Technological Innovation Drives Green and Low-Carbon Development: An Empirical Analysis Based on Low-Carbon Economics

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Abstract: This paper explores the theoretical potential of low-carbon economics and discusses the driving force of technological progress on the path of green and low-carbon development. It adopts an empirical model construction method system to analyze the influence mechanism and action mechanism of technological innovation on the green and low-carbon development model. This analysis screens the research objects based on relevant data indicators and conducts a detailed study using multiple regression analysis methods. The empirical research confirms that technological progress has a significant positive driving force for green and low-carbon development. The experimental results illustrate that the adoption of innovative technologies can significantly reduce the carbon emission level and promote the expansion and deepening of the economic transformation path towards green and low-carbon. The stability of the research conclusions is further confirmed by the robustness test. This thesis presents a theoretical foundation and empirical verification to policymakers, indicating that the realization of green and low-carbon development is inseparable from the core support of technological innovation.

Keywords: Technological Innovation; Green and Low-Carbon Development; Low-Carbon Economics

Introduction

Given the continuous deterioration of global climate change and the increasing pressure on resources and the environment, the international community generally recognizes the strategic path of green and low-carbon development. Focusing on the subject category of the mutual influence between economic development and carbon emissions, low-carbon economics provides theoretical support and practical paths in the exploration of the low-carbon development model, laying the theoretical foundation for sustainable development. Technological innovation is the core driving force for economic growth and environmental protection. In the chain of green and low-carbon development, this factor is the core power for its successful implementation. At present, the existing research results have not clearly concluded the specific influence path of technological innovation on the green and low-carbon development mechanism. This study plans to conduct a detailed discussion through empirical analysis, explore the leading value of technological innovation in the process of green and low-carbon development, and comprehensively discuss its internal action mechanism and the evolution of its influence.[1-3]

1. Theoretical Basis of Technological Innovation Driving Green and

Low-Carbon Development Based on Low-Carbon Economics

The green and low-carbon development model led by technological innovation can trace its theoretical origin back to the profound theoretical system of low-carbon economics. In the energy industry sector, relying on innovative resources and focusing on the research and development of renewable energy technologies such as efficient solar energy and wind energy can significantly reduce the proportion of dependence on traditional energy and the absolute level of carbon emissions. In recent years, China's solar photovoltaic technology has developed rapidly, with a significant reduction in cost and a remarkable leap in energy conversion efficiency. Around the world, the application scale of solar power generation technology is gradually expanding, forming a new upsurge in energy utilization, successfully achieving a significant reduction in the consumption of traditional energy such as coal and a significant decrease in the absolute value of carbon emissions.[4]

In the industrial manufacturing line, adopting a modern environmentally friendly production technology path, such as the policy support for environmental protection technologies like carbon capture and storage (CCS) technology and zero-emission manufacturing processes, can effectively reduce the impact of carbon emissions during the production operation stage. Several steel giants have adopted carbon capture and storage technology to capture and geologically store the carbon dioxide emitted during the production process, greatly reducing the emission level of carbon dioxide.

The innovative application of digital technology has played a key role in improving key efficiency. Relying on big data and artificial intelligence technology, it can achieve precise energy management and optimized configuration, significantly improving the effectiveness of energy utilization. By sorting out and looking forward to the innovation achievements in the transportation technology field and the development track of the new energy vehicle industry, it has achieved a major breakthrough in the traditional transportation mode, implemented the green travel feedback of building a green transportation system. Technological innovation is the core support point for addressing climate change and the key core of the core driving force for economic sustainable development, and its promoting role in the field of green and low-carbon development is increasingly enhanced.[5]

2. Technological Innovation Drives Green and Low-Carbon Development: An Empirical Analysis Based on Low-Carbon Economics

2.1 Data Sources and Indicator Selection

When examining the practical significance of scientific and technological innovation in leading green and low-carbon development, it is necessary to ensure that the data sources are both extensive and authoritative. The macroeconomic data such as energy consumption, carbon emissions, and economic growth collected from official channels such as the National Bureau of Statistics and the International Energy Agency are scientific. Indicators at the micro level of enterprises, such as research and development (R&D) investment and the number of patent applications, are included in the analysis system.

From the dimension of indicator selection, in-depth analysis is carried out. The carbon emission intensity per unit of GDP is used as a measure to quantify the level of green and low-carbon development. The proportion of R&D investment and the patent authorization ratio are used to show the technological innovation level of enterprises. Indicators for the optimization of the energy structure are included in the system. The empirical analysis of the share of clean energy in the energy consumption structure deeply analyzes the significant impact of energy transformation on the green and low-carbon field. Relevant indicators of industrial structure adjustment are included in the comprehensive evaluation category to illustrate the proportion of high-energy-consuming industries in the composition of the national economic output value, and deeply analyze the driving force of technological innovation on the process of green and low-carbon transformation in the evolution of various industrial structures, guiding the data and indicators towards the standards of scientificity and representativeness. When selecting the evaluation indicator of the proportion of clean energy, the evolution law of the proportion of clean energy such as hydropower, wind power, and solar energy in the energy structure and its impact on the revision of carbon emission reduction regulations are systematically sorted out.

2.2 Empirical Model Construction

In the stage of empirical model construction, fully considering the unique characteristics of time series and cross-sectional data, this study, after careful consideration, finally uses the panel data model for rigorous empirical analysis. The reason for choosing the panel data model is that it can effectively combine the information of the two dimensions of time and individuals, thus more comprehensively capturing the relationships between variables.

In this study, the evaluation indicators of green and low-carbon development are used as the dependent variable, and the evaluation indicators of technological innovation are used as the core explanatory variables. At the same time, key variables such as the scale of economic development, industrial structure adjustment, and energy costs are comprehensively coordinated and managed, striving to fully grasp the trend of technological change. In addition, the values recorded in the lagging stage of technological progress are included to more accurately reflect the long-term impact of technological innovation.

For the potential endogeneity obstacles, the instrumental variable technique is adopted to evaluate the correlation parameters. External variables such as the number of regional higher education institutions and government science and technology funding are selected as instrumental variables for empirical analysis. These instrumental variables are related to the core explanatory variables but not related to the error term, which can effectively solve the endogeneity problem and maintain the consistency of the prediction results. By establishing an interaction term model, the interaction between technological progress and changes in the energy and industrial structure on the trend of green and low-carbon development is explored, and the internal driving mechanism and internal connection of technological innovation promoting green and low-carbon

development are comprehensively explained.

2.3 Analysis of Empirical Results

The empirical analysis results confirm that scientific and technological innovation plays a particularly prominent positive role in promoting green and low-carbon development. With the development of the economy, the continuous increase in R&D investment and the steady increase in the number of patents are like injecting a powerful driving force, effectively reducing the carbon emission intensity per unit of GDP. In the action of energy conservation and emission reduction, technological innovation undoubtedly plays a core role, like a lighthouse leading the way, illuminating the path of green and low-carbon development.

The coupling coefficient between the optimization of the energy structure and technological innovation shows a positive value, which means that technological innovation and the progress of clean energy are intertwined, forming a powerful joint force that jointly promotes the optimization and upgrading of the energy structure and then strongly promotes the pace of the green and low-carbon transformation. The adjustment of the industrial structure is of great significance for promoting green and low-carbon development. By reducing the proportion of high-energy-consuming industries in the overall industry, the potential of technological innovation in emission reduction can be significantly improved.

The empirical analysis shows that there is an inverted U-shaped influence law between the level of economic development and the green and low-carbon development model. In the initial stage of economic growth, the expansion of economic activities is closely related to the increase in carbon emissions because in this stage, economic development more depends on traditional high-energy-consuming industries. However, when entering a new stage of development, economic growth will accelerate the pace of green and low-carbon development, and at this time, factors such as technological innovation and industrial structure adjustment begin to play a greater role. Policy makers should use the results of this study as a key support for decision-making and formulate policies that are more in line with the actual situation to promote green and low-carbon development.

2.4 Robustness Test

Striving for the authenticity and reliability of the empirical research data, it is crucial to implement a multi-field robustness test process. The core explanatory variables are replaced, and the proportion of R&D investment is replaced with the full-time equivalent indicator of R&D personnel. The purpose of this is to explore the stability of the influence of technological innovation on green and low-carbon development from different angles and avoid the deviation of the results caused by the limitations of a single indicator.

The parameter configuration of the model is further optimized, and diverse estimation methods such as the fixed effects model and the random effects model are used for comparative analysis. These different models have their own characteristics, and through comparative analysis, the optimal form of the model can be more accurately determined.

Group tests are carried out on the samples. According to the regional economic development level and energy resource

endowment, the samples are classified to evaluate the different impacts of technological development on the implementation of the green and low-carbon strategy. There are differences in the economic development level and energy resource endowment in different regions, and the role of technological development in these regions will also vary. Strategies such as removing abnormal samples and adding control variables are adopted to conduct an in-depth test on the stability of the model.

After a series of strict test processes, the empirical research confirms that the positive driving effect of technological innovation on green and low-carbon development is still obvious. The empirical analysis results reveal the stability and reliability of the conclusions, which also provides a solid foundation for subsequent research and policy formulation.

3 Conclusion

This paper conducts an academic discussion with the theoretical background of low-carbon economics. The empirical analysis confirms that technological innovation is the key driving force for green and low-carbon development. The research conclusions are confirmed that technological innovation is an effective way to achieve a reduction in carbon emissions, helping the economic field move towards a new stage of green transformation and building a solid support system for realizing sustainable development. After the robustness test, the credibility of the research conclusions is effectively enhanced. Future research should deeply analyze the specific impacts of various technological innovation-induced effects and their promotion of human civilization progress, and discuss the applicable scope of countries and regions around the world.

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