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Research on the Impact of New Quality Productivity on the Level of Green and Low-Carbon Development

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Abstract

Against the backdrop of global warming and increasingly prominent environmental issues, green and low-carbon development has become a common pursuit of the international community. In this context, the concept of new-form productivity provides a new theoretical and practical pathway for sustainable development. This paper employs panel data from 30 provinces (municipalities, and autonomous regions) in China from 2010 to 2022, constructs relevant indicators, and uses the TOPSIS entropy weight method to calculate the levels of new-form productivity and green and low-carbon development in each province. Combining a fixed-effects model, we empirically analyze the impact of new-form productivity on the level of green and low-carbon development and its mechanism of action. The results show that new-form productivity can enhance the level of green and low-carbon development by improving technological levels and promoting consumer upgrading. However, this impact effect varies across regions. In the economically developed eastern regions, where the industrial structure is more mature, the transformation effect of new-form productivity is more evident. In contrast, the central and western regions, constrained by the level of infrastructure construction, still need to enhance the impact of new-form productivity on the level of green and low-carbon development.

Keywords

New-form productivity; Green and low-carbon; Mechanism of impact; Energy conservation and emission reduction; Panel data

1. Introduction and Literature Review

The concept of green development has become a societal consensus, and promoting the greening of economic and social development is key to achieving high-quality development. How to pursue a green development path relies not only on government policy tools but also on the active role of social productive forces [1]. The Third Plenary Session of the 20th Cen-tral Committee of the Communist Party of China, in its decision on further comprehensively deepening reform and advancing

Chinese modernization, pointed out the need to "improve the institutional mechanisms for devel-oping new-form productivity in accordance with local conditions" and to "develop green and low-carbon industries, improve incentive mechanisms for green consumption, and promote the construction of a green, low-carbon, and circular economic system." Under the guidance of the "dual carbon" goals and the construction of ecological civilization, developing new-form productivity in accordance with local conditions and green and low-carbon development are inherently integrated and harmoniously coex-istent as a unified whole. New-form productivity is an advanced form of productive force led by innovation, breaking through traditional economic growth models and paths of productive force development. It is charac-ter-ized by high technology, high efficiency, and high quality, and is in line with the new development philosophy [2]. New-form productivity originates from revolutionary technological breakthroughs, innovative allocation of production factors, and in-depth transformation and upgrading of indus-tries. Its core connotation lies in the qualitative improvement of the com-bination of laborers, means of labor, objects of labor, and their optimized integration, with significant improvement in total factor productivity as the key indicator. With the progress of science and technology, economic de-velopment, and the evolution of industrial forms, the theoretical connota-tions of new-form productivity are becoming increasingly enriched, and its practical significance is also becoming more profound [3].

In fact, studying the impact mechanism of new-form productivity on green and low-carbon development is of great significance for promoting a fun-damental transformation of the economic growth model and achieving a virtuous interaction between economic development and environmental protection [4]. China's economy has entered a stage of high-quality devel-opment, and the traditional economic growth model characterized by high input, high consumption, and high pollution no longer meets the require-ments of modern society. There is an urgent need to shift towards a green, circular, and low-carbon economic model [5]. A thorough analysis of the key role of new-form productivity in green and low-carbon development can provide strong support for optimizing the industrial structure and guide the flow of resources towards more environmentally friendly and efficient industrial fields. It also helps to enhance public awareness of the im-portance of green and low-carbon development and to encourage all sectors of society to actively participate in environmental protection and climate change actions. The driving force of emerging technological innovation is gradually emerging, and the new round of technological revolution and in-dustrial transformation has injected new vitality into economic and social development. The cultivation and development of new-form productivity have become the core force in promoting economic transformation and up-grading. Therefore, it is very necessary to integrate the development con-cept of new-form productivity into the goal of green and low-carbon de-velopment.

The concept of new-form productivity has attracted widespread attention in the academic community. At present, research on new-form productivity focuses on its connotation and form (Luo Bilian, 2024; Guo Fei, 2025) [6][7], measurement and evaluation (Wang Shaohua, 2025; Yan Ke'gao, 2025) [8][9], and impact effects (Yang Ximing, 2025; Huang Danli, 2025) [10][11], and has achieved a series of fruitful results. In terms of connotation, Li Zheng et al. (2024) believe that new-form productivity is the continuous improvement in quality of productive forces factors, showing the direction of updating and progress of productive forces [12]. Hu Ying et al. (2024) ar-gue that new-form productivity is closely related to emerging industries and fields, with innovation as the core [13]. In terms of measurement, Li Yongjian et al. (2025) constructed an evaluation index of new-form produc-tivity development level from three dimensions: new types of productive forces factors, new types of combination modes of elements, and new types of production relations, and comprehensively measured the development level of new-form productivity in China [14]. Huang Huayi et al. (2025) be-lieve that the emergence of scientific and technological innovation, the in-tegration of elements, the expansion and strengthening of industrial chains, and the reconstruction of new types of production relations are four links in the development of new-form productivity. Based on these four links, an evaluation index system for the development level of new-form productivi-ty was constructed [15]. In terms of impact effects, Liu Junting et al. (2025) explored the impact of new-form productivity on China's green trade from the perspective of export margins. The study found that new-form produc-tivity has a positive effect on both the intensive and extensive margins of green trade exports [16]. Ma Dan et al. (2025) studied the impact of new-form productivity on urban industrial chain resilience and found that new-form productivity plays a promoting role in enhancing industrial chain resilience [17].

Since the 18th National Congress of the Communist Party of China proposed the concept of green and low-carbon development, Chinese scholars have conducted a large number of related studies. At present, research on green and low-carbon development mainly focuses on the level of green devel-opment, green transformation, and related impact mechanisms. Liu Anzhi et al. (2025) constructed an index system based on the connotation of agri-cultural green and low-carbon development from four dimensions: "carbon reduction, pollution reduction, greening expansion, and growth." They an-alyzed the level, spatiotemporal characteristics, and regional differences of agricultural green and low-carbon development in China from 2011 to 2020. The study shows that agricultural green and low-carbon development is in-fluenced by multiple factors such as agricultural fiscal support, agricultural production efficiency, and adjustment of planting structures. Currently, most provinces in the country are at a relatively low level of agricultural green and low-carbon development, with significant regional differences [18]. Xu Kexi et al. (2025) developed a theoretical framework for assessing the quality of urban green and low-carbon development through multi-scale spatial and multi-objective interactions. They constructed a localized eval-uation index system considering the rationality and operability of indica-tors and conducted empirical research on the index system in Hangzhou. The study shows that promoting urban green and low-carbon development can achieve pollution reduction, economic growth, and improvement of people's livelihoods [19]. In terms of green transformation, Qiu Huanguang et al. (2025) explored the connotation and theoretical logic of agricultural green transformation and high-quality coordinated development, analyzing the difficulties and challenges faced by China in achieving agricultural green transformation and high-quality coordinated development. The study shows that the key to future agricultural development in China is to achieve green transformation and high-quality coordinated development while ensuring food security [20]. Huang Fang et al. (2024) studied the problems encoun-tered by resource-based cities in China during the green transformation process and found that a single economic structure, short industrial chains, and ecological destruction and environmental pollution caused by resource extraction and processing severely restrict the sustainable development of resource-based cities in China. To solve these problems, industrial green transformation is necessary [21]. In terms of impact mechanisms, Dai Qi-wen et al. (2025) studied the impact mechanism of green financial policies on corporate green development and found that the implementation of green credit policies significantly promotes corporate green development and improves green production, green innovation, environmental quality, and green institutional levels [22]. Jiang Fan et al. (2024) studied the level of agricultural green development in Hebei Province and its influencing factors. The results show that ecological environment security is the main factor hindering agricultural green development in Hebei Province, fol-lowed by resource conservation and breeding factors [23].

At present, research on new-form productivity and green and low-carbon development is relatively abundant, but studies on the impact mechanisms between the two are still relatively scarce. Hao Miyan et al. (2024) con-ducted an empirical study on the impact mechanism of new-form produc-tivity on the low-carbon transformation of the livestock industry and found that new-form productivity can significantly promote the low-carbon transformation of livestock enterprises. In terms of impact mechanisms, green new-form productivity can drive the low-carbon transformation of livestock enterprises through promoting green technological innovation and industrial structure upgrading [24]. Guo Shaohua et al. (2024) studied the mechanism by which agricultural new-form productivity promotes the leap in agricultural green total factor productivity and found that agricul-tural new-form productivity promotes the leap in agricultural green total factor productivity through two pathways: industrial structure upgrading and industrial cluster development, with more pronounced effects in areas with higher levels of new-form productivity [25]. Guo Shaohua et al. (2024) explored the direct impact of new-form productivity on agricultural carbon emission intensity and its non-linear effects. The empirical results show that new-form productivity reduces agricultural carbon emission intensity by improving agricultural labor productivity, but its effect is influenced by factors such as the intensity of agricultural fiscal support, major grain-producing areas, and the Yangtze River Economic Belt. However, the effect shows an inverted U-shaped relationship, with carbon emission in-tensity rebounding after new-form productivity reaches a certain level [26].

In summary, current research in China on the impact mechanisms between new-form productivity and green and low-carbon development is still rela-tively limited, mainly focusing on agriculture and the livestock industry, while research on regional differences is relatively scarce. Based on this, this paper uses panel data from 30 provinces (municipalities, and autono-mous regions) in China from 2010 to 2022 to construct relevant indicators. Using the TOPSIS entropy weight method, we measured the levels of new-form productivity and green and low-carbon development in each province. Combined with a fixed-effects model, we empirically analyzed the impact of new-form productivity on the level of green and low-carbon de-velopment and its mechanism of action, and proposed corresponding policy recommendation.

2. Theoretical Analysis and Research Hypotheses

2.1 The Direct Effect of New-Form Productivity on the Level of Green and Low-Carbon Development

Looking at the development history of China, traditional industries such as agriculture and industry have long relied heavily on natural resources, hu-man resources, and animal power. These industries have focused primarily on increasing output and expanding scale, resulting in a development model characterized by high carbon emissions, low greenness, and relatively low quality. In contrast, new-form productivity emphasizes innovation in mod-els, technology, and management. It is inherently rich in elements such as innovation, information, and data, which are replacing traditional produc-tion factors and becoming the dominant factors influencing the production of traditional industries in China. Ultimately, this shift drives the devel-op-ment toward low-carbon and green practices. Based on this, the following hypothesis is proposed:

Hypothesis 1: The development of new-form productivity has a positive ef-fect on the level of green and low-carbon development.

2.2 The Mechanisms through Which New-Form Productivity Affects the Level of Green and Low-Carbon Development

2.2.1 Technological Progress: Optimizing Resource Allocation

New-form productivity places special emphasis on the significant contributions of technology to the development of various industries in China. These contributions are not only reflected in the robustness, stability, and rational structure of development, but also in its green and low-carbon nature. In the agricultural sector, the development of various high-tech approaches, such as waste-to-land technology, carbonization and fixation techniques, and technologies for converting waste into fertilizers, feed, or fuel, can help improve soil quality and increase the comprehensive utilization rate of waste. In the industrial sector, the development of decarbonization technologies and carbon dioxide capture and storage techniques can effectively control carbon emissions. Additionally, the development and application of biofuels, reduced reliance on traditional fossil fuels like coal, and increased use of clean energy sources such as natural gas can also effectively lower carbon emissions. The construction industry is also a significant source of carbon emissions in China. According to the latest statistics, in 2024, the total carbon emissions from the construction and building sectors in China amounted to 4.73 billion tons of carbon dioxide, accounting for 41.6% of the country's energy-related carbon emissions. By using efficient insulation materials, airtight designs, and optimized building layouts, energy consumption in buildings can be significantly reduced. Moreover, the application of artificial intelligence and Internet of Things technologies to monitor energy and water usage in real time can optimize energy management and reduce energy consumption during the construction process. Based on this, the following hypothesis is proposed:

Hypothesis 2: New-form productivity enhances the level of green and low-carbon development by promoting technological progress.

2.2.2 Upgrading of Consumer Demand: Promoting Circular Economy

As an advanced form of productivity, new-form productivity contains a large amount of data and information, which helps to break the spatial constraints on the flow of production factors and products. On the one hand, it guides workers to choose suitable jobs based on their skills and resource endowments, promoting employment diversification and rationalization of the industrial structure. On the other hand, with the development of Internet technology, the sales channels for various goods in China have become more diverse, and the market scope has been further expanded. This has accelerated the growth of residents' income to some extent, thereby promoting the upgrading of consumer demand. The upgrading of consumer demand, in turn, provides momentum for the development of green and low-carbon levels. Specifically, according to the Environmental Kuznets Curve hypothesis, as people's income levels rise, environmental pollution first increases and then decreases. The upgrading of consumer demand enhances environmental awareness, providing a driving force for low-carbon and green development. Moreover, the upgrading of consumer demand improves people's living standards, making them more concerned about health issues in daily life. This drives the development of various goods in the directions of green and low-carbon in aspects such as clothing, food, housing, and transportation. Based on this, the following hypothesis is proposed:

Hypothesis 3: New-form productivity enhances the level of green and low-carbon development by promoting the upgrading of consumer demand.

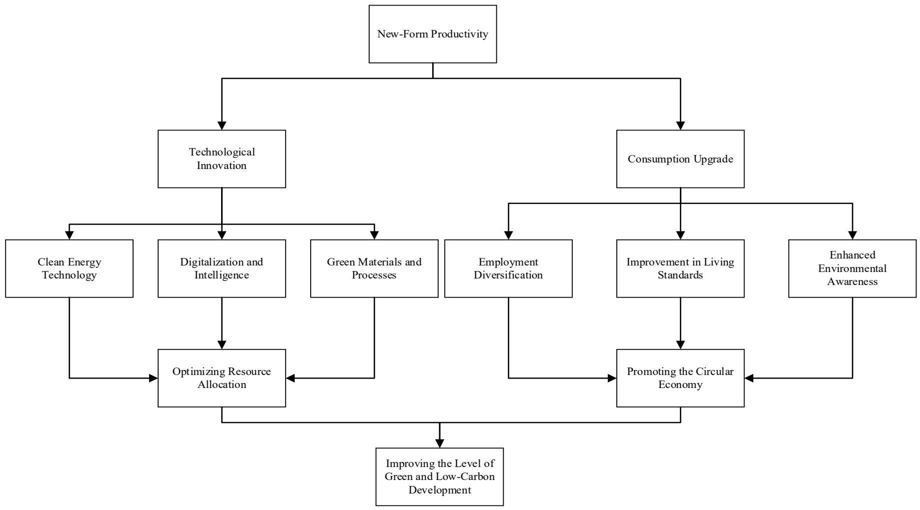

Figure 1: Mechanisms through Which New-Form Productivity Affects the Level of Green and Low-Carbon Development

3 Research Design

3.1 Research Method

3.1.1 TOPSIS Entropy Weight Method.

The traditional entropy weight method primarily focuses on calculating weights based on the degree of data variation. Although it is relatively objective in weight calculation, it is difficult to distinguish the subtle differences between evaluation objects solely based on weights. Moreover, it lacks a comprehensive judgment of the overall superiority or inferiority of the evaluation objects. By integrating the TOPSIS method with the entropy weight method, the differences between each evaluation object and the ideal solution as well as the negative ideal solution can be calculated. This approach can comprehensively reflect the superiority or inferiority of the evaluation objects and the differences between different schemes. This combined method not only overcomes the limitations of a single method but also enhances the scientific and accuracy of the evaluation results through the objective weighting of indicators by the entropy weight method. In practical applications, this method can be widely used in the field of multi-indicator comprehensive evaluation, such as project assessment, performance evaluation, and regional development comparison. It provides decision-makers with more valuable quantitative references, helping them quickly identify the optimal solutions in complex and changing decision-making environments [30]. The core steps are as follows:

① Homogenize the raw data (this paper chooses to normalize the indicators in a positive direction).

For minimization indicators:

$$X' = M - X \tag{1}$$

(M represents the maximum value of the indicator among all provinces, and X represents the value of the indicator for the specific province.)

Since this data set does not involve intermediate-type indicators and interval-type indicators, they are not elaborated upon.

②Construct the standardized matrix:

$$Z_{ij} = \frac{X_{ij}}{\sqrt{\sum_{k=1}^{n}\left(X_{ij}\right)^2}} \tag{2}$$

③ Calculate the distances between each evaluation indicator and the optimal and worst vectors. (where wj represents the weight of the j-th attribute)

Define the distance between the i-th evaluation object and the maximum value:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^+ - z_{ij}\right)^2} \tag{3}$$

Define the distance between the i-th evaluation object and the minimum value:

$$D_i^- = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^- - z_{ij}\right)^2} \tag{4}$$

④ The degree of closeness of the evaluation object to the optimal solution:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{5}$$

3.1.2 Mediation Effect Method

When exploring the influencing factors of energy resilience, it is necessary to analyze how these factors exert their effects. This study employs the mediation effect analysis method to conduct the investigation. This method can reveal the pathways through which the independent variable X affects the dependent variable Y, that is, whether X has a direct effect on Y or indirectly influences Y through a mediating variable M. It can also measure the strength of the mediating effect of M. Wen Zhonglin proposed that if step-by-step testing yields significant results, there is no need to worry about the power of the test [31]. Through comprehensive analysis, this study ultimately adopts the method of step-by-step testing of regression coefficients to determine the presence or absence of the mediating effect. The equations for testing are as follows:

$$Y = cX + e_1 \tag{6}$$

$$M = aX + e_2 \tag{7}$$

$$Y = c'X + bM + e_3 \tag{8}$$

First step: Testing the total effect of the independent variable X on the dependent variable Y represented by coefficient c in Equation (6). If c is significant, proceed to the next step; if c is not significant, it may indicate the presence of a suppression effect, and other methods should be considered for testing.

Second step: Testing the effect of the independent variable X on the mediating variable M represented by coefficient a in Equation (7); and testing the effect of the mediating variable M on the dependent variable Y after controlling for the influence of the independent variable X, represented by coefficient b in Equation (7). The mediating effect is the product of coefficients a and b. If both coefficients a and b are significant, proceed to the next step; otherwise, conduct a further Sobel test.

Third step: Testing the direct effect of the independent variable X on the dependent variable Y after controlling for the influence of the mediating variable M, represented by coefficient c′ in Equation (8). If coefficient c′ is significant, the mediating effect is significant; if c′ is not significant, it indicates a full mediating effect.

3.2 Model Construction

Compared with traditional cross-sectional or time-series data, panel data provides more information, thereby enhancing the efficiency of model estimation. The fixed-effects model, by controlling for individual heterogeneity, can more accurately estimate the relationships between variables and reduce estimation errors. Based on the model and literature analysis [32], this paper proposes to construct a two-way fixed-effects model to explore the impact of new-form productivity on the level of green and low-carbon development. The two-way fixed-effects model can control for potential confounding factors, improve estimation efficiency, and capture dynamic effects, thereby providing a more comprehensive analysis of the relationship between the two. The specific empirical model is set as follows:

$$glc_{it} = \beta nqp_{it} + \gamma X_{it} + \sigma_i + \mu_i + \varepsilon_{it} \tag{9}$$

3.3 Variable Description

3.3.1 Core Explanatory Variable

New-form productivity is a complex entity that includes at least three major elements: digital, green, and technology. Its evaluation and measurement require the use of multi-attribute comprehensive evaluation methods. The application of comprehensive evaluation methods in the field of economic management has become quite mature. The core operations include four steps: establishing an evaluation system, processing evaluation data, determining indicator weights, and constructing an evaluation model. The systematic and scientific nature of these steps has led to their wide application in various fields, such as the evaluation of high-quality development levels, measurement of common prosperity, and the evaluation and measurement of Chinese-style modernization. These methods can effectively handle complex issues with multiple indicators and dimensions, providing a scientific basis for decision-making [33][34]. Referring to existing research results, we have constructed a comprehensive evaluation system that includes 3 first-level indicators, 6 second-level indicators, and 15 third-level indicators. We have used an improved TOPSIS entropy weight method to weight each indicator and then calculate the level of new-form productivity development [35][36]. The specific indicators are shown in Table 2.

Table 2. Evaluation Indicator System for New-Form Productivity

First-Level Indicator	Second-Level Indicator	Third-Level Indicator	Unit	Indicator Attribute
Technology Productivity	Innovation Productivity	Number of Patents Authorized by Region	Units	+
		Revenue of High-Tech Industry	Thousand Yuan	+
		Innovation Funding of Large-Scale Industrial Enterprises	Ten Thousand Yuan	+
	Technological Productivity	Full-Time Equivalent of R&D Personnel in Large-Scale Industrial Enterprises	Hours	+
		Labor Productivity of Large-Scale Industrial Enterprises	%	+
Green Productivity	Resource-Efficient Productivity	Energy Consumption / Gross Domestic Product (GDP)	%	—
	Environment-Friendly Productivity	Industrial Water Consumption / GDP	%	—
		Comprehensive Utilization of Industrial Solid Waste / Generation Volume	%	+
		Industrial Wastewater Discharge GDP	%	—
		Industrial SO_2 Emissions / GDP	%	—
Digital Productivity	Digital Industry Productivity	Total Volume of Telecommunications Business	Hundred Million Yuan	+
	Industrial Digital Productivity	Number of Internet Broadband Access Ports	Ten Thousand Units	+
		Revenue from Software Business	Ten Thousand Yuan	+
		Optical Cable Length / Regional Area	Meters	+
		E-commerce Sales	Ten Thousand Units	+

The weight calculation results of the entropy weight method for new-form productivity are shown in Table 3. By analyzing the weights of the indicators, we can observe the differences in the contributions of various indicators to the comprehensive evaluation model. First, looking at the entropy values (e), the entropy values of all indicators are generally high, indicating that the data have a certain degree of dispersion and can reflect the differences among the evaluation objects. Further examining the information utility values (d) and weights (%), we can see that the indicators "software business revenue (ten thousand yuan)" and "revenue of high-tech industry (thousand yuan)" have relatively high information utility values and weights, reaching 0.238 and 15.001%, as well as 0.206 and 12.963%, respectively. This indicates that these two indicators hold a more important position in the evaluation system. Their data dispersion is relatively large, providing effective distinguishing information for the differences among the evaluation objects. In contrast, some indicators have relatively low weights, indicating that their contributions to the comprehensive evaluation are smaller.

Since new-form productivity is a concept involving multiple indicators, and each indicator covers a different scope, it is normal for there to be differences in the influence of each indicator on the results. Moreover, the entropy method is an objective way to determine weights. It does not rely on subjective judgment but is directly calculated from the data. Therefore, the differences in weights are a direct reflection of the characteristics of the data themselves. Although indicators such as "industrial wastewater discharge per GDP" and "comprehensive utilization of industrial solid waste per generation volume" have lower weights, considering their actual impact in real life, these indicators are still important for evaluating the level of new-form productivity in a region.

Table 3. Weight Calculation Results of the Entropy Weight Method for New-Form Productivity

Item	Entropy Value *e*	Information Utility Value *d*	Weight (%)
Full-Time Equivalent of R&D Personnel in Large-Scale Industrial Enterprises (h)	0.885	0.115	11.098
Comprehensive Utilization of Industrial Solid Waste / Generation Volume	0.98	0.02	1.919
Innovation Funding of Large-Scale Industrial Enterprises (Ten Thousand Yuan)	0.889	0.111	10.694
Total Volume of Telecommunications Business (Hundred Million Yuan)	0.893	0.107	10.345
Revenue of High-Tech Industry (Thousand Yuan)	0.884	0.116	11.256
E-commerce Sales (Ten Thousand Yuan)	0.867	0.133	12.886
Optical Cable Length / Regional Area	0.9	0.1	9.712
Revenue from Software Business (Ten Thousand Yuan)	0.882	0.118	11.404
Number of Internet Broadband Access Ports (Ten Thousand)	0.942	0.058	5.579
Number of Patents Authorized by Region	0.868	0.132	12.796
Energy Consumption / Gross Domestic Product (GDP)	0.989	0.011	1.081
Industrial Water Consumption / GDP	0.994	0.006	0.595
Industrial SO_2 Emissions / GDP	0.997	0.003	0.322
Industrial Wastewater Discharge / GDP	0.997	0.003	0.312

3.3.2 Dependent Variable

The construction of the green and low-carbon development level indicator is a systematic project, involving the consideration of multiple dimensions and indicators. The degree of green and low-carbon development in a region also needs to be assessed comprehensively from various aspects, including environment and ecology, to ensure a comprehensive evaluation of the green and low-carbon development level of a region or city. Drawing on existing research results [37][38], this paper clarifies the specific evaluation connotations and criteria of each evaluation dimension, and integrates the availability and operability of data to construct two first-level indicators, five second-level indicators, and 26 third-level indicators. A multi-dimensional indicator evaluation system has been built from multiple aspects such as pollutant emission treatment and environmental governance investment. The specific content is shown in Table 4.

Table4. Comprehensive Evaluation Indicator System for Green and Low-Carbon Development Level

First-Level Indicator	Second-Level Indicator	Third-Level Indicator	Unit	Indicator Attribute
Green	Green City	Wastewater Treatment Plant	Units	+
		Reclaimed Water Volume	Ten thousand tons	+
		Urban Wastewater Treatment Rate	Percentage (%)	+
		Municipal Solid Waste Collection Volume	Ten thousand tons	+
		Number of Harmless Treatment Plants	Units	+
		Capacity for Harmless Treatment of Municipal Solid Waste	Tons per day	+
		Volume of Harmless Treatment of Municipal Solid Waste	Ten thousand tons	+
		Rate of Harmless Treatment of Municipal Solid Waste	Percentage (%)	+
	Green Environment	Green Coverage Rate in Built-Up Areas (%)	Percentage (%)	+
		Forest Coverage Rate (%)	Percentage (%)	+
	Green Investment	Investment Completed for Industrial Pollution Control	Ten thousand yuan	+
		Investment Completed for Wastewater Treatment Projects	Ten thousand yuan	+
		Investment Completed for Air Pollution Control Projects	Ten thousand yuan	+
	Green Finance	Total Credit for Environmental Protection Projects	Hundred million yuan	+
		Investment in Environmental Pollution Control (Hundred Million Yuan)	Hundred million yuan	+
		Revenue from Environmental Pollution Liability Insurance (Hundred Million Yuan)	Hundred million yuan	+
		Total Issuance Amount of Green Bonds (Hundred Million Yuan)	Hundred million yuan	+
		Fiscal Expenditure on Environmental Protection (Hundred Million Yuan)	Hundred million yuan	+
		Carbon Trading, Energy Rights Trading, and Pollution Rights Trading (Hundred Million Yuan)	Hundred million yuan	+
Low-Carbon	Carbon Emissions	Total Carbon Emissions - Carbon Dioxide (Ten Thousand Tons)	Ten thousand tons	—
	Industrial and Agricultural Carbon Emissions	Carbon Emissions from Industrial Production Processes	Ten thousand tons	—
		Carbon Emissions from Agriculture, Forestry, and Land Use Changes	Ten thousand tons	—
	Lifestyle Carbon Emissions	Carbon Emissions from Transportation and Buildings	Ten thousand tons	—
		Carbon Emissions from Waste Treatment	Ten thousand tons	—
		Carbon Emissions from Purchased Electricity	Ten thousand tons	—
		Carbon Emissions from Heating and Cooling	Ten thousand tons	—

The weight calculation results of the entropy weight method for the level of green and low-carbon development are shown in Table 5. From the given data, we can observe the differences in the entropy values (e), information utility values (d), and weights (%) of various indicators. Among them, the indicator with the highest weight is the "urban wastewater treatment rate," with a weight as high as 31.006%, significantly exceeding other indicators. This result indicates that in assessing the comprehensive performance of environmental protection and green development, the "urban wastewater treatment rate" holds an extremely important position, and its value has a significant impact on the overall evaluation results.

In addition, several other indicators also have relatively high weights, such as the "total credit for environmental protection projects," "volume of reclaimed water," and "investment completed for wastewater treatment projects," with weights of 16.565%, 8.988%, and 5.315%, respectively. These indicators also play important roles in the comprehensive evaluation, reflecting the emphasis on funding investment, resource utilization, and pollution control in the field of environmental protection and green development.

It is worth noting that some indicators have relatively low weights, such as "forest coverage rate," "green coverage rate in built-up areas," and "harmless treatment rate of municipal solid waste," all of which are below 1%. This does not mean that these indicators are unimportant. The entropy method is an objective way to determine weights. It does not rely on subjective judgment but is directly calculated from the data. Considering the actual situation, indicators with low weights, such as "forest coverage rate" and "green coverage rate in built-up areas," are still important and should not be overlooked in daily life. They remain one of the important indicators for evaluating the level of green and low-carbon development in a region.

Table 5. The Weight Calculation Results of Entropy Weight Method for Green and Low-Carbon Level

Item	Entropy Value e	Utility Value d	Weight (%)
Fiscal Expenditure on Environmental Protection (billion yuan)	0.961	0.039	2.222
Forest Coverage Rate (%)	0.965	0.035	2.011
Greening Coverage Rate in Built-up Areas (%)	0.992	0.008	0.445
Total Issuance of Green Bonds (billion yuan)	0.961	0.039	2.243
Transactions of Carbon Emissions, Energy Use Rights, and Pollution Rights (billion yuan)	0.977	0.023	1.351
Revenue from Environmental Pollution Liability Insurance (billion yuan)	0.979	0.021	1.193
Municipal Solid Waste Collection Volume	0.949	0.051	2.928
Investment in Environmental Pollution Control (billion yuan)	0.981	0.019	1.109
Total Credit for Environmental Protection Projects	0.713	0.287	16.565
Municipal Solid Waste Sanitization Rate	0.994	0.006	0.326
Municipal Solid Waste Sanitization Volume	0.945	0.055	3.161
Municipal Solid Waste Sanitization Capacity	0.94	0.06	3.462
Number of Sanitization Plants	0.959	0.041	2.381
Investment Completed in Exhaust Gas Control Projects	0.918	0.082	4.7
Reclaimed Water Volume (ten thousand tons)	0.844	0.156	8.988
Investment Completed in Wastewater Control Projects	0.908	0.092	5.315
Investment Completed in Industrial Pollution Control	0.933	0.067	3.872
Urban Wastewater Treatment Rate (%)	0.462	0.538	31.006
Number of Wastewater Treatment Plants	0.955	0.045	2.576
Carbon Emissions from Agriculture, Forestry, and Land Use Changes	0.99	0.01	0.599
Total Carbon Emissions - Carbon Dioxide (ten thousand tons)	0.984	0.016	0.949
Carbon Emissions from Industrial Production Processes	0.987	0.013	0.755

Carbon Emissions from Waste Treatment	0.994	0.006	0.334
Carbon Emissions from Heating and Cooling	0.995	0.005	0.312
Carbon Emissions from Purchased Electricity	0.991	0.009	0.492
Carbon Emissions from Transportation and Buildings	0.988	0.012	0.705

3.3.3 Control Variables

The impact of new-quality productivity on the level of green and low-carbon development is a complex process, which is usually influenced by multiple factors. Firstly, in the process of urbanization, the concentration of population in cities leads to the aggregation of labor and capital, driving the industrial structure to transform towards higher-end and service-oriented sectors. This optimization of the industrial structure may help reduce the proportion of highly polluting and energy-intensive industries. Moreover, due to the different levels of economic development across provinces in the country, there may be disparities in the number of talents, taxation, and informatization, which may in turn affect the local level of green and low-carbon development. Based on this, and referring to existing literature [39], the following control variables are selected in this paper: Urbanization Rate (czhl), calculated as the proportion of urban population to the total resident population at the end of the year; Number of Talents (nt), measured by the number of local science and technology talents; Level of Informatization (loi), calculated as the ratio of local postal and telecommunications business volume to regional production volume; Industrial Structure (cyjg), measured by the ratio of the added value of the tertiary industry to that of the secondary industry; Tax Burden Level (ltb), calculated as the ratio of tax revenue to regional gross domestic product.

3.3.4 Mediating Variable

New-quality productivity emphasizes technological innovation as a core element, and its essence is to drive a qualitative change in productivity through high-level technological innovation. Technological innovation not only directly improves production efficiency but also promotes green and low-carbon development through optimizing resource allocation, popularizing green technologies, and enhancing energy utilization efficiency. In addition, the development of new-quality productivity can directly increase residents' income and consumption capacity. With the improvement of residents' consumption level, the consumption structure is also continuously upgrading, shifting from traditional material consumption to a more technology-oriented, green, and service-oriented direction. This consumption upgrade not only provides a demand basis for new-quality productivity but also feeds back to the production side through market mechanisms, encouraging enterprises to adopt green and low-carbon technologies [40]. Based on this, this paper selects the following mediating variables: Technological Level (est), measured by the proportion of science and technology expenditure in the total fiscal expenditure, and Residents' Consumption Level (rcl), measured by per capita consumer expenditure.

3.4 Data Sources and Descriptive Statistics

The data are primarily sourced from the China Energy Statistical Yearbook, China Statistical Yearbook, China Environmental Statistics Yearbook, China Science and Technology Statistical Yearbook, and China Industrial Statistics Yearbook. For some missing data, we used the moving average method and interpolation to fill in the gaps.

The descriptive statistical analysis of the variables and relevant data from 2010 to 2021 is shown in Table 8. The results indicate that the average value of New-Quality Productivity (NQP) is 0.179, with a maximum value of 0.697 and a minimum value of 0.065. The standard deviation is 0.087, which suggests significant differences in the level of new-quality productivity among the provinces in China. The average value of Green and Low-Carbon (GLC) is 0.207, with a standard deviation of 0.04, a minimum value of 0.113, and a maximum value of 0.447. This implies that there are substantial differences among the provinces in China in terms of green and low-carbon development. The descriptive statistical results of the control variables for each province also highlight these differences quite prominently.

Table 7. Descriptive Statistics of Variables

Variable Name	Mean	Standard Deviation	Maximum Value	Minimum Value	Observations
nqp	0.179	0.087	0.697	0.065	390
glc	0.207	0.04	0.447	0.113	390
czhl	0.595	0.116	0.896	0.338	390
nt	13.173	11.945	71.7	1.2	390
loi	1706.157	2952.906	39489.43	47.994	390
cyjg	1.327	0.737	5.283	0.527	390
ltb	0.083	0.028	0.188	0.036	390

4. Empirical Results Analysis

4.1 Model Specification Tests

4.1.1 Multicollinearity Test

Before employing a fixed-effects model, it is essential to ensure the linear independence among the explanatory variables in the model. This step is crucial to avoid instability and inaccuracy in the model estimation results due to multicollinearity issues. When there is a high degree of linear correlation among the variables, the estimates of the regression coefficients become unstable, and the standard errors increase. Consequently, the reliability of statistical tests is compromised. The test results indicate that the Variance Inflation Factor (VIF) is less than 5, which confirms that there is no significant multicollinearity problem in the model.

Table 8. Results of Multicollinearity Test

Variable	VIF	1/VIF
nqp	2.89	0.346223

czhl	2.43	0.409686
nt	3.36	0.297677
loi	1.95	0.511906
cyjg	2.44	0.409686
ltb	2.15	0.465387
Mean VIF	2.54	

4.1.2 F-Test

Due to the presence of unobservable heterogeneity among different individuals, this heterogeneity may have an impact on the dependent variable. By conducting an F-test, we can examine whether such individual heterogeneity exists. The test results are as follows. According to the test results, Prob=0.000<0.01, which indicates that the differences among individuals are significant and it is necessary to introduce a fixed-effects model.

Table 9. Results of the F-Test

glc	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
nqp	.133	.035	3.85	0	.065	.201	***
czhl	.084	.03	2.80	.005	.025	.144	***
nt	.002	0	3.55	0	.001	.003	***
cyjg	.009	.005	1.58	.116	-.002	.019	
loi	.005	.002	2.90	.004	.001	.008	***
ltb	.253	.1	2.52	.012	.056	.45	**
Constant	.048	.019	2.54	.011	.011	.085	**
Mean dependent var	0.207	SD dependent var	0.047				
R-squared	0.480	Number of obs	390				
F-test	54.422	Prob > F	0.000				
Akaike crit. (AIC)	-2005.494	Bayesian crit. (BIC)	-1977.731				
*** p<.01, ** p<.05, * p<.1							

4.2 Benchmark Model Regression Results

This paper employs a stepwise approach to regression by incrementally adding control variables. The regression results are as follows. Model 1 only includes the regression result of new-quality productivity on the level of green and low-carbon development. Models 2 to 6 demonstrate the results with the gradual addition of control variables. The results show that the coefficient of new-quality productivity is significantly positive and remains significant even after the inclusion of all control variables. This indicates that a higher level of new-quality productivity is associated with a higher level of green and low-carbon development, thereby confirming Hypothesis 1.

Table 10. Fixed-Effects Regression Results of New-Quality Productivity on the Development of Green and Low-Carbon Levels

	(1)	(2)	(3)	(4)	(5)	(6)
	glc	glc	glc	glc	glc	glc

nqp	0.293***	0.242***	0.130***	0.119***	0.147***	0.133***
	(15.305)	(10.315)	(3.918)	(3.574)	(4.224)	(3.846)
czhl		0.095***	0.123***	0.094***	0.109***	0.084***
		(3.670)	(4.767)	(3.245)	(3.731)	(2.799)
nt			0.002***	0.002***	0.001***	0.002***
			(4.599)	(4.204)	(3.178)	(3.555)
cyjg				0.012**	0.013**	0.009
				(2.231)	(2.515)	(1.575)
ltb					0.267***	0.253**
					(2.638)	(2.521)
loi						0.005***
						(2.901)
_cons	0.154***	0.107***	0.084***	0.090***	0.057***	0.048**
	(42.989)	(8.067)	(6.035)	(6.380)	(3.025)	(2.545)
N	390	390	390	390	390	390
R2	0.395	0.417	0.449	0.457	0.467	0.480
F	234.247	127.927	97.137	74.908	62.321	54.422

4.3 Robustness Test

A reverse causality test is employed to conduct the robustness test, and the results are shown in Table 11. The level of green and low-carbon development is significantly positive, indicating that regions with a high level of green and low-carbon development may also have a higher level of new-quality productivity. Thus, the model may be affected by reverse causality. Drawing on the research method of She Shuo et al. [41], this paper incorporates the level of green and low-carbon development from the previous period as a control variable into the model for examination, and the results are presented in Table 13. The analysis shows that after considering the potential impact of the previous period's level of green and low-carbon development, the estimated coefficient of the core independent variable remains significant.

Table 11. Regression Analysis Results of Reverse Causality Test

	-1
	nqp
glc	1.254***
	-13.136
_cons	-0.078***
	(-3.880)
N	360
R2	0.544
F	172.564

Table 12. Results of Robustness Test

	-1
	glc
nqp	0.011***
	-0.115
czhl	0.061*
	-1.596
nt	0.001***

	-2.769
cyjg	0.009*
	-1.519
ltb	0.262**
	-2.338
loi	0.006***
	-3.294
glc1	0.134
	-1.273
_cons	0.053**
	-2.266
N	360
R2	0.635
F	35.494

***p<0.01, **p<0.05, *p<0.10

4.4 Endogeneity Test

The primary focus of this study is the impact of new-quality productivity on the level of green and low-carbon development. However, during the empirical process, there are factors that may violate the basic assumptions of econometric models, leading to potential endogeneity issues. First, there is a bidirectional causality between new-quality productivity and the level of green and low-carbon development. On the one hand, developing new-quality productivity is a necessary path for green development. On the other hand, green development is an important requirement for the development of new-quality productivity. Second, there is the possibility of omitted variable bias. Since it is not possible to control all variables that may affect new-quality productivity, there may still be some omitted variable issues.

To address the potential endogeneity problems caused by bidirectional causality and omitted variables, this paper introduces the first-order lag of new-quality productivity as an instrumental variable to effectively mitigate the endogeneity issue. The analysis results are shown in the following table. In the first stage, the coefficient of the instrumental variable nqp1 is significantly positive, which validates the effectiveness of the instrumental variable. The regression coefficient of new-quality productivity (0.135) is significantly positive at the 1% statistical level, which is basically consistent with the previous result (0.133). This indicates that the endogeneity problem has been well controlled, ensuring the stability of the research conclusions.

Table 13. Results of Endogeneity Test

	-1	-2
	nqp	glc
nqp1	1.025***	0.135***
	-82.717	-3.707
czhl		0.061
		-1.599

nt		0.001***
		-2.782
cyjg		0.009
		-1.529
loi		0.006***
		-3.529
ltb		0.262**
		-2.339
_cons	0.006**	0.053**
	-2.473	-2.272
N	360	360
R2	0.954	0.435
F	6842.058	41.534

***p<0.01, **p<0.05, *p<0.10

4.5 Heterogeneity Analysis

4.5.1 Regional Heterogeneity of New-Quality Productivity on the Level of Green and Low-Carbon Development

Due to the uneven distribution of production efficiency, infrastructure, and technological levels, there are significant differences in the level of green and low-carbon development across regions in China. The driving effect of new-quality productivity on green and low-carbon development also exhibits spatial heterogeneity [42]. To verify this phenomenon, this study, based on provincial panel data, divides all provinces in China into three major geographical regions for analysis: Central, Western, and Eastern regions (the three Northeastern provinces are included in the Eastern region).

The test results are shown in Table 14. In all three regions—Eastern, Central, and Western—the coefficient of new-quality productivity is significantly positive, indicating that the development of new-quality productivity has a significant positive effect on the local level of green and low-carbon development in each region. However, there are differences in the t-values, suggesting variations in the impact effects of new-quality productivity, with the highest effect in the Eastern region and the lowest in the Western region. The likely reason is that the Eastern region is relatively economically developed with more mature technology application, resulting in a higher marginal effect of new-quality productivity on the level of green and low-carbon development. In contrast, the Western region may be constrained by lower technology dissemination efficiency or uneven resource distribution, leading to a weaker effect.

Looking at the results of the control variables, the urbanization rate (czhl) is positive but not significant in the Eastern and Central regions, while it is more significant in the Western region. The probable reason is that urbanization in the Eastern and Central regions is already relatively stable and mature, whereas the Western region is still in a growth phase. Regarding the number of science and technology talents (nt), the Central region shows a more significant effect, while the Eastern and Western regions have smaller impacts. This is likely because the Central region is currently making greater efforts and achieving better results in talent introduction, while the Eastern region is experiencing talent saturation and the Western region faces a talent shortage, leading to weaker effects. In terms of industrial structure (cyjg), the Western region has a stronger effect, probably because the industrial structure in the Western region is in the process of optimization, which has a greater impact on green transformation. The Eastern and Central regions, which are more stable or advanced, have smaller impacts. Regarding the tax burden level (ltb) and the level of informatization (loi), the Eastern region shows a significant positive effect, while the Central and Western regions have negative but insignificant effects. This is likely because the Eastern region is economically developed, with a larger proportion of tax revenue allocated to environmental protection investments and more complete informatization infrastructure. In contrast, the Central and Western regions, which are still in the growth phase, have relatively less investment in environmental protection and less developed informatization infrastructure.

Table 14. Results of Regional Heterogeneity Test

	Eastern	Central	(Western
	glc	glc	glc
nqp	0.155**	0.118***	0.094***
	-2.245	-1.887	-1.254
czhl	0.107	0.014	0.043**
	-1.11	-0.154	-1.558
nt	0.001	0.003**	0
	-1.588	-2.335	-0.555
cyjg	0.003	0.028*	0.021***
	-0.28	-1.834	-3.287
ltb	0.624***	-0.282	-0.019
	-2.886	(-1.115)	(-0.169)
loi	0.008*	0.003	0.002
	-1.74	-1.638	-1.415
_cons	-0.021	0.112***	0.110***
	(-0.306)	-4.586	-5.337
N	169	78	143
R2	0.482	0.693	0.444
F	15.444	24.886	16.776

***p<0.01, **p<0.05, *p<0.10

4.5.2 Heterogeneity of New-Quality Productivity on the Level of Green and Low-Carbon Development Based on the Level of Economic Development

Provinces with different levels of economic development have significant differences in production methods, resource endowments, and policy support, which may lead to different emission reduction effects of new-quality productivity in these two types of regions. Below, based on indicators such as total economic output and per capita GDP, the provinces in China can be divided into two major categories: provinces with high economic development levels and those with general economic development levels for verification. From the regression results, the impact of new-quality productivity on the level of green and low-carbon development is significantly positive in both regions with high economic development and those with general economic development, indicating that new-quality productivity has a positive promoting effect on the level of green and low-carbon development. However, the coefficient is higher in the high-level regions, suggesting that the impact effect of new-quality productivity on the level of green and low-carbon development is stronger in these regions. The likely reason is that high-level economic regions usually have complete scientific research infrastructure and mature industrial chains, which can form a positive feedback loop of innovation-reduction through linkages in technology, market, and talent, making new-quality productivity more efficiently converted into green and low-carbon results.

In terms of control variables, the urbanization rate and industrial structure are negative or insignificant in high-level economic regions but significantly positive in regions with general economic development. The probable reason is that the urbanization rate and industrial structure in high-level economic regions have already become stable and mature, with limited development space, while in regions with general economic development, they are still in a growth phase and have a larger development space. Meanwhile, science and technology talents, taxation, and the level of informatization are significantly positive in high-level economic regions but not significant in regions with general economic development. This may be related to the different levels of infrastructure construction in the two regions. High-level economic regions have a higher degree of infrastructure completeness, which is superior to regions with general economic development in terms of informatization level, talent introduction efforts, and green investment, thus leading to better conversion effects on the level of green and low-carbon development.

Table 15. Results of Heterogeneity Test Based on the Level of Economic Development

	(High Level)	(Mid Level)
	glc	glc
nqp	0.145***	0.015**
	-3.779	-0.151
czhl	0.076	0.114**
	-1.386	-2.056
nt	0.002***	0.002
	-3.346	-1.626

cyjg	-0.002	0.014*
	(-0.298)	-1.85
ltb	0.342**	0.183
	-2.171	-1.336
loi	0.010***	0.003
	-3.294	-1.632
_cons	0.009	0.062***
	-0.229	-2.65
N	143	247
R2	0.699	0.461
F	48.774	13.041

4.6 Analysis of the Mechanism of Action

4.6.1 Mechanism of Technological Level

As analyzed earlier, new-quality productivity enhances the level of green and low-carbon development by promoting technological progress. The test results are shown in Table 16. In Model 1 and Model 2, new-quality productivity has a significantly positive impact on both the level of green and low-carbon development and the technological level. In Model 3, after including the technological level as a mediating variable, the coefficient of new-quality productivity remains positive but is reduced compared to Model 1, indicating that the technological level has played a partial mediating role in the process of new-quality productivity improving the level of green and low-carbon development. New-quality productivity, through the development of various high-tech technologies and the optimization of resource management, has significantly improved the level of green and low-carbon development. Hypothesis 2 is confirmed.

