

Exploration of the Path of High-Quality Development of Green Building Industry under the Dual-carbon Background

-- Take Anhui Province as an Example

Mengting Lu¹, Yu Liu^{1,*}, Tianle Zhu¹, Qianchun Wu¹ and Nan Chen²

¹Anhui University of Finance and Economics, Anhui, China

²North China University of Science and Technology, Anhui, China

*3368096562@qq.com

Abstract

Under the background of the goal of "carbon peak, carbon neutral", green development has become a hot issue in focus, in which the new low-emission infrastructure field, mainly green building, has been vigorously invested in, which is an opportunity for the development of the green building industry, and it is urgent to solve the problem of the high-quality development path of the green building industry, and analyze the factors affecting the development of the green building industry based on the development goals and concepts. construction industry development obstacles, as well as the construction of evaluation indicators for the development of the green construction industry is an urgent problem to be solved. Based on the background of double-carbon target, this topic will select some representative green building enterprises in Anhui Province as the research object; take the development of green building enterprises in Anhui Province and the data obtained from the National Bureau of Statistics on the whole life cycle of green building, energy saving and energy utilization, and the growth rate of green building area as the main research data; refer to the research theories of domestic and foreign research scholars from the development of the green building industry, the industrial foundation, building products, social benefits, and the development of the green building industry as the main research data. The development evaluation index system of green building industry is constructed in accordance with the current development situation in five aspects: industrial foundation, construction products, social benefits, internationalization, and sustainable development; the fuzzy comprehensive evaluation method is used to select the indicators from the constructed development evaluation index system, and the entropy weight method is used to determine the weight of each evaluation factor, so as to study the factors that affect the high-quality development of green building industry. At the same time, the selected indicators are quantified and the future development prospects of the industry are predicted using the Arima prediction model. It aims to provide certain reference and reference for the optimization and improvement of the development policy of green building industry in Anhui Province, and to make up for the problem that the influence factors and the degree of influence are not clear in the process of the development and construction of green building industry.

Keywords

Green Building; Carbon Neutral; Fuzzy Comprehensive Evaluation Method; Evaluation Index.

1. Foreword

Under the background of the dual-carbon target, all industries carry out corresponding policies and methods to strive for the early realization of the dual-carbon target of carbon peak and carbon neutrality, and the construction industry is a typical high-energy-consuming and high-emission industry. According to the data released by the China Building Energy Conservation Association (CBECA), the total amount of carbon emissions from the whole process of the construction industry in the country accounted for more than half of the country's total carbon emissions. As an important part of the construction industry, the large-scale promotion of green building industry will help to reduce carbon emissions, promote the development of low-carbon economy, and help to realize the "dual-carbon" goal. This paper intends to conduct an in-depth study on the factors influencing the development of the green building industry in the context of dual-carbon, and to study the measurement methodology and index evaluation system of the factors influencing the development of the green building industry, in order to make up for the problem of unclear influencing factors and the degree of influence in the development of the green building industry.

We will conduct a comprehensive measurement and evaluation of the development of the green building industry, explore the reasons affecting the development of the green building industry through multi-dimensional stereoscopic analysis, examine the influence of evaluation indexes on the high-quality development of the green building industry, and on the basis of which, we will look for effective paths for the high-quality development of the green building industry in the context of the dual-carbon background to solve the problem of impediments to the development of the green building industry.

