is integrated into the industry and the allocation of resources is completed, and the industrial structure has undergone qualitative changes accordingly. The transformation of technological achievements is an important way to integrate technology into the industry to complete resource allocation. The improvement of the ability to transform technological achievements will deepen the penetration of the environmental protection industry into traditional industries, and promote its own development while promoting the development of traditional industries. A win-win situation will be achieved between the traditional industry and the environmental protection industry.

Whether it is the introduction of high-quality talents or the improvement of technical level, a certain degree of capital investment is required. In the current context of "de-leveraging", some small and medium environmental protection companies have fallen into the "fundless" situation. Generally speaking, when the total investment in environmental pollution control accounts for more than 2% of GDP, the improvement of environmental quality can be supported. In the past seventeen years, the proportion has not exceeded 2%, as shown in Fig. 3.

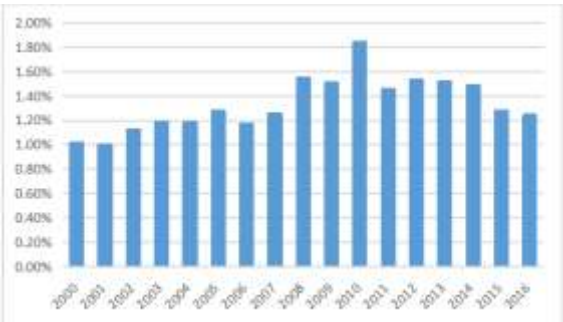

Fig. 3. The proportion of total investment in environmental pollution control in GDP

Technological progress can attract capital to enter as an internal condition of the enterprise. When a certain amount of capital investment is used as the initial capital of small and medium environmental protection enterprises, the company's talent introduction and technology research and development are guaranteed. At the same time, small and medium environmental protection enterprises can also expand their production and operation scales, win more voice in market competition, and further improve economic efficiency. Due to the profit-seeking nature of capital, in the process of industrial expansion, the accumulation of capital has attracted the investment of other capital. And the investment of these capitals has become the initial capital for a new round of enterprise development, providing a steady stream of power for the development of small and medium environmental protection enterprises and the expansion of industries.

C. Coupling Mechanism Based on the Adjustment of Demand and Supply Structure

The degree to which the industrial structure matches the demand structure determines the reasonable degree of the industrial structure (demand adaptability judgment method). Technological progress affects the demand structure, which leads to changes in the industrial structure. The main performance is that technological progress will upgrade and update equipment and production processes, which reduces the raw materials and energy consumed by unit products, but the total demand for raw materials and energy increases, changing the production structure of raw materials. At the same time, technological progress has brought new products and new demand space, breaking the original market equilibrium, making the industrial sector with rapid technological progress rise rapidly, occupying most of the market share, while the industrial sector without technological breakthroughs was The gradual elimination has accelerated the process of upgrading between industries, changed the production structure of consumer goods, and promoted the upgrading of the industrial structure. When the industrial structure tends to stabilize and profits disappear, under the guidance of market demand, companies are stimulated to carry out a new round of technological progress, thereby realizing a new round of industrial structure upgrade process.

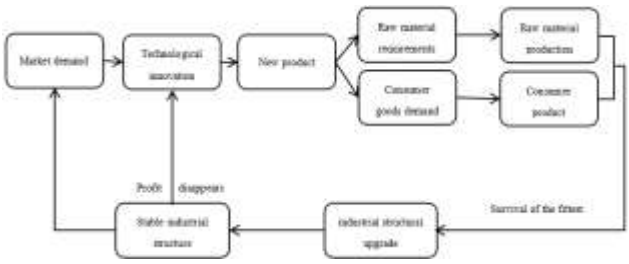

Fig. 4. Coupling mechanism based on the level of demand structure adjustment

The environmental protection industry is a high-tech industry, which has strong industrial relevance and can quickly penetrate into traditional industries. New technologies and new products brought about by technological progress have caused the change in production structure to gradually penetrate from

the end of the environmental protection industry to all production links of the traditional industry, changing the production and service methods of the traditional industry. The horizontal integration between environmental protection enterprises and traditional industry enterprises has accelerated the process of industrial integration, which enables small and medium environmental protection enterprises with a weak foundation at the present stage to form a symbiotic relationship with traditional manufacturing industries and upgrade other industrial structure. Technological progress not only promoted industry penetration, but also promoted the deepening of the industrial division of labor. According to the 2017 report on the development status of China's environmental protection industry, the current enterprises in the environmental protection industry are mainly divided into two categories: environmental protection product production and environmental services. As shown in table II.

TABLE II. TWO CLASSIFICATIONS OF ENVIRONMENTAL PROTECTION ENTERPRISES

Types	**Specific areas**								
Environmental services	Water pollution control	Air pollution control	Solid waste disposal and recycling	Environmental restoration	Noise and vibration control	Environmental monitoring	Other areas		
total	2224	640	876	43	31	1522	498		
Environmental protection products	Water pollution prevention equipment	Air pollution prevention equipment	Fixed waste disposal equipment	Soil remediation equipment	Noise and vibration control equipment	Environmental monitoring equipment	Supporting materials for environmental pollution control	Equipment for comprehensive utilization of resources	Environmental emergency equipment
total	529	443	105	13	44	113	125	15	7

Further deepening the division of labor not only strengthens the collaboration and cooperation among enterprises, but also enhances the cohesion of the industry. It can also breed many emerging industries to complement and extend the functions of the environmental protection industry, and help promote the regional economic integration with the environmental protection industry as the core to form a complete industrial chain, promote the upgrading of industrial structure, and lay a solid industrial foundation for subsequent technological progress.

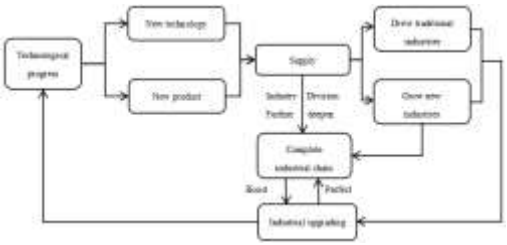

Fig. 5. Coupling mechanism based on the level of supply structure adjustment

D. Coupling Mechanism Based on Environmental Support Level

The mutual promotion between technological progress and industrial upgrading not only has internal factors, but also external factors such as technological environment and institutional environment also play a vital role.

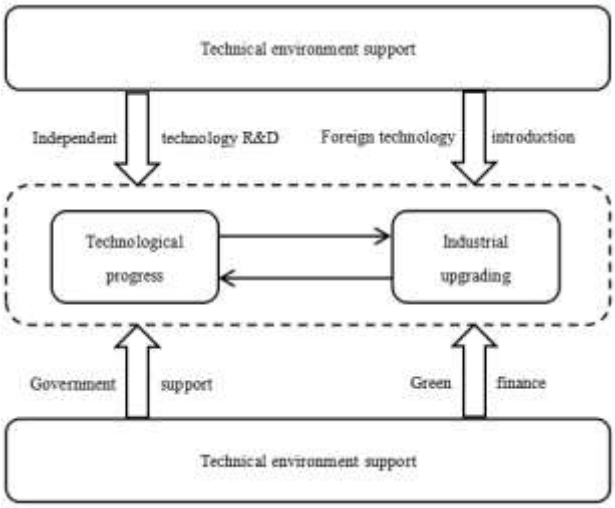

Fig. 6. Coupling mechanism based on environmental support

Independent technology research and foreign technology introduction are two important paths for technological progress. At present, there is still a big gap between the technological research and development level of Chinese environmental protection enterprises and the international advanced level. Therefore, the active introduction of foreign advanced technical levels can help domestic small and medium-sized environmental protection enterprises to overcome the lack of technical level through technical imitation, and can also further guide small and medium-sized environmental protection. Enterprises have explored their own technological R&D road. While introducing technology, learn advanced foreign production technology and management concepts to create a production link and management level that matches it, so that small and medium environmental protection companies have the ability to digest and absorb high and new technology.

However, domestic environmental protection enterprises cannot go far by relying solely on technology imports. Independent technological R&D is the lifeblood of domestic environmental protection enterprises' survival and development, and the fundamental way of technological progress. The independent technology research and development of domestic environmental protection companies can better meet the needs of the domestic market, and technical results can also be put into the production process faster. At the same time, independent technology research and development has also accelerated the process of technology diffusion among domestic environmental protection industries. Through the "innovation-diffusion-innovation" cycle form, the technical level of the entire environmental protection industry has been improved, which has led to the transformation and upgrading of the environmental protection industry structure.

In terms of policies, the domestic environmental protection industry is a policy support industry. At present, although the country has implemented tax and subsidy support policies for the environmental protection industry, due to the limitations of the policy and the restrictions of accounting information standards, small and medium environmental protection companies that are the main body of the environmental protection industry cannot enjoy the relevant preferential policies. Moreover, due to the promulgation of a series of national policies and regulations, a large number of non-environmental protection companies have entered the market, disrupting the market order. In terms of investment and financing, small and medium environmental protection companies in the development stage are caught in a difficult and expensive financing situation. From the perspective of institutional environmental support, government support will alleviate the fiscal and tax pressures of environmental protection enterprises, reduce the turnover pressure of environmental protection enterprises' funds, and provide economic guarantee for the early survival and development of environmental protection enterprises. Transformation and upgrade to escort. Green finance has expanded financing channels for environmental protection companies, continued "blood transfusion" for corporate technology research and development, stimulated the enthusiasm of environmental protection companies for technological innovation, and promoted the transfer and diffusion of technological achievements between industries, which is of great significance to industrial upgrading.

IV. CONCLUSION

In terms of enterprises themselves, environmental protection enterprises should realize that technology is the lifeblood of their survival and development. Based on the actual development situation of the enterprise, actively introduce foreign advanced technology, increase investment in scientific research funds, and build a team of high-quality scientific research talents. In the process of transformation and upgrading, enterprises should regard independent technological innovation as the focus of upgrading their technological level. They must not neglect the cultivation of technological achievement transformation ability and cultivate their own core competitiveness. At the same time, they must focus on improving their own management level and transforming their development methods. To eliminate backward production capacity and get rid of backwardness.

In terms of institutional environment, the government should play a good role in guiding and serving. First of all, the government should establish a bridge between environmental protection enterprises and the government and the market, actively guide the investment direction through environmental protection policies, stimulate capital's enthusiasm for investment in environmental protection enterprises, and expand financing channels for small and medium-sized environmental protection enterprises. At the same time, the government should improve relevant policies and regulations to guide and encourage independent innovation of environmental protection enterprises. In terms of industrial environment, actively guide the connection of environmental protection enterprises with traditional industries and emerging industries, strengthen the correlation between industries, build regional high-tech industrial development zones with environmental protection industries as the core, and establish high-level environmental protection industry clusters. Finally, we must pay attention to standardize market order, strengthen market supervision, and promote the development of environmental protection industry to high quality.

In the three levels of factor flow, demand and supply structure adjustment, and environmental support, the technological progress and industrial upgrading of environmental protection enterprises are coupled. Under the adjustment of demand structure and supply structure and environmental support, technological progress and industrial upgrading form a coupling system through the flow of elements.

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