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Study on the Measurement and Influencing Factors of Chongqing Residents' Carbon Inclusion Literacy under the "Double Carbon" Target

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Abstract: In the context of the global "double carbon" goal, this article uses the Analytic Hierarchy Process and Multiple Linear Regression combined with a survey questionnaire to study the issue of carbon literacy among residents in Chongqing. The weights of each dimension are determined to promote the formation of a good situation of multi-party collaborative promotion and help achieve the "double carbon" goal. The level of carbon literacy reflects the residents' understanding of carbon literacy and has important significance for economic and social operation and environmental protection. The results indicate that the deepening of the concept of carbon inclusiveness and the continuous advancement of technology will lead to a continuous process of improving the carbon inclusiveness literacy of Chongqing residents. Corresponding suggestions are proposed on how to improve the carbon inclusiveness literacy of Chongqing residents, which is of great research significance.

Keywords: Carbon inclusive literacy; Influencing factors; Chongqing resident; Analytic hierarchy process

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1. Introduction

In 2015, the Guangdong Provincial Development and Reform Commission first put forward the concept of carbon inclusion, which is a mechanism to encourage public participation in green and low-carbon ways. It aims to quantify and give small and micro enterprises, community families, and individuals a certain value in energy conservation and carbon reduction behaviors and promote the participation of the whole people in low-carbon behaviors. In October and November 2022, the Chinese government successively released the "2022 Annual Report on China's Climate Change Policies and Actions" and the "Progress Report on China's Implementation of Nationally Determined Contribution Targets (2022)," proposing to explore and carry out innovative voluntary emission reduction mechanisms — carbon inclusion and incentives for the whole society to participate in carbon emission reduction. In October 2023, the "2023 Annual Report on China's Climate Change Policies and Actions" issued by the Ministry of Ecology and Environment once again emphasized the development of green and low-carbon actions for all. Enhance the degree of public participation in carbon inclusion; in the "Opinions of the

Central Committee of the Communist Party of China and the State Council on the Comprehensive Promotion of the Construction of a Beautiful China" issued on January 11, 2024, it is proposed to explore the establishment of public participation mechanisms such as "carbon inclusion" [1]. To adapt to the development of carbon inclusion literacy in the times, this study defines the relevant content of measuring the carbon inclusion literacy of residents in our country through the development and research of the Carbon Generalized System of Preferences at home and abroad, as well as related theoretical analysis. It constructs a measurement index system for the carbon inclusion literacy of residents in our country. And analyzes the influencing factors of the carbon inclusion literacy of residents in Chongqing through the analytic hierarchy process. The study of carbon inclusion literacy helps to enhance public awareness of climate change and environmental protection, promote the formation of low-carbon lifestyles, and help to achieve the "double carbon" goal.

2. Research status

Generalized System of Preferences (GSP) is a pioneering low-carbon development system to mobilize all walks of life, especially the public, to participate in carbon emission reduction, quantify daily low-carbon behavior and incentives. Although there were issues such as legislation, trading mechanisms, and regulatory systems in the early stage, Zeng proposed to upgrade the legislative level and enhance synergy [2]. Hu proposed that its core includes three elements: Focusing on "carbon" to tap the potential for emission reduction, focusing on "universal" diversity and inclusiveness, and settling on "beneficial" quantitative incentives [3]. Yan *et al*. said that it can promote green technology innovation and is a system of quantitative incentives, diversified operation, and local conditions [4]. Xiang *et al*. summarized that it has low-carbon [5], inclusive, and incentive The characteristics of marketization, the practice of many places in China has been effective and challenging, such as Guangdong, Wuhan, and Chongqing, which also give transportation and industry-related points rewards in combination with the characteristics of mountain cities; in terms of carbon inclusion and low-carbon behavior, Alexander *et al*. and many scholars define low-carbon behavior from different perspectives [6], pointing out that the key to carbon emission reduction is energy conservation, emission reduction, and promotion of clean energy. Actions can be taken in many fields in daily life. Ajzen pointed out the willingness of low-carbon behavior to lead public action [7]. The theory of planned behavior emphasizes the coordinated promotion of multiple factors. Chongqing citizens practice energy conservation, emission reduction, and clean energy utilization according to their urban characteristics and use the carbon inclusion mechanism to encourage the creation of a low-carbon future. As for carbon inclusion and low-carbon consumption, scholars have different opinions, covering concepts that are Views, mainly including reducing energy consumption, Wang and other scholars' experiments showed that multiple factors cause carbon emissions to increase [8], Peng *et al*. divided direct and indirect carbon emissions, and there are also problems such as the disconnect between public low-carbon willingness and behavior [9]. Shi *et al*. empirically found that residents' low-carbon consumption is affected by psychological, personal cognition and other factors [10]. Zeng proposed to guide residents' green consumption to force the transformation of the production side [11]. Wu said that carbon inclusion helps to promote the goal of a beautiful China [12], and there are many factors affecting the public's attitude towards carbon inclusion.

3. Research method

3.1. Construct an indicator system

Based on the relevant literature and the construction principles of the indicator system, we constructed a carbon inclusion literacy assessment system that includes three first-level indicators of carbon inclusion knowledge, low-carbon behavior, and participation willingness, and 11 second-level indicators. The specific indicator design is

shown in **Figure 1**, covering a comprehensive assessment of carbon inclusion policies, platforms, incentives, relevant knowledge, low-carbon behavior, and participation willingness.

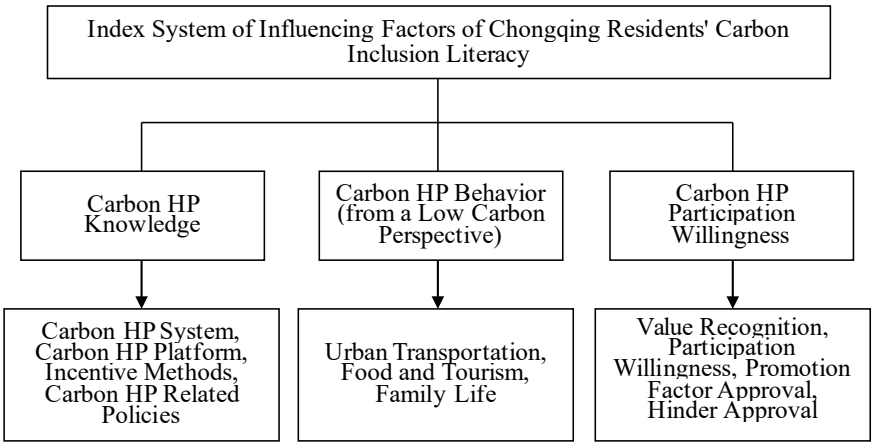

Figure 1. Chongqing residents' carbon inclusive literacy influencing factors index system

3.2. Method selection

Common comprehensive evaluation methods include the analytic hierarchy process, weighted comprehensive scoring method, fuzzy comprehensive evaluation method, data packet network analysis, entropy method, TOPSIS method, etc. These methods provide a variety of tools and frameworks to improve the validity and reliability of the evaluation. The analytic hierarchy process adopted in this paper is also one of them.

3.3. Data evaluation and analysis

First, according to the Chongqing residents' carbon inclusive literacy influencing factors index system to establish a judgment matrix. Among them, the data of the judgment matrix in this paper is obtained by consulting the relevant index data such as "2023 China Urban Green and Low-Carbon Development Competitiveness Index Report," "Wuhan Carbon Inclusion Scenario Evaluation Specification" and "Low-Carbon City Evaluation Index System," and combining the index data with the expert scoring method. Secondly, using the analytic hierarchy process through the SPSS software, the relative importance of the indicators is compared to obtain the judgment matrix. Next, the characteristic roots are calculated, and the consistency is checked. Finally, the weights are calculated and sorted to evaluate the indicators.

The detailed steps are as follows:

(1) According to the 1–9 scale method, the importance of each index is indicated. As shown in **Table 1**.

Table 1. Importance comparison evaluation

a	Definition	a	Definition
1	a_i is equally important as a_j	2	It is between equally important and slightly more important
3	a_i is slightly more important than a_j	4	It is between slightly more important and obviously more important
5	a_i is obviously more important than a_j	6	It is between obviously more important and very obviously more important
7	a_i is very obviously more important than a_j	8	It is between very obviously more important and absolutely more important
9	a_i is absolutely more important than a_j	Countdown	a_{ij} is the result of the comparison of the importance between index i and j, and a=1/a.

(2) Comparing the importance of the indicators, a judgment matrix about the factors affecting the carbon inclusion literacy of Chongqing residents is obtained, as shown in **Table 2**.

As can be seen from **Table 2**，λmax = 8.6213, R = 0.525, CR = CI/RI = 0.062 ≤ 0.1, the judgment matrix is consistent.

Table 2. First-level indicator judgment matrix

First-level indicators	Knowledge of carbon inclusion B1	Carbon inclusion behavior B2	Willingness to participate in carbon inclusion B3	W weight value (%)
Carbon inclusion knowledge B1	1	0.143	0.2	7.193
Carbon inclusion behavior B2	7	1	3	64.912
Carbon inclusion participation willingness B3	5	0.333	1	27.895

(3) Compare the elements in the carbon inclusion knowledge index in pairs, as shown in **Table 3**.

As can be seen from **Table 3**, λmax = 4.043, R = 0.882, CR = CI/RI = 0.016 ≤ 0.1, obviously the judgment matrix is consistent.

Table 3. Carbon inclusion knowledge index

Carbon inclusion knowledge	Generalized system of preferences C1	Carbon inclusion platform C2	Incentive mode 3	W weight value (%)
Generalized System of Preferences C1	1	0.333	0.2	7.759
Carbon Inclusion Platform C2	3	1	0.333	20.096
Incentive Mode 3	5	3	1	52.049
Policy C4	3	1	0.333	20.096

(4) Compare the elements in the carbon inclusion knowledge index in pairs, as shown in **Table 4**.

As can be seen from **Table 4**, λmax = 3.0, R = 0.525, CR = CI/RI = 0.0 ≤ 0.1, obviously the judgment matrix is consistent.

Table 4. Carbon inclusion behavior

Carbon inclusive behavior	Urban transportation D1	Catering tourism D2	Family life D3	W weight value (%)
Urban transportation D1	1	5	1	45.455
Catering tourism D2	0.2	1	0.2	9.091
Family life D3	1	5	1	45.455

(5) Compare the elements in the carbon inclusion knowledge index in pairs, as shown in **Table 5**.

As can be seen from **Table 5**, λmax = 4.037, R = 0.882, CR = CI/RI = 0.028 ≤ 0.1, obviously the judgment matrix is consistent.

Table 5. Carbon inclusion willingness index

Willingness for carbon inclusion	Value recognition E1	Willingness to participate E2	Promotion factor approval E3	Hindrance factor approval E4	W weight value (%)
Value recognition E1	1	0.2	3	3	19.149
Willingness to participate E2	5	1	7	7	65.406
Promotion factor approval E3	0.333	0.143	1	1	7.723
Hindrance factor approval E4	0.333	0.143	1	1	7.723

Finally, the weights of each indicator are summarized as shown in **Table 6.**

Table 6. Weight calculation results

Dimension	Weight (%)	Secondary indicator	Relative weight (%)	Total weight	Ranking
Carbon Inclusion Knowledge	7.193	Generalized System of Preferences C1	7.759	0.078	7
		Carbon Inclusion Platform C2	20.096	0.201	4
		Incentive Mode 3	52.049	0.520	2
		Policy C4	20.096	0.201	4
Carbon inclusive behavior	64.912	Urban transportation D1	45.455	0.455	3
		Catering tourism D2	9.091	0.091	6
		Family life D3	45.455	0.455	3
Willingness for carbon inclusion	27.895	Value recognition E1	19.149	0.191	5
		Willingness to participate E2	65.406	0.654	1
		Promotion factor approval E3	7.723	0.077	8
		Hindrance factor approval E4	7.723	0.077	8

According to the data analytics in **Table 6**, the influencing factors of Chongqing residents' carbon inclusion literacy can be summarized into three main dimensions: Carbon inclusion behavior, carbon inclusion awareness, and carbon inclusion knowledge. Among them, the weight of carbon inclusion behavior is as high as 64.912%. Under this dimension, residents' participation willingness and family life habits have a particularly significant role in promoting carbon emission reduction behavior, accounting for 65.406% of participation willingness and 45.455% of catering tourism and family life, respectively. Secondly, the weight of carbon inclusion awareness is 27.895%, of which value recognition is the key factor affecting literacy, while the satisfaction of promoting and hindering factors is 7.723%, respectively. Finally, the weight of carbon inclusive knowledge is low, only 7.193%, but the implementation of incentive measures and related policies can effectively improve the knowledge level of residents.

4. Establishment of the model

4.1. Selection of indicators

This paper defines the influencing factors of carbon inclusive literacy as eight factors: Age, gender, education level, occupation field, personal monthly disposable income, permanent residence and region, and based on the above descriptive statistical analysis, it is found that Chinese residents have high levels of carbon inclusive literacy.

To further study whether the above factors have an impact on the carbon inclusive literacy of Chinese residents and the corresponding degree of influence, we first conducted a normal test on the carbon inclusive literacy level of Chinese residents and then used a multiple linear regression model to analyze its influencing factors.

4.2. Empirical analysis

4.2.1. Normality test of the data

Because the data collected through the questionnaire are individual-level data of residents, it is not suitable for multiple linear regression models, so we need to perform a normality test on it first and then determine whether the data group obeys or approximately obeys the normal distribution. The normality test of the data is carried out, and the test results are shown in **Figure 2**.

	Kolmogorov-Smirov			Shapiro-Wilk		
	Statistics	Degrees of freedom	Significance	Statistics	Degrees of freedom	Significance
Average	0.157	9	0.200	0.924	9	0.429

Figure 2. The average level of carbon inclusion literacy in each main urban area

It can be seen from the test results in **Figure 2** above that the P values of the KS test and SW test are 0.200 and 0.429, respectively, both greater than 0.05. Therefore, the null hypothesis cannot be rejected; that is, the data are considered to follow a normal distribution. Secondly, the Q-Q graph is plotted at the level of the average level of carbon inclusion literacy of residents in each main urban area, as shown in **Figure 3** below. It can be seen from the graph that the points in the graph are roughly on a straight line, indicating that the theoretical percentiles of the data are in good agreement with the actual percentiles, so the set of data satisfies the normal distribution, and the next step can be studied.

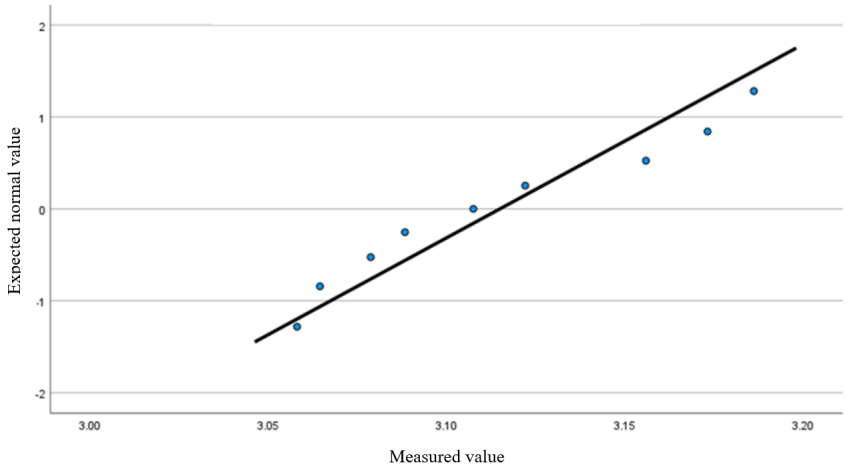

Figure 3. Normal Q-Q of the average carbon inclusion literacy level in each main urban area

Finally, a Q-Q map is drawn for the carbon inclusion literacy level of individual residents. The results are shown in **Figure 4**:

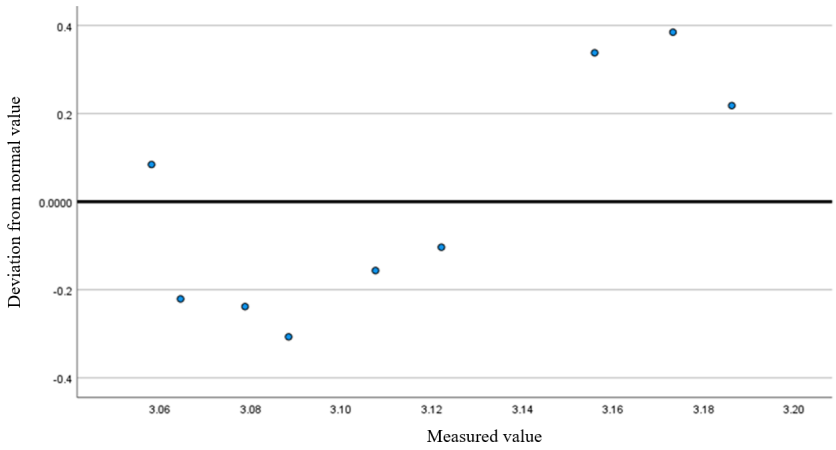

Figure 4. Detrending normality Q-Q of the average carbon inclusion literacy level in each main urban area

It can be generally seen from the above chart that the measurement value of the carbon inclusion literacy level in each main urban area and the individual level of residents is in line with the assumption of constructing a multiple linear regression model; that is, the collected data sets are normally distributed. Therefore, the next step is to construct a multiple linear regression model to further explore whether the factors contained in the basic information affect the residents' carbon inclusion, literacy level, and its influence.

4.2.2. Multiple linear regression model construction

Since there are many factors affecting the residents' carbon inclusion literacy level, this paper uses multiple linear regression analysis to model. Among them, a series of factors affecting residents' carbon inclusion literacy level are used as independent variables, and residents' carbon inclusion literacy level is used as a dependent variable. The specific model is as follows:

$$CL = \alpha 0 + \alpha 1 gender + \alpha 2 age + \alpha 3 region + \alpha 4 education$$

$$+ \alpha 5 profession + \alpha 6 income + \varepsilon$$

Among them: α0 -- intercept variable; αj (j = 1, 2, 3... 7) -- regression coefficient to be estimated; ε – stochastic perturbation term; CL – carbon inclusive literacy level of residents.

The age, gender, region, education, profession, and income in the model represent the age, sex, permanent residence, educational level, occupation, and personal monthly disposable income of the respondents, respectively. The above variable definitions are shown in **Table 7** below:

Table 7. Variable definitions

Variable type	Variable name	Variable indicator	Definition or assignment
Explained variables	Carbon inclusion literacy		Taken from a survey questionnaire and calculated using a scoring method
Explanatory variables	Age	Under 18 years old	agei=1,2,3,4,5=0
		18–25 years old	Age1,agei=2,3,4,5=0
		26–35 years old	Age2,agei=1,3,4,5=0
		36–45 years old	Age3,agei=1,2,4,5=0
		46–60 years old	Age4,agei=1,2,3,5=0
		61 years old and above	Age5,agei=1,2,3,4=0
	Gender	Male	1
		Female	2
	District	Yuzhong District	Regioni=1,2,3,4,5,6,7,8=0
		Dadukou District	Region1=1, regioni=2, 3,4,5,6,7,8=0
		Jiangbei District	Region2=1, regioni=1,3, 4,5,6,7,8=0
		Shapingba District	Region3=1, regioni=1,2,4,5,6,7,8=0
		Jiulongpo District	Region4=1, regioni=1,2,3,5,6,7,8=0
		Nanan District	Region5=1, regioni=1,2,3,4,6,7,8=0
		Beibei District	Region6=1, regioni=1,2,3,4,5,7,8=0
		Yubei District	Region7=1, regioni=1,2,3,4,5,6,8=0
		Banan District	Region8=1, regioni=1,2,3,4,5,6,7=0
	Highest education	High school and below	1
		College	2
		Undergraduate	3
		Graduate and above	4
	Occupation	Students	Professioni=1,2,3,4,5=0
		Administrative and institutional personnel	Profession1=1, professioni=2,3,4,5=0
		Enterprise personnel	Profession2=1, professioni=1,3,4,5=0
		Individuals and freelancers	Profession3=1, professioni=1,2,4,5=0
		Retirees	Profession4=1, professioni=1,2,3,5=0
		Other	Profession5=1, professioni=1,2,3,4=0
	Disposable monthly income	Less than 1,000 yuan	1
		1001–3000 yuan	2
		3001–5000 yuan	3
		5001–8000 yuan	4
		8001–10000 yuan	5
		10000 yuan or more	6

4.2.3. The correlation test of the regression equation

(1) The degree of fit and independence test

As can be seen from **Figure 5** below, the degree of fit of the relevant predictor variable R^2 = 21.9% > 10%, indicating that the predictor variable has a certain impact on the dependent variable; In addition, the Durbin-Watson statistic is equal to 1.862 < 2, and the gap between the two is small, indicating that the varieties are independent.

Model	R	R-Square	Adjusted R-Square	Errors in Standard Estimates	Durbin-Watson
1	0.468	0.219	0.212	0.114	1.862

Figure 5. Model summary

(2) Significance analysis of specific predictor variables on dependent variables

It can be seen from **Figure 6** below that the significance analysis corresponding to the variables of age, highest education, occupation, and disposable monthly income is less than 0.05, which has a certain impact on the dependent variables. Among them, the unstandardized regression coefficient of age and disposable monthly income of residents in the main urban area is > 0, indicating a positive correlation with the carbon inclusive literacy level of residents in the main urban area; the unstandardized regression coefficient of the highest education and occupation of residents in the main urban area is < 0, indicating a negative correlation with the carbon inclusive literacy level of residents in the main urban area.

Model	Variable	Standard coefficient	t	Sig.
	Gender	0.064	1.838	0.067
	Age	0.181	4.711	0
	Residence	0.014	0.395	0.693
	Education	-0.162	-4.853	0
	Occupation	-0.112	-3.138	0.002
	Income	0.322	8.331	0

Figure 6. Significance analysis

(3) Residual test

After building the regression model, the residual is tested, and it can be seen from the scatter distribution in **Figure 7** below that there is no heteroscedasticity in this regression, so the multiple regression model is valid.

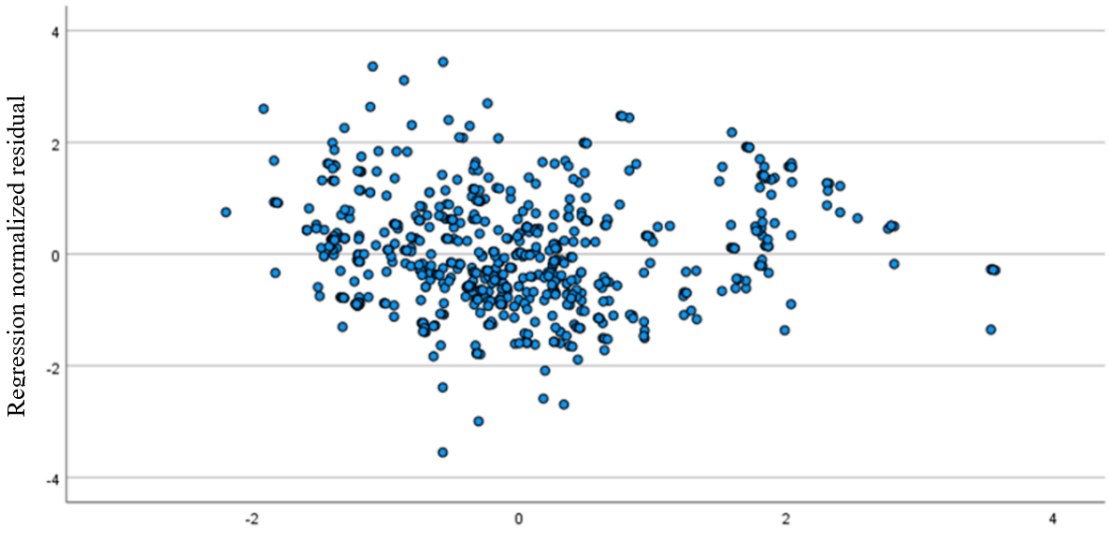

Figure 7. Scatter chart

4.3. Regression results analysis

Analyzing **Figure 8** below, we can obtain the degree and correlation of different factors on the carbon inclusion literacy of residents in the main urban area of Chongqing.

Model	Variables	Standard coefficients	t	Sig.
	Gender	0.038	1.817	0.070
	Age	0.031	1.296	0.195
	Permanent residence	0.034	1.660	0.098
	Education	-0.041	-1.909	0.057
	Occupation	-0.024	-1.146	0.252
	Monthly income	-0.023	-0.869	0.385
	Whether you have heard or not	-0.019	-0.911	0.363
	Whether you understand	-0.011	-0.535	0.593
	Travel mode	0.339	16.028	0
	Personal wishes	0.155	5.353	0

Figure 8. Regression result analysis

According to the above regression result table, it can be seen that the variables significantly related to the carbon inclusion literacy level of residents in the main urban area of Chongqing are: Age, permanent residence, educational level, daily living habits and attitudes towards carbon inclusion, while gender, occupation, income level and carbon inclusion base have no significant impact on the carbon inclusion literacy level of residents in the main urban area of Chongqing.

5. Research conclusions and policy recommendations on the carbon inclusion literacy of residents in Chongqing

5.1. Research conclusions

The age of Chongqing residents positively affects the carbon inclusion literacy level of residents. This means that the older the age, the higher the carbon inclusion literacy of residents, and the middle-aged and the elderly have higher carbon inclusion literacy levels than young people. We should expand the cognitive opportunities of young people for carbon inclusion related knowledge. The education level of the population has a negative correlation with the carbon inclusion literacy level of residents. The higher the education level of residents, the smaller the individual carbon inclusion literacy level. We guess that with the increase of educational level, the carbon inclusion learning may be ignored, and the enthusiasm to participate in related activities may be lacking. However, they are more likely to understand and accept carbon inclusion knowledge in this area, so we suggest that colleges and universities can increase the publicity of carbon inclusion knowledge and open more carbon reduction activities and related courses. Residents' occupations significantly affect residents' carbon inclusion literacy. Students and individuals associated with public administration and institutions have higher levels of carbon inclusion literacy than others. Because students and individuals working in public administration and institutions are often affected by related activities, their carbon inclusion literacy levels are improved. Monthly disposable income is negatively correlated with residents' carbon inclusion literacy levels. Income levels indirectly reflect social status. The higher the per capita disposable income level, there may be excessive consumption, extravagant and wasteful behavior, which in turn leads to a lower level of carbon inclusion literacy per capita among high-income people. Low-income people, on the other hand, are constrained by their spending power and passively choose more low-carbon

behaviors in their lives, such as taking public transportation and participating in carbon inclusion behaviors, and their carbon inclusion literacy is also higher.

5.2. Recommendations

To promote green and low-carbon development, individual residents can register low-carbon behaviors and obtain carbon points or carbon assets through the registered carbon inclusion platform. These points can be traded or exchanged for rewards in the carbon trading market. The platform should pay attention to user information protection and clarify rules to protect rights and interests. At the same time, it is necessary to publicize the concept and typical cases of carbon inclusion through multiple channels such as TV, radio, Internet and community activities to enhance public awareness and participation enthusiasm; the government should organize activities such as energy conservation and emission reduction competitions, and establish feedback mechanisms to optimize policies and services. In addition, the government should take the lead in building a unified carbon inclusion platform, promote its integration with the carbon trading platform, strengthen the construction of data security and management standards, and integrate social resources through policy guidance. Joint enterprises and scientific research institutions will jointly promote carbon inclusion, and enhance the content of science and technology and social participation.

6. Conclusion

This study proposes targeted measures to improve the carbon inclusion literacy of Chongqing residents through in-depth analysis and discussion. In terms of promoting individual residents' participation in carbon inclusion, the importance of enhancing residents' awareness and ability of carbon inclusion was emphasized; In terms of carrying out multi-form and multi-channel carbon inclusion activities, specific measures such as promoting successful cases, organizing activities and establishing feedback mechanisms were put forward; In terms of building a carbon inclusion platform, the leading role of the government was emphasized, as well as the necessity of data management and security. These countermeasures aim to improve the carbon inclusion literacy of Chongqing residents and promote carbon emission reduction and sustainable development. Looking to the future, with the deepening of the concept of carbon inclusion and the continuous progress of technology, the improvement of Chongqing residents' carbon inclusion literacy will be a continuous process. The government should continue to strengthen policy guidance and support to promote the in-depth development of carbon inclusion work. At the same time, all sectors of society should actively participate and jointly promote the development of carbon inclusion. Through continuous efforts, it is believed that the carbon inclusion literacy of Chongqing residents will be significantly improved and contribute to building a green and low-carbon society.

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Disclosure statement

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