2. Current Status and Development of Research At Home and Abroad

Li Lanlan (2018) puts forward the three major development ideas of green transformation of the construction industry, namely, innovation drive, circular economy, and industrial integration, in "Research on the Path of Green Transformation and Development of China's Construction Industry"; Wang Li (2020), in "Measurement of the Level of High-quality Development of the Construction Industry and Selection of the Path - Taking Shaanxi Province as an Example," based on the goal of the development of the construction industry, constructs a comprehensive index system of the level of development of the construction industry, and measures the Shaanxi Province, measures the level of development of the construction industry, gets the main direction of the future development of the construction industry in Shaanxi Province, and proposes that the foundation of the development of the construction industry should be laid, the transformation mode should be optimized continuously, the power of the construction industry should be enhanced, and the construction industry should be promoted to develop further. Yan Hui et al. (2021) mentioned in "Analysis of the distribution and spatial effect of carbon emission intensity of China's construction industry based on SDM" that they constructed a carbon emission measurement model of the construction industry to measure China's construction industry, selected the influencing factors of the carbon emission intensity of the construction industry and applied a multiple regression model to analyze them.

Kauskale (2018) et al. emphasized the importance of green building by studying the sustainable development of construction market and construction activities. Adeeb A. Kutty (2020) pointed out that the development of the construction industry is of great significance to the GDP, ecological and social coordination, etc., and then constructed a model for balanced development of the construction industry. Thanwadee Chinda (2020) based on the PDCA and building construction environment etc. to build a model of construction quality assessment.

3. Variable Selection and Modeling

3.1. Variable Selection

In the selection of indicators in this paper, we draw on the Statistical Yearbook and other indicators previously constructed by relevant scholars, and finally select the industrial foundation, construction products, social benefits, internationalization, and sustainable development as the first set of factors, which are recorded as $U_1, U_2, U_3, U_4,$ and U_5 respectively, and select 13 indicators in the green building industry, such as the area of housing completion, the growth rate of gross output value, the productivity of labor, the new green floor area, the new green area, the financial contribution rate, the contribution rate of employment, and the contribution rate of output, etc. as the second set of factors, and construct the evaluation indicator system of the development of the green building industry, which is shown in the table1:

Table 1. Evaluation index system for green construction industry development

The first factor set	symbol	The second factor set	symbol
Industrial foundation	U_1	Completion area of the house	U_{11}
		Total output value growth	U_{12}
		productivity of labour	U_{13}
building products	U_2	New green building area	U_{21}
		New green area	U_{22}
Social effect results benefit	U_3	Financial contribution rate	U_{31}
		Employment contribution rate	U_{32}
		Output contribution rate	U_{33}
internationalization	U_4	Share of output value of foreign-invested enterprises	U_{41}
		Share of foreign-invested enterprises	U_{42}
Sustainable development	U_5	produce rubbish	U_{51}
		Cement consumption	U_{52}
		carbon emission	U_{53}

3.2. Fuzzy Comprehensive Evaluation Model Establishment

Let $U = \{u_1, u_2, \dots, u_n\}$ be the set of nschemes to be evaluated, and $V = \{v_1, v_2, \dots, v_m\}$ the set of evaluation factors, Then each scheme in U is measured by each factor in V to obtain a observation matrix.

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$$

Where a_{ij} represents the j index value of the evaluation factor for item i . The steps of fuzzy comprehensive evaluation are as follows;

(1) Establish an ideal plan $u = \{u_1^0, u_2^0, \dots, u_m^0\}$

$$\text{Among } u_m^0 = \begin{cases} \max\{a_{ij}\}, \text{ When } a_{ij} \text{ is the benefit type index} \\ \min\{a_{ij}\}, \text{ when } a_{ij} \text{ is a cost - type index} \end{cases}$$

(2) The relative bias ambiguity matrix was established R

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix}$$

$$\text{Among: } r_{ij} = \frac{|a_{ij} - u_j^0|}{\max\{a_{ij}\} - \min\{a_{ij}\}}$$

(3) Establish the weight of each indicator W_j

Information entropy is a measure of the degree of disorder of the system, and information is a measure of the degree of order of the system, both of which are equal in absolute value but opposite in sign. The greater the degree of variability of the indicator value of an indicator, the smaller the value of information entropy, the greater the amount of information provided by the indicator, the greater the weight of the indicator accordingly, this paper talks about the use of information entropy as a tool to calculate the weight of each indicator, the specific steps are:

1) Measure each index together to calculate the proportion of the i scheme index value under the j index P_{ij}

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^m X_{ij}}$$

2) Calculate the entropy value of item j index e_j

$$e_j = -k \sum_{i=1}^m P_{ij} \ln P_{ij}$$

Where $k > 0$, \ln is the natural logarithm and $e_j \geq 0$. If X_{ij} is equal to all of the given j , then $P_{ij} = 1/m$, then e_j takes the maximum, that is:

$$e_j = -k \sum_{i=1}^m \frac{1}{m} \ln \frac{1}{m} = k \ln m$$

If $k = 1/\ln m$ then there is $0 \leq e_j \leq 1$

3) The coefficient of difference of item j index is calculated

For a given j , when the difference of X_{ij} is greater, then e_j is smaller; when X_{ij} is all equal, $e_j = \max e_j = 1$ has no effect on the scheme, so the difference coefficient is taken

$$g_j = 1 - e_j$$

4) Normalize the difference coefficient to calculate the weight:

$$W_j = \frac{g_j}{\sum_{i=1}^m g_j} \quad (j = 1, 2, \dots, m)$$

(4) Establish a comprehensive evaluation model F_j

$$F_j = \sum_{i=1}^m w_{ij} r_{ij} \quad (i = 1, 2, \dots, n)$$

And if $F_t < F_s$, Then the t scheme is ranked before the s scheme

3.3. The ARIMA Prediction Model was Established

ARIMA model, also known as autoregressive integral sliding average model, is a widely used time series model, when using ARIMA model for forecasting, the first need to test the smoothness of the original data series, if the original data series is not smooth, it needs to be transformed into smooth data.

ARIMA model principle and modeling process as:

- 1) Use the ADF unit root to test whether the signal is a smooth series.
- 2) If the signal is non-stationary, it needs to be differentiated by d -order.
- 3) Use the ACF function and PACF function to determine the order q of the AR model and MA model by truncation or tailing, and the determination method is shown in Table 2.
- 4) Determine the arima model parameters p, d, q , you can use the prediction function to predict the value of the test data set.

ARIMA(p, d, q) The model expression is.

$$\begin{cases} \varphi(L)\nabla^d X_t = \theta(L)\varepsilon_t \\ \varphi(L) = 1 - \varphi_1 L - \varphi_2 L^2 - \dots - \varphi_p L^p \\ \theta(L) = 1 + \theta_1 L + \theta_2 L^2 + \dots + \theta_p L^p \end{cases}$$

where: $\varphi_i (i = 1, 2 \dots p)$ and $\theta_i (i = 1, 2 \dots p)$ are the autocorrelation coefficient and the moving average coefficient, respectively; $\varphi(L)$ is the autocorrelation coefficient polynomial; $\theta(L)$ is the moving average coefficient polynomial; L is the lag operator ∇^d ; ∇^d refers to the d th order of the backward difference; t is the period; x_t is the time series; and ε_t is the residual term for the t th period.

Table 2. Order determination method

Model	ACF	PACF
AR(p)	Nature of tailing	Property of truncation
MA(q)	Property of truncation	Nature of tailing
ARMA(p,q)	Nature of tailing	Nature of tailing

4. Empirical Results

According to the data collected from the Statistical Yearbook about the green building industry related to the use of fuzzy comprehensive evaluation to calculate the development of the green building industry in Anhui Province, each evaluation of the weight of the indicators, as the final evaluation of the development of the green building industry in Anhui Province, Anhui Province, the final weights of the indicators are shown in Table 3:

Table 3. Weight of green construction industry development evaluation index

The first factor set	symbol	w_{ij}	The second factor set	symbol	w_{ij}
Industrial foundation	U_1	0.244	Completion area of the house	U_{11}	0.312
			Total output value growth	U_{12}	0.421
			productivity of labour	U_{13}	0.267
building products	U_2	0.211	New green building area	U_{21}	0.539
			New green area	U_{22}	0.461
Social effect results benefit	U_3	0.204	Financial contribution rate	U_{31}	0.432
			Employment contribution rate	U_{32}	0.237
			Output contribution rate	U_{33}	0.331
internationalization	U_4	0.144	Share of output value of foreign-invested enterprises	U_{41}	0.731
			Share of foreign-invested enterprises	U_{42}	0.269
Sustainable development	U_5	0.197	produce rubbish	U_{51}	0.321
			Cement consumption	U_{52}	0.339
			carbon emission	U_{53}	0.43

From the results in the table, it can be seen that the five first factor sets in the evaluation indexes of the green building industry in Anhui Province have different influence effects on the development of the industry, in which the industrial base of the green building industry, building products, and social benefits are dominant, and the internationalization of the industry and the sustainable development are second.

At the same time, the relevant data of the green building industry in Anhui Province from 2018 to 2022 were collected, and the scheme results were evaluated, and the ARIMA model was used to predict them. The estimated value of the prediction results is shown in Table 4.

Table 4. Forecast of development evaluation value in 2018-2025

Year	original value	Predicted value	residual error	fractional error (%)
2018	0.653	0.653	0	0
2019	0.641	0.643	-0.002	0.241
2020	0.634	0.632	0.002	0.333
2021	0.622	0.621	0.001	0.095
2022	0.61	0.611	-0.001	0.181
2023		0.601		
2024		0.591		
2025		0.581		

According to the results of the results in the table, the smaller the evaluation value of the scheme, the smaller the evaluation value, the better the scheme. We know that the green building industry will develop into an upward trend in the next three years.

5. Study Conclusion and Research Recommendations

5.1. Research Conclusion

Through the weights of the elements in the fuzzy set corresponding to the matrix obtained above, it can be seen from the comparison of the weights of their corresponding elements, for the first factor set given in this paper and the second factor set given in this paper, these two categories of influencing factors, the industrial base of the green building industry has the deepest influence on the high-quality development of the green building industry in the context of dual-carbon, and such factors directly reflect the industrial base of the green building industry in Anhui Province, which is the most powerful part of guiding the development of the industry, followed by the building products in the green building industry. This kind of factor directly reflects the fact that the industrial base of the green building industry in Anhui Province is the most powerful part in guiding the development of the industry, and strengthening and improving the industrial infrastructure is conducive to further improving the development of the industry, followed by the construction products in the green building industry, and the results of this kind of data also show that the introduction of green building products in the development process of the green building industry will promote the development and progress of the industry's quality.

In summary, to improve the development of the green building industry in Anhui Province, the first priority should be to improve the green building industry infrastructure construction, the government and its relevant departments can increase the green building industry in Anhui Province, such as investment in industrial infrastructure construction.

5.2. Research Advice

High-quality development of the green building sector is crucial and requires comprehensive and strong efforts in the areas of policy, technology, standards and promotion. The following

research recommendations for high-quality development of the green building industry are provided, detailing the importance of each aspect and specific measures.

Provide Policy Guidance and Support, Strengthen Technological Innovation and Application.

The government plays an important role in green building development and needs to formulate policy measures to encourage and support green building. This includes formulating relevant laws and regulations, establishing fiscal and tax policy incentives, and providing subsidies and rewards. The government can also consider promoting green bonds and green financial products to provide financing support for green building projects.

Technological innovation is the key to promoting the high-quality development of green buildings. There is a need to strengthen the research and development of green building technologies and products, including technological innovation in building energy efficiency, water resource management, indoor environmental quality improvement, and renewable energy utilization. Meanwhile, the application of intelligent building technologies, such as intelligent control systems and energy consumption monitoring systems, should be encouraged to improve the efficiency and sustainability of building operations.

Establish standards and certification systems, and do a good job of training and introducing professionals.

Establishing a sound green building evaluation system and certification standards is crucial to promoting the development of the green building industry. It is recommended to carry out research and formulation of green building standards in line with China's national conditions on the basis of existing standards to ensure that the standards are scientific, authoritative and operable. At the same time, the construction of green building certification system should be strengthened, and building projects should be encouraged to apply for certification, so as to increase the popularity and market recognition of green building certification.

The green building industry requires talents with relevant professional knowledge and skills. It is recommended to increase support for green building education, encourage universities to open green building-related majors, and strengthen cooperation with the construction industry to improve the practicality and adaptability of education. In addition, it is also necessary to strengthen the training and transformation of existing construction industry talents, introduce excellent talents from home and abroad, and improve the overall quality and level of the industry.

Raise public awareness and increase industry promotion.

Public recognition and participation are important factors in the development of the green building industry. It is necessary to increase the publicity and promotion of green building to improve public awareness and understanding of green building. The government, enterprises and social organizations can jointly carry out green building exhibitions, seminars, public education activities, etc. to convey the importance and value of green building to the public, and encourage the public to pay attention to green building, and to support and participate in related projects.

In conclusion, to realize the high-quality development of the green building industry, the joint efforts of the government, enterprises, professionals and the public are needed. Through policy guidance and support, technological innovation and application, standards and certification systems, professional talent training and introduction, as well as public awareness and promotion and other aspects of the joint concerted efforts.

Acknowledgments

This work is supported by Anhui University of Finance and Economics provincial undergraduate innovation and entrepreneurship training program project "Exploration of the path of high-quality development of green building industry under the dual-carbon background--- Take Anhui Province as an example"(S202210378088).

References

- [1] WANG Yusong, SHI Huimeng, YAN Hui, HUANG Wenwei, HAO Zhibiao. Distribution and spatial effect analysis of carbon emission intensity in China's construction industry based on SDM[J]. Journal of Engineering Management,2021,35(05):1-6.
- [2] WANG Li, LI Huimin. Measurement and Path Selection of High Quality Development Level of Construction Industry--Taking Shaanxi Province as an Example[J]. Construction Economy,2020, 41 (09):24-28.
- [3] Li Lanlan. Research on the path of green transformation and development of China's construction industry[D]. Wuhan University of Technology,2019.
- [4] Meng Chong, Deng Yuechao, Li Jiaying, Li Qiong, Dai Ruiye, Gao Cheng. Introduction to T/CECS 1149-2022 International Multilateral Green Building Evaluation Standard[J]. HVAC, 1-7.
- [5] YAO Xin, QIU Wenhong, CHENG Na, YANG Lei, WU Yinguang, LI Yunjiang, FAN Bo, DENG Jinyan, ZHANG Hui, KE Zikang. Research on Post-use Evaluation of Environmental Performance of Green Campus Based on AHP-FCE--Taking an Administrative College (New Campus) as an Example[J]. Central China Architecture, 2023, 41 (10): 63-67.
- [6] LIN Manhua, ZHANG Wanna, ZHENG Rongbao, ZHAO Kefei, ZHONG Qi, LIN Lijie. Spatial and temporal evolution of green buildings in Guangzhou and analysis of influencing factors[J]. Tropical Geography, 2023, 43 (09): 1823-1834.
- [7] Liu Renhuan. Research on green building development issues and countermeasures in Hunan Province under the goal of "double carbon"[J]. Construction Economy, 2023, 44 (S1): 354-358.
- [8] LI Xiaoliang, HUANG Lijun, LI Qiuyuan. Research on the index system of green rural building construction--Taking Jiangsu Province as an example[J]. Town and Country Planning, 2023, (02): 70-77.
- [9] Wang Cheng. Comparison of the development of green building and low carbon building evaluation systems in China and suggestions for optimization[J]. Building Science, 2023, 39 (02): 235-244.
- [10] Jiang Kai. Comparative study of Green Office Building Evaluation Standards based on health concept[J]. Construction Economy, 2022, 43 (S2): 326-331.