Table 16. Test of the Mechanism of Technological Level

	-1	-2	-3
	glc	est	glc
nqp	0.293***	0.052***	0.260***
	-15.305	-11.162	-11.844
est			0.621***
			-2.916
_cons	0.154***	0.012***	0.147***
	-42.989	-13.704	-33.486
N	390	390	390
R2	0.395	0.258	0.409
F	234.247	124.593	123.825

4.6.2 Mechanism of Residents' Consumption Level

New-quality productivity promotes employment diversification and rationalization of the industrial structure, thereby increasing residents' income and subsequently promoting residents' consumption level. This leads to residents paying more attention to health issues in their lives, which in turn encourages industries to develop in a green and low-carbon direction. The test results are shown in Table 17. In Model 1 and Model 2, new-quality productivity has a significantly positive impact on both the level of green and low-carbon development and the consumption level. In Model 3, after including the consumption level as a mediating variable, the coefficient of new-quality productivity remains positive but is reduced compared to Model 1, indicating that the consumption level has played a partial mediating role in the process of new-quality productivity improving the level of green and low-carbon development. Hypothesis 3 is confirmed.

Table 17. Test of the Mechanism of Residents' Consumption Level

	-1	-2	-3
	glc	rcl	glc
nqp	0.293***	71838.557***	0.204***
	-15.305	-25.588	-6.432
rcl			0.000***
			-3.507
_cons	0.154***	4446.101***	0.149***
	-42.989	-8.434	-38.461
N	390	390	390
R2	0.395	0.646	0.415
F	234.247	654.756	126.96

5. Research Conclusions and Policy Recommendations

5.1 Research Conclusions

Based on the data related to green and low-carbon development and new-quality productivity from 30 provinces (regions, municipalities) in China from 2010 to 2022, this paper investigates the promoting effect of the level of new-quality productivity on green and low-carbon development and its mechanism of action. The research conclusions are as follows. First, the TOPSIS entropy weight method was used to calculate the level of new-quality productivity and green and low-carbon development in each province across the country. Among them, Guangdong, Beijing, Zhejiang, Jiangsu, and Shanghai are at the forefront of the country in terms of both new-quality productivity and green and low-carbon development. Second, the fixed-effects test shows that new-quality productivity can drive green and low-carbon development, and the effect remains stable after the level of green and low-carbon development from the previous period is included as a control variable. Third, the study reveals two key pathways through which new-quality productivity improves the level of green and low-carbon development, namely, enhancing the level of technology and promoting the upgrading of residents' consumption, and there is a certain correlation between the two pathways. A higher level of technology creates more advanced green technologies, and the upgrading of residents' consumption makes residents pay more attention to health issues, thereby prompting industries to adopt more advanced green technologies to achieve green transformation. Finally, there are significant differences in the impact of new-quality productivity on the level of green and low-carbon development in China. These differences are not only reflected in geographical location but also in the level of economic development. In terms of geographical location, the eastern region, with a more mature industrial structure, has the strongest effect of new-quality productivity. The central and western regions, which are still in the development stage and have relatively backward infrastructure construction, have a relatively weaker effect of new-quality productivity. In terms of the level of economic development, regions with a high level of economic development usually have stronger capabilities for technological innovation and resource investment. These regions often concentrate more scientific research institutions, universities, and high-tech enterprises and are also able to attract more talents, thereby more effectively carrying out the research and development and application of green and low-carbon technologies. Therefore, the impact of new-quality productivity on the level of green and low-carbon development is also stronger.

5.2 Policy Recommendations

Based on the above research conclusions, the following policy recommendations are made:

First, increase research and development investment. As shown by the analysis, the level of technology has a positive effect on the local level of green and low-carbon development to a certain extent. Promoting the research and development and progress of high-tech technologies can accelerate industrial structure upgrading and innovation-driven development. In the future, continuous strengthening of technological innovation, cultivation of new industrial growth points, and joint progress of the upstream and downstream of the industrial chain should be maintained. Meanwhile, promoting interdisciplinary research is also a key way to achieve technological breakthroughs. By integrating the latest research findings from cutting-edge disciplines such as information technology and new materials technology, revolutionary green and low-carbon technologies that are adaptable to different environments can be developed. This integration not only promotes the cross-fusion of knowledge from different disciplines but also accelerates the innovation and application of new technologies. Applying the achievements of technological innovation to specific industries and industrial chains, creating efficient and ecological green industrial clusters, upgrading traditional industries, continuously shaping new competitive advantages, and increasing the proportion of green and low-carbon industries in the total economy can bring more efficient and environmentally friendly production methods to various industries in China.

Second, the government should enhance its focus on low-carbon environmental protection. The primary task is to formulate and improve relevant policies and regulations, covering core areas such as carbon emission control, energy utilization enhancement, and environmental protection. These policies should include both incentive measures, such as tax incentives, subsidies, and rewards, and regulatory measures, such as restricting the expansion of high-emission industries or penalizing non-compliant enterprises. Secondly, strengthening publicity and education is essential. The government can use various channels, such as media, the internet, and community activities, to raise public awareness and participation in low-carbon environmental protection and to popularize low-carbon lifestyles and environmental knowledge. Finally, it is necessary to improve the monitoring and evaluation system. A carbon emission monitoring and evaluation system should be established to track the dynamic changes in carbon emissions and environmental quality in real-time, providing a scientific basis for policy adjustments. At the same time, the target assessment and accountability mechanism for environmental protection should be perfected to ensure the effective implementation of environmental protection work.

Thirdly, enhance education on green and low-carbon development. Although China has made a series of significant achievements in green and low-carbon education and has established a relatively systematic policy framework and implementation path, there is still room for improvement in practical application. Moreover, due to the limitations of educational levels, progress in some remote areas remains relatively slow. At the same time, there is a certain shortage of talents in the field of green and low-carbon development in our country. Under the current social background, there are more talents in traditional energy, manufacturing, chemical industry and other high-paying fields, but these industries also produce relatively high carbon emissions, which is not conducive to the development of green and low-carbon level in our country. By strengthening the application-based research in the field of green and low-carbon and cultivating a group of professional talents in this field, and establishing corresponding incentive mechanisms, it can provide continuous intellectual support and technological innovation for the green and low-carbon development of our country.

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