

Residents' Willingness Based on Principal Component Analysis and Logistic Regression Modeling

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Abstract: Under the background of the "dual-carbon" target and green transformation of the construction industry, the promotion of green buildings in Shandong Province is facing challenges due to the divergence of residents' perceptions and the insufficient motivation of enterprises. This paper analyzes residents' green building promotion from the dimensions of "utility outcome", "personal perception", "environmental impact", "government effectiveness", and "environmental impact" through 1141 residents' questionnaires using principal component analysis and logistic regression modeling. "government effectiveness" dimensions to analyze residents' willingness to accept green building. The results show that the degree of recognition by friends and relatives, the degree of trust in government policies, the positive role of media publicity and occupational differences are significant driving factors, the first three have a strong positive effect on the willingness to buy, and there are significant differences in the willingness of different occupational groups to accept. This study provides an actionable path for the promotion of green buildings in Shandong Province, which is of great theoretical and practical significance in cracking the bottleneck of promotion, promoting the low-carbon transformation of the construction industry, and helping the realization of the "dual-carbon" goal.

Keywords: Green building, Principal component analysis, Logistic regression, Willingness to accept

1. Introduction

Driven by the goal of "double carbon", the green transformation of the construction industry has become a key path for the global response to climate change. As a major construction province, Shandong Province actively promotes green building policies, but faces challenges such as divergent perceptions among residents, insufficient motivation among enterprises to promote green building, and sloppy implementation of technologies. Existing research focuses on technological innovation and lacks an in-depth analysis of users' subjective attitudes. Therefore, this paper is based on the residents' perspective to explore the willingness to promote green building and the influencing factors, in order to provide empirical evidence for cracking the promotion bottleneck.

Many scholars have pointed out that green building technology innovation is of great significance in reducing energy consumption and promoting the low-carbon transformation of the industry. Ji Nianlong proposed that technological innovation faces high cost, insufficient policy support, shortage of talents, low market awareness, and other issues, and needs to promote the promotion of green building through increasing research and development, improving policies, cultivating talents, enhancing awareness, and other strategies [1]. Lai Xingjian emphasizes the application potential of technologies such as "light storage, direct and flexible", pointing out the need to focus on key technology research and development and policy support to accelerate the transition [2]. Xia Yanfei believes that passive house technology can reduce energy consumption and improve the

environment, and its promotion needs government support to achieve coordinated development of the economy, society, and the environment [3]. Hou Shijie pointed out that green buildings have broad prospects due to environmental protection demand and sustainable development trends, environmental awareness, policy support, technological innovation, and market demand growth, which will promote their wide application [4]. Luo Yi believes that the promotion of urban and rural green low-carbon transformation, energy efficiency, etc., is of great significance in raising the awareness of the whole population, accelerating the implementation of the "dual-carbon" policy, and the transformation of the construction industry [5]. Wang Yanqian and Li Xiangqian et al. found that the development of green buildings in Shandong Province is standardized, but the residents' experience is weak and cognitively insufficient, so it is necessary to strengthen the publicity to improve the willingness to consume [6]. that 2%-5% biochar as binder replacement enhances mechanical properties and reduces CO₂ emissions by 15%-30%, with optimal dosages varying for different uses[7]. Ruiz VJ et al. conducted a Delphi study to define integrative lighting descriptors and indicators for green building rating systems, reaching expert consensus on dimensions like Visual Visualization and Lighting, and the use of the same for green building rating systems. Reaching expert consensus on dimensions like Visual performance and weighting procedures for different contexts[8]. Xilong Jin and Qiuyun Zhu explored the application strategy of whole process engineering cost management in the modern green building economy, elaborating on key links and proposing solutions to the problem. Xilong Jin and Qiuyun Zhu explored

the application strategy of whole process engineering cost management in the modern green building economy, elaborating on key links and proposing solutions to promote its widespread application [9].

The paper conducted questionnaire research through multi-stage sampling (1141 residents' questionnaires), combined with principal component analysis and logistic regression to systematically analyze the current status of residents' knowledge, the key drivers of their willingness to accept the technology, and the pain points of promotion. It is found that residents' willingness to accept the technology is significantly affected by social influence, policy trust, and technology awareness, and different groups have differentiated needs; enterprises regard technology development and policy support as the core breakthrough point. The study innovatively constructs a regional adaptive technology evaluation model and proposes the strategy of "policy guidance - technology adaptation - multiple synergies", which provides an actionable path for the precise promotion of green buildings in Shandong Province.

