

Article

Factors Influencing Residents' Intention toward Green Retrofitting of Existing Residential Buildings

Qing He ¹, Haiyang Zhao ^{1,*}, Lin Shen ², Liuqun Dong ^{3,*}, Ye Cheng ¹ and Ke Xu ¹¹ School of Management Engineering, Shandong Jianzhu University, Jinan 250101, China² Bohai College, Hebei Agricultural University, Cangzhou 061100, China³ School of Civil Engineering, Tongji University, Shanghai 200092, China

* Correspondence: venusalvapartvj@yahoo.com (H.Z.); dongliuqun@hytc.edu.cn (L.D.); Tel.: +86-189-5413-2598 (H.Z.)

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Abstract: The green retrofitting of existing residential buildings is an important approach to realise the sustainable development of stock buildings. In addition to the new technologies and materials related to green retrofitting, the intention of residents toward the green retrofitting of existing residential buildings must be understood. However, the factors affecting such intentions are still unclear. Hence, this study refers to the extended theory of planned behaviour and constructs a theoretical model of the intention toward the green retrofitting of existing residential buildings. On the basis of the data from 507 questionnaires collected from eastern and western China, the theoretical model is tested via structural equation modelling (SEM). Multigroup SEM is used to analyse the differences in population characteristics and the intention of residents toward the green retrofitting of existing residential buildings in residential areas. Research results reveal the following: (1) the most important factors affecting residents' intention toward green retrofitting are policy factors, followed by cognition of green retrofitting, behaviour, subjective norms, and perceived behavioural control; (2) policy factors not only directly affect residents' intention toward green retrofitting but also indirectly affect their intention toward existing residential green retrofitting through perceived behavioural control; (3) residents' cognition of green retrofitting exerts no significant direct impact on their intention toward green retrofitting, but it does indirectly affect their intention toward green retrofitting through behaviour and subjective norms; (4) behaviour, subjective norms, and perceived behavioural control have direct and significant influences on intention toward green retrofitting; (5) demographic characteristics (gender, age, monthly family income, education level, and occupation) and regional variables (east and west) present significant differences in different influence paths. The conclusion of the study provides a targeted path reference for the promotion of the green retrofitting of existing residential buildings.

Keywords: existing residential building; intention toward green retrofitting; theory of planned behaviour; multigroup structural equation modelling

1. Introduction

The construction industry plays an important role in the impact of various industries on the natural environment. It is a typical industry with high energy and resource consumption and high pollution [1]. Studies show that the energy consumption of existing buildings is approximately 30% of the cumulative energy consumption, and the use of energy may lead to nearly 30% of carbon emissions [2]. In the entire life cycle of a building, 80% of building energy consumption occurs in the actual use stage rather than the construction stage [3]. Therefore, a reasonable solution to reduce global greenhouse gas emissions and total energy consumption is the green retrofitting of

existing buildings. As an inevitable requirement of the deep development of green buildings, green retrofitting has undergone minimal development in China. As of 2017, China's existing construction area has exceeded 60 billion square metres, and it continues to expand by 1.6 billion to 2 billion square metres every year [4]. However, the green building area only measures 460 million square meters, which is less than 1% of the total construction area; moreover, the existing building area open to green retrofitting is only approximately 3.07 million square metres [5]. Therefore, retrofitting in this context is suitable. At present, most existing buildings suffer from issues such as functional degradation, high energy consumption, high emissions and large negative environmental impact. Reducing the impact of existing buildings on the environment through green retrofitting is urgent [6,7]. The service life of most existing buildings is 50–100 years [7]. On the one hand, the demolition of existing nongreen buildings not only involves a huge waste of resources and energy but also causes secondary pollution and damage to the ecological environment [8]. On the other hand, if nongreen buildings continue to be used, their negative impact on the environment will continue [9]. Therefore, the green retrofitting of existing buildings is more resource efficient and sustainable than developing new green buildings [10]. Through retrofitting, demolition and reconstruction can be avoided [11], thereby reducing the generation of construction waste [12] and the consumption of materials and other resources to promote the sustainable development of the society.

Sustainable development entered the world stage after the United Nations published a report titled 'World Commission on Environment and Development' (WCED). The Sustainable Development Goals (SDGs), otherwise known as the global goals, are a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity. SDGs need to satisfy economic development while taking care not to impair the benefits of the next generation. SDGs include three dimensions, namely, economic, environmental and social [13,14]. The green retrofitting of existing residential buildings echoes the principles of sustainable development defined in the WCED. Retrofitting is the modification or alteration of an existing process, facility or structure and is thus contrary to a complete replacement [15]. For example, it may involve the addition, deletion, rearrangement, or replacement of one or more parts of a facility [16]. Scholars agree that green retrofitting should stick to the three bottom lines of the economy, the environment, and social harmony [17]. Furthermore, the green retrofitting of existing housing is a type of building retrofitting mode which accords with the core concept of sustainable development. It is based on original building data that cover the aspects of energy saving, water saving, and indoor and outdoor environment and structural safety and were obtained to satisfy the standard of green building, save resources and energy, protect the environment to the greatest extent, and provide a healthy, safe, and comfortable living environment for occupants. The green retrofitting of existing buildings is different from that of ordinary green buildings. It is carried out on the basis of the original buildings. It generally includes the improvement of the performance of air-conditioning systems [18], upgrade of lighting systems [19], implementation of lighting control [20], thermal insulation of roof systems [21,22], and retrofitting of wall and mechanical ventilation systems [23]. The green retrofitting of existing buildings significantly reduces the energy consumption and cost of existing buildings and provides a healthy, suitable, and efficient space for occupants. These features are important in prolonging the life cycle of buildings [24], saving resources, protecting the environment, and resolving the bottleneck of energy resource constraints [25]. Moreover, green retrofitting is a crucial way to quicken the implementation of strategies for green city development and the construction of energy-saving and environmentally friendly cities. Green retrofitting is beneficial to sustainable development and urban renewal.

With the release and implementation of GB/T51141-2015, the assessment standard for the green retrofitting of existing buildings, marks the official shift from 'new construction' to 'retrofit' in the development of green buildings in China. Existing buildings are retrofitted and upgraded from 'energy-saving retrofitting' to 'green retrofitting'. However, the green retrofitting of existing buildings is still in the awkward situation of 'pushing but not moving'. This condition is due to the fundamental determining power of micro subjects. As the main body of the green retrofitting of existing buildings,

residents directly impact the promotion of the green retrofitting of existing buildings. Only if residents have subjective will and participate in the upgrading can the green retrofitting of existing buildings be effectively promoted. However, the determinants that significantly affect residents' intention toward green retrofitting and the relationship between these determinants and residents' intention toward green retrofitting remain unclear. In addition, previous studies on the green retrofitting of existing residential buildings mainly focused on technical retrofitting, evaluation methods [26–28], energy efficiency improