

Analysis of Green and Low-carbon Policies in Promoting the Transformation of Chinese Manufacturing Industry

Haopeng Li^{1,*}

¹School of Foreign Languages and Literature, Wuhan University, Wuhan, China

*Corresponding author:
2022301021166@whu.edu.cn

Abstract:

According to carbon emission data in 2024, global carbon emissions reached 37.8 billion tons, setting a new record high. The global carbon peak has not yet arrived. As the world's largest carbon emitter, China must implement green and low-carbon policies to promote its own green and low-carbon development and achieve the goal of energy conservation and emission reduction. The manufacturing industry is the sector with the highest carbon emissions in China. Therefore, the transformation and upgrading of manufacturing is closely related to China's green and low-carbon development. Based on this, this paper investigates the relevant data of China's manufacturing industry and selects some typical enterprises for research. It concludes that the current impact mechanism of green and low-carbon policies in China mainly focuses on four aspects: cost, personnel structure, technological innovation and market reshaping. At the same time, it proposes that future green and low-carbon policies need to be improved in three aspects: policy optimization, enterprise response, and supporting system construction.

Keywords: China; green and low-carbon policies; transformation; manufacturing industry.

1. Introduction

To address severe challenges posed by global warming, all countries around the world have pursued green and low-carbon development during the past decades. In recent years, numerous countries have been longing to reduce carbon emissions and achieve a green and low-carbon transition. The signing of the Paris Agreement signifies the global community's resolute commitment to advancing economic transformation towards green and low-carbon devel-

opment. Amid them, as the world's largest source of energy consumption and carbon emissions and the second-largest economy, China undoubtedly bears significant responsibility to make the promotion and refinement of green and low-carbon policies an immediate priority. Chinese manufacturing sector is the largest globally. Therefore, the transformation and upgrading of this sector are of paramount importance.

Over the past decade, China has achieved remarkable progress in green development, with carbon emis-

sion intensity decreasing by 34.4%, while sustaining an average annual Gross Domestic Product (GDP) growth of 6.6% with an energy consumption growth rate of 3.0%. Solely considering the first ten months of 2024, China's carbon dioxide emissions decreased by 0.5% year-on-year. Therefore, China's manufacturing sector has already made notable strides in transitioning towards green and low-carbon development. However, several deficiencies remain in the implementation of green and low-carbon policies within China's manufacturing sector. Firstly, the government's policy framework is still incomplete. There are discrepancies in detailed objectives of low-carbon policies across different departments, leading to poor coordination and hindering effective implementation by enterprises. Secondly, the market mechanism still has some inherent flaws. The current green and low-carbon market mechanism is underdeveloped, with issues such as inadequate trading rules and low market activity in carbon trading markets, which adversely affect the efficiency and effectiveness of carbon reduction efforts and long-term development in the manufacturing sector. Thirdly, traditional manufacturing industries are facing significant pressure to transform. Apparently, green and low-carbon policies impose stringent demands on capital, technology, and labor in traditional manufacturing, posing a stern challenge for China's foundational manufacturing sector, which employs 100 million people and accounts for 40% of industrial output. For instance, the coal mining and dressing industry employs over 2 million people in China. Achieving emission reduction targets through green and low-carbon policies in the coal industry will require careful management of workforce transitions and socioeconomic stability. In these aspects, China's green and low-carbon policies still have significant deficiencies to be settled [1]. For manufacturing industries, their industrial transformation extends beyond the mere application of green technologies or energy conservation and emission reduction. It is a comprehensive revolution encompassing the institutional structure, production technologies and processes. This transformation will exert profound impacts on the sustainable development of the manufacturing industry. Therefore, plentiful research has been conducted on this theme. Some scholars indicate that the green transformation of Chinese enterprises has a negative effect on the stock market, suggesting that single market-driven green transformation will inevitably encounter obstacles. In combination with government policies, efficient transmission of information through high-quality disclosure plays a crucial role [2]. Some scholars posit that policies should encourage enterprises to promote the digital transformation of traditional industries, optimize production processes through information technology. Simultaneously, it is imperative for government to enhance support for strategic emerging industries to increase the stability

and sustainability of industrial development [3]. Some research conclude that Chinese Environmental Fee-to-Tax Policy (EFTT) plays a significant role in promoting green innovation and should be implemented according to local conditions across different regions in China. Also, local governments should integrate regional economic development with local environmental carrying capacity when implementing policies [4]. Similarly, some scholars note that the Low-Carbon City Pilot Program (LCCP) positively impacts energy efficiency. In more developed regions, the policy should leverage the radiation effect, utilizing the economic influence of developed areas to expedite green and low-carbon technological innovation in surrounding regions [5]. Other scholars summarize that the number of policies has increased from few to many, policy types have shifted from singular government interventions to combinations with market and public participation and policy concepts have evolved from pollution control to promoting overall ecological civilization construction. They also point out that current green and low-carbon policies face implementation issues at the local level, reducing the efficiency of industrial transformation and development. Based on previous research reports, it is evident that current green and low-carbon policies encounter bottlenecks, necessitating policy innovation to further drive industrial transformation and upgrading [6]. Therefore, this paper primarily focuses on analyzing and elaborating on the following two aspects: First, the influence of green and low-carbon policy on China's manufacturing industry. Second, the methods of current green and low-carbon policies.

2. Green and Low-carbon Policy Categories

Before addressing these two questions, this paper first categorizes green and low-carbon policies into Mandatory Policies, Market-based Policies, and Voluntary Policies. Because their corresponding contents and expected objectives of differentiate from each other and their policies exhibit certain variations. This systematic classification facilitates a more comprehensive analysis and evaluation of various green and low-carbon policies.

2.1 Mandatory Policy

Mandatory policies refer to those with compulsory enforcement within government policy implementation, which can be further divided into standard and permission categories. Representative policies in the standard category include establishing industrial energy efficiency benchmarks and formulating relevant carbon footprint certification standards. These policies aim to limit carbon emissions in the industries by setting fixed indexes, thereby promoting low-carbon development. Permission

policies include requiring enterprises to obtain emission permits prior to production and setting total quotas for carbon emission trading. These policies aim to ensure that enterprises achieve lower carbon emissions and pollution levels before conducting production actions through monitoring and restrictions.

2.2 Market-based Policy

Market-based policies refer to those that aim to regulate and standardize carbon emissions through market mechanisms to achieve low-carbon effects. The first type utilizes price mechanisms for regulation. Typical examples are carbon taxes and green electricity trading. The former refers to a tax on carbon dioxide emissions and the latter involves direct power purchase agreements between electricity consumers and renewable energy generators for green electricity. Both of them limit carbon emissions through pricing. The second type employs financial mechanisms for regulation, exemplified by green securities. Green bonds are securities specifically designed to support green economic activities that meet specified conditions. Issuing such securities can promote green economic activities from the perspective of the bond market, enhancing the prospects of green and low-carbon development and thereby achieving the goal of regulating carbon emissions.

2.3 Voluntary Policies

These policies are designed to enhance corporate consciousness and encourage enterprises to voluntarily reduce carbon emissions. The first type is establishing demonstration projects. For instance, government policies establish zero-carbon factories and set related incentive mechanisms to encourage enterprises to voluntarily align with relevant standards, thereby achieving carbon emission reductions. The second type is enacting industry initiatives. In 2019, China established the China Green Supply Chain Alliance. China utilizes such cooperative organizations to integrate resources, thereby mobilizing more enterprises to engage in green manufacturing and low-carbon application research.

In conclusion, China has implemented various green and low-carbon policies, utilizing different types to promote low-carbon policy development and industrial transformation and upgrading from multiple dimensions.

3. The Impact of Green and Low-carbon Policies on China's Manufacturing Industry

3.1 Cost Variation

The implementation of green and low-carbon policies will undoubtedly lead to cost transformations across various

manufacturing industries. Firstly, compliance costs for manufacturing enterprises will increase. Taking Kelun Pharmaceutical as an example, from 2017 to 2020, with the rise in total operating costs, the company's environmental protection costs also continuously increased, reaching 779.912237 million yuan in 2020, approximately double the 2017 figure [7]. The increase in compliance costs primarily manifests in two aspects: the construction of environmental protection facilities and the investment in new emission reduction technologies. Driven by the continuous advancement of green and low-carbon policies, enterprises will persistently enhance their environmental protection expenditures and carry out technological innovation to achieve carbon emission and peak carbon targets. These processes will involve increasingly substantial capital investments. Secondly, the opportunity costs of manufacturing industries will undergo changes. For example, the steel and chemical industries need to implement electrification, increase the proportion of non-electric clean energy and address the issue of carbon emissions associated with coal or natural gas at the raw material stage to reduce their carbon emissions. During this transition, traditional energy sources and their related processes must align with clean energy, resulting in the reallocation of different resources in this low-carbon cost transformation [8]. Following the completion of this reallocation, changes in the original proportions and processes will correspondingly alter the industries' opportunity costs.

3.2 Personnel Structure Changes

On the one hand, with the development of green and low-carbon policies, the manufacturing industry will undergo a process of improving the quality of its workforce. During this process, it is unavoidable that many of the original employees will be dismissed, and new advanced employees will be hired, thus causing changes in the personnel structure of the manufacturing industry. On the one hand, for low-end workers, they mainly handle jobs with lower requirements in the industry, who mainly work in traditional industries and energy sectors. They are already lagging behind in the face of new energy and are bound to be replaced in the transformation and upgrading of the manufacturing industry. On the other hand, to strengthen technological innovation, the demand for high-tech workers in the manufacturing industry will increase, which will lead to a greater proportion of them in the future transformation process and changes in the original personnel structure. In addition, green and low-carbon policies and economic fluctuations will affect the costs of enterprises. To reduce costs, the manufacturing industry will change the original personnel structure through personnel management measures such as layoffs. For example, in 2024, numerous enterprises such as Hisense Group Holdings,

Wuxi Lead Intelligent Equipment and Hesai Technology all announced layoffs and personnel optimization measures. The implementation of green and low-carbon policies by enterprises will lead to an increasing investment in pollution control and energy conservation. This increases the enterprises' cost burden. Therefore, through layoffs optimizing costs is undoubtedly an important step. Thus, under the influence of green and low-carbon policies, the personnel structure of the manufacturing industry itself will also change.

3.3 Technological Innovation

The government's green and low-carbon policies have a compelling effect on technological innovation. The government will use mandatory policy tools to force the manufacturing industry to carry out industrial innovation to reduce carbon emissions [9]. In 2025, the Ministry of Ecology and Environment of China set standards to regulate technical specifications for ultra-low emission engineering of waste gas in the sintering process of iron and steel industries. The purpose of the regulations is to prevent environmental pollution and improve the quality of the ecological environment. Under such regulations, manufacturing industries are forced to conduct technological innovation to achieve the effect of reducing carbon emissions and preventing pollution through more advanced processes. Besides, the government also promotes technological breakthroughs in low-carbon technologies through innovative incentive mechanisms and green technology research and development subsidies. In the first quarter of 2025 alone, China has introduced and proposed 29 direct green and low-carbon subsidy policies across the country, covering 14 provinces, municipalities and autonomous regions. Take Beijing as an example. For new energy enterprises with a new energy heating capacity ratio of 30% or more, at least 20% of the funds will be supported based on the specific proportion. Under such strong economic support and policy encouragement, the manufacturing industry has a higher enthusiasm for green and low-carbon technological innovation. This also promotes sustainable development of the manufacturing industry.

3.4 Market Reshaping

Green and low-carbon policies change manufacturing industries' development direction and their products. This also drives the reshaping of the manufacturing market. In recent years, Chinese consumers' green preferences and their understanding of green consumption have been improving continuously. According to China E-commerce Green Development Report 2023, more than 60% of respondents are aware of green consumption. Apart from it, Data from the Research Center for Environmental and Economic Policy of the Ministry of Ecology and Environment shows that the proportion of people who

frequently purchase green products increased to over 60% in 2022. Moreover, 2023 China Consumption Trend Report shows that 73.8% of consumers give priority to green and environmentally friendly products or brands in their daily lives. This indicates that under the guidance of government green and low-carbon policies and the promotion of green and low-carbon lifestyles, more and more Chinese consumers are turning to low-carbon market, and the demand for low-carbon market products is showing an expansion trend. For the internal market of the manufacturing industry, under the implementation of green and low-carbon policies, the supply chain of the manufacturing industry becomes greener and low-carbon. To achieve energy conservation and emission reduction throughout the entire industrial chain, upstream and downstream industries need to collaboratively handle green and low-carbon affairs. For example, environmental protection standards force downstream enterprises to limit carbon emissions. This, in turn, prompts them to request upstream suppliers to replace the original products with low-carbon ones. During this process, the products in the internal market of the manufacturing industry are reshaped to meet green and low-carbon standards.

The impact of green and low-carbon policies is mainly reflected in cost variation, personnel structure changes, technological innovation, and market reshaping. Also, this paper states that any policy has both advantages and disadvantages for the transformation and development of the manufacturing industry. The process of transformation and upgrading of the manufacturing industry is destined to be accompanied by changes and pains. Green and low-carbon policies should minimize the painful phase of the manufacturing industry and promote its smooth transition to green and low-carbon.

4. Future Policy Suggestions

4.1 Government Policy Optimization

At present, the implementation of green and low-carbon policies in many places is hindered. The main problem is that these policies mostly fail to take into account the differences in production scale and output value of local manufacturing industries. Meanwhile, the economic levels of different regions also vary.

Therefore, in terms of policy optimization, the most important thing is to implement different design and management based on local conditions. First, developed regions have a greater radiation effect, and their manufacturing industries also have a greater driving force. By implementing large-scale energy conservation and emission reduction policies in these regions, the government can prioritize the transformation of manufacturing industries in developed regions [10,11]. It drives the transformation

and upgrading of manufacturing industries in other regions. Second, industries also need to set up phased standards based on the carbon emission intensity of different sectors instead of simply applying a one-size-fits-all approach [12]. Take the industrial sector as an example. Currently, industrial carbon emissions account for over 70% of the country's total carbon emissions. Therefore, the low-carbon development of the industrial sector requires different policies, with phased standards set according to different development periods to promote the reduction of industrial carbon emissions. In addition, phased standards should also be included in the transitional period. The government should set a certain buffer period for high-energy-consuming manufacturing industries to help them transition more smoothly. Moreover, local governments should also pay attention to the objective transformation progress of local manufacturing industries when implementing policies. Government policies need to be in line with the actual development speed of manufacturing industries. When necessary, government policies should also provide economic assistance to accelerate the transformation instead of stubbornly restricting manufacturing industries in a one-size-fits-all manner.

4.2 Accelerating Self-renewal of Manufacturing Industry

In addition to making themselves more reasonable and targeted through adjustments, government policies can also promote green and low-carbon development by driving the innovation within manufacturing industries. The government can promote the establishment of technological innovation alliances to enhance innovation within the manufacturing industry. Take the steel industry as an example. Since the establishment of the Steel Recyclable Process Technology Innovation Strategic Alliance in 2007, it has achieved certain development. However, it still has major problems such as incomplete common technology research and a lack of long-term and systematic support. Therefore, government policies can increase assistance for manufacturing industry alliances and encourage the establishment of new technological innovation alliances. Moreover, the government can also encourage joint efforts of upstream and downstream enterprises in industrial chains to tackle low-carbon technologies [12]. Low-carbon policies themselves can force downstream industries to push upstream suppliers. In this case, upstream and downstream enterprises within the same industrial chain can strengthen technological collaboration to jointly promote the transformation of the industry towards green and low carbon. Additionally, government policies can focus on promoting business model innovation in the manufacturing industry and the development of service-oriented manufacturing, with contract energy management being a typical example. The upstream of this industrial chain

mainly consists of infrastructure. The midstream is the contract energy management service layer. The downstream consists of energy users with energy-saving demands. All three parts can work cooperatively to reduce Carbon Emission. This energy-saving investment method uses the saved energy costs to cover the entire costs of energy-saving projects. It helps manufacturing industries transform from "selling products" to "selling services", thereby promoting energy conservation and emission reduction.

4.3 Construction and Improvement of Supporting Systems

In addition to considering the starting point of policies and the recipients of policies, improvements should also be made in the construction of some supporting systems for green and low-carbon policies. Currently, the talent demand gap in China's ten major manufacturing fields will approach 30 million people, with a shortage rate of 48%. Therefore, green and low-carbon policies should also promote the establishment and improvement of the vocational training system. The government needs to encourage policies for manufacturing industries to conduct retraining for workers in high-carbon industries to transfer to low-carbon positions during the transformation process. On the one hand, this helps the originally unemployed to find new jobs and maintain social stability. On the other hand, it cultivates more high-level talents to adapt to the development of enterprises after transformation, promoting the sustainable development of enterprises and reducing the talent gap.

Moreover, nowadays, young people have insufficient understanding of technology-intensive and innovation-driven modern manufacturing industries and are reluctant to seek employment in manufacturing. Government policies also need to change this traditional concept in policy promotion and enhance the attractiveness of manufacturing jobs. This enables manufacturing to attract more highly skilled talents and promote the transformation and upgrading of the manufacturing industry.

5. Conclusion

To conclude, this paper mainly analyzes the impact of current green and low-carbon policies on the manufacturing industry and provides some feasible suggestions for the future development of policies. In terms of impact, this paper states that green and low-carbon policies will cause cost variation, resource reallocation, personnel structure changes, innovation in technologies and reshaping markets. At the same time, this paper also proposes that future policies should further optimize policies themselves, assist the manufacturing industry with its self-renewal and improve related supporting systems.

This article contributes to the transformation of manufacturing industries and Chinese green and low-carbon policies. However, it does not analyze and discuss a specific branch within the manufacturing industry. It does not include other industries outside the manufacturing industry for comparative analysis or considering whether there are cross-industry collaborations, either. These perspectives would also provide references for energy conservation and carbon reduction in the manufacturing industry in the future, which offers some research directions for future studies.

China's green and low-carbon policies have achieved many phased achievements. However, considering the huge scale of the manufacturing industry itself, its transformation and energy conservation and emission reduction require long-term policy guidance and support from the government. At the same time, policies also need to be adjusted according to their specific development situation to ensure the smooth completion of the transformation of the manufacturing industry.

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