This paper focuses on the bottleneck of green building promotion in Shandong Province under the goal of "dual-carbon", obtains 1,141 residents' questionnaires through multi-stage sampling, and systematically explores the influencing factors of residents' willingness to accept green buildings by using principal component analysis and logistic regression modeling. In the first step, principal component analysis (PCA) was applied to reduce the dimensionality, extract four principal components, and construct a four-dimensional evaluation system to reveal the core roles of technological perception, subjective judgment, social network effects, and institutional factors. This paper verifies the key drivers through logistic regression model: taking willingness to accept as the dependent variable and incorporating 9 types of independent variables, it is found that the degree of recognition by family and friends, the degree of trust in government policies, the positive role of media publicity and occupational differences significantly affect the willingness to buy. For the first time, the study integrates qualitative dimensions and quantitative models to construct a regionally adapted green building acceptance evaluation system, and proposes a four-dimensional promotion strategy based on occupational differences: "social network activation-policy effectiveness enhancement-accurate media dissemination-occupational circle adaptation", and a four-dimensional promotion strategy based on the differences in occupational circles. The study also proposes a four-dimensional promotion strategy based on differences in

occupational circles: "social network activation - policy effectiveness enhancement - precise media dissemination - occupational circle adaptation", which provides an operable path for the low-carbon transformation of the construction industry under the "dual-carbon" goal.

2. Introduction to the model

2.1. Principal component analysis

Principal Component Analysis (PCA) is a classical dimensionality reduction technique that centers on transforming multiple correlated variables in the original data into a small number of linearly uncorrelated composite metrics (principal components) through orthogonal transformations [10]. This process aims to maximize the data variance, with each principal component extracting the main information of the original variables in turn - the first principal component capturing the maximum variance, and subsequent principal components capturing the remaining variance in turn and orthogonal to the former. After eliminating the influence of magnitude through data standardization, the covariance matrix is calculated, and eigenvalue decomposition is performed, and the number of principal components is determined according to the cumulative contribution rate (usually selected as $\geq 80\%$), and the linear combination expression is finally constructed. This method effectively simplifies the structure of high-dimensional data and eliminates variable redundancy while retaining the core information, which is widely used in multivariate data dimensionality reduction, pattern recognition, and visualization analysis, and provides an efficient solution for key information extraction from complex data sets.

2.2. Logistic regression model

Logistic regression model is a statistical method used to solve classification problems, the core of which lies in mapping the linear prediction results to (0,1) probability intervals through Logit transformations, which makes it applicable to multi-categorization scenarios[11]. Its linear combination of independent variables is converted into the probability of event occurrence, and the regression coefficients can be further transformed into Odds Ratio (Odds Ratio), which intuitively reflects the multiplicative influence of independent variables on the advantage of event occurrence, and combines both probabilistic prediction and factor analysis functions. The model expression of the multiple logistic regression model is shown below:

$$P(Y = k|X) = \frac{e^{\beta_{k0}} + e^{\beta_{k1}X_1} + e^{\beta_{k2}X_2} + \dots + e^{\beta_{kp}X_p}}{1 + \sum_{m=1}^{k-1} e^{\beta_{m0}} + e^{\beta_{m1}X_1} + e^{\beta_{m2}X_2} + \dots + e^{\beta_{mp}X_p}} \quad (1)$$

2.3. Notations

In the above logistic model, $X_1, X_2, \dots, X_p$ is the independent variable, β_{kj} is the regression coefficient of the dependent variable of category k with respect to the reference category, reflecting the effect of the independent variable X_j on the probability of occurrence of events of the

dependent variable of category k , and $\beta_{kj} > 0$ indicates that the probability of occurrence of category k increases with an increase in X_j , while $\beta_{kj} < 0$ indicates that the probability decreases in relative terms.

When applying the multiple logistic regression model, the independent variables need to be coded and the dependent variables converted to dichotomous or multichotomous forms

firstly, and then the maximum likelihood estimation method is used to fit the model parameters, and the model fitting effect is evaluated through the likelihood ratio test, AIC/BIC, and other indexes, to filter out the independent variables that have a significant impact on the classification results. Finally, the direction and strength of the influence of each factor on the results were interpreted through regression coefficients or dominance ratios.

3. Modeling and Analysis of Results

The data in this paper comes from a multi-stage sample questionnaire survey of residents in Shandong Province, and a total of 1,141 valid questionnaires were collected through a combination of online and offline methods. The results of the reliability and validity test show that the Cronbach's α coefficient of each scale is 0.876, the KMO value is 0.889, and the significance of the Bartlett's test of sphericity is $p < 0.001$, which indicates that the questionnaires have good internal consistency and structural validity. The results of the reliability and validity test were passed, indicating that the reliability and structural rationality of the data were rigorously verified, providing scientific support for the

subsequent analysis.

3.1. Evaluation of residents' willingness to accept green buildings based on principal component analysis

Based on sufficient research preparation and in-depth knowledge of green building, combined with the current green building construction practice and public acceptance status, this paper constructed a questionnaire containing 20 items to evaluate the willingness of residents to accept green building behavior. In order to verify the applicability of the index data to the principal component analysis method, this paper implements the KMO test and Bartlett's sphericity test. The test results are shown in the table, The KMO value is 0.981 while the significance level of Bartlett's sphericity test is 0.000, which fully proves that there is a significant correlation between the variables, and the data structure is suitable for principal component analysis.

In order to facilitate the subsequent development of clustering analysis, it is necessary to assign reasonable values to the processing of each question item, and the processing results are shown in Table 1:

Table 1. Assignment of variables

variant	concern	Scoring principles
X_1	I believe that compliance with green building environmental regulations is very important to protect the environment.	According to the five attitude levels of "strongly disagree," "disagree," "generally," "agree," and "strongly agree," the scale assigns a score of 2, 4, 6, 8, and 10 in descending order of attitude intensity. "Strongly Agree", the scale assigns scores of 2, 4, 6, 8, and 10 in descending order of attitude intensity."
X_2	I think the current green building energy efficiency standards can effectively promote energy conservation.	
X_3	The eco-design concept of green building is in line with the requirements of sustainable development.	
X_4	I understand the specifics of green building environmental regulations.	
X_5	Everyone around me agrees that buying a green building is a smart choice.	
X_6	Expert recommendations for green buildings have made me more willing to consider purchasing a green building.	
X_7	The media's promotion of green building has given me a more positive view of green building.	
X_8	I will be influenced by the attitudes of those around me towards green building.	
X_9	I believe the green building policy formulated by the Government can effectively promote the development of green buildings.	
X_{10}	Government regulatory measures for green buildings can ensure the quality of green buildings.	
X_{11}	Government investment in the promotion of green buildings can make more people accept green buildings.	
X_{12}	The Government is capable of solving the problems encountered in the development of green buildings.	
X_{13}	I think green building is the future trend in building development.	
X_{14}	The design and functionality of a green building are more in line with my life needs.	
X_{15}	I am more than happy with the look and style of the green building.	
X_{16}	I would recommend green building to those around me.	
X_{17}	I am willing to pay a higher price for a green building.	
X_{18}	I am willing to purchase a green building as my place of residence if conditions permit.	
X_{19}	I also prefer green and conventional buildings when they are the same price.	
X_{20}	I will be proactive in keeping up with green building information for future purchasing opportunities.	

The principal component analysis in this paper finally selected four principal components with eigenvalues greater than 1, with a cumulative contribution rate of 68.42%, i.e., the four principal components cover more than 68.42% of the

data information of the 20 indicators. After the calculation, we get the principal component loading matrix, as shown in Table 2:

Table 2. Loadings matrix of the four principal components

variant	principal component			
	1	2	3	4
X_1	0.787	0.973	0.114	0.070
X_2	0.677	0.128	-0.084	-0.217
X_3	0.691	-0.020	-0.075	0.023
X_4	0.686	-0.034	-0.042	0.060
X_5	0.048	-0.125	0.557	0.172
X_6	0.054	0.081	0.875	0.122
X_7	0.008	-0.012	0.704	0.069
X_8	0.091	0.027	0.816	0.075
X_9	-0.175	-0.067	-0.074	0.420
X_{10}	-0.009	0.050	-0.170	0.399
X_{11}	-0.161	-0.040	-0.035	0.515
X_{12}	-0.101	0.028	-0.181	0.818
X_{13}	0.771	-0.030	0.372	-0.199
X_{14}	0.070	0.895	-0.110	0.162
X_{15}	0.168	0.032	0.072	0.507
X_{16}	0.004	0.743	0.125	-0.123
X_{17}	0.087	0.905	0.027	-0.025
X_{18}	-0.028	0.584	0.560	0.210
X_{19}	-0.176	0.822	-0.005	-0.187
X_{20}	0.001	-0.032	-0.075	0.684

Based on the results of the principal component loading matrix and the actual meaning of each item, the four principal components were defined as "utility outcome", "personal perception", "environmental impact", and "government effectiveness". "government effectiveness". Based on the above four principal components and their influencing factors, a multilevel evaluation system of residents' willingness to accept green building behaviors was constructed. The "utility outcome" component covers technical perception variables, such as the effectiveness of energy-saving standards, eco-design fit, regulatory awareness, etc., reflecting residents' perception of the effectiveness of green building technology and regulatory compliance, and reflecting the actual value of technology application; "personal perception" Focusing on subjective willingness variables, such as recommendation, payment premium, purchase tendency, etc., which characterize residents' willingness to accept green buildings and value judgment, highlighting individual subjective attitudes; "environmental impact" includes social network variables, such as recognition by friends and relatives, recommendation by experts, and influence of media publicity, etc., reflecting the conduction of social relations and external information on residents' attitudes; "government

effectiveness" involves institutional variables, such as policy trust, regulatory effectiveness, and government problem-solving ability, reflecting the influence of government policies and governance effectiveness on residents' willingness to accept.

3.2. Analysis of Green Building Acceptance Willingness Based on Logistic Regression Modeling

The multivariate logistic regression model established in This paper uses the public's willingness to accept green buildings as the dependent variable, which is categorized into "strongly disagree", "disagree", "unsure", "agree" and "strongly agree", The dependent variable is divided into "strongly disagree", "disagree", "not sure", "agree" and "strongly agree", and the model of the public's willingness to accept green building is constructed according to the selection of the above variables. The model likelihood ratio chi-square test results show that the significance p-value of 0.000 is significant at the level of 0.000, rejecting the original hypothesis, and thus the model is valid. The test results of each independent variable are shown in Table 3:

Table 3. Multinomial Logistic Regression Likelihood Ratio Tests

independent variable	chi-square (math.)	significance
distinguishing between the sexes	1.925	0.749
(a person's) age	6.831	.0976
careers	28.885	0.025
Monthly household income	17.174	0.374
Type of housing currently occupied	17.328	0.365
Green Building Awareness	9.294	0.318
The degree to which friends and family recognize green building (social relations influence)	33.900	0.006
Level of confidence in government policies	41.537	0.000
Positive role of media sensitization	74.636	0.000

The significance results obtained show that of the nine independent variables analyzed, gender, age, monthly household income, type of house currently lived in, and the

degree of green building awareness are not significant at a p-value of less than 0.05, so their influence on the public's willingness to accept green building is relatively small, and

therefore the analysis is centered around the four independent variables with higher significance one by one.

4. Conclusions and recommendations

This study systematically identifies key influencing factors and mechanisms of residents' willingness to accept green buildings in Shandong Province via principal component analysis and a multivariate logistic regression model. Four core dimensions are summarized: "utility outcomes" (technical perceptions like energy-saving standards and eco-design fit), "personal cognition" (subjective judgments on regulations and future trends), "environmental influence" (social network effects from relatives/friends and expert recommendations), and "government effectiveness" (institutional factors such as policy trust and regulatory efficiency). Recognition from relatives/friends significantly enhances purchase willingness, with the "highly recognized" group showing a notably higher odds ratio, indicating word-of-mouth communication as a key acceptance pathway. Policy trust correlates positively with acceptance willingness, with the "highly trusting" group demonstrating the highest regression coefficient, underscoring the central role of government credibility. Positive media publicity significantly boosts acceptance by shaping environmental awareness (e.g., energy-saving advantages), with the "strongly agreeing" group having a significantly higher coefficient. Employees, government/institutional staff, and freelancers exhibit higher acceptance than other occupations, while students show lower propensity due to financial constraints and information exposure gaps. A four-dimensional promotion strategy is proposed: ① Activate social networks via community experience activities (e.g., energy-saving demonstrations) to leverage "strong trust relationships" for conveying real experiences; ② Enhance policy effectiveness through refined subsidies (e.g., tiered by energy efficiency), transparent policy implementation disclosures, and public opinion engagement; ③ Deliver targeted media communication by customizing content for occupations (e.g., industry cases for employees, policy dividends for officials, quality-of-life benefits for freelancers); ④ Strengthen demonstration effects via "policy demonstration projects" for government/institutional groups and "Green Life Festival" experiences for freelancers to highlight personalized green building designs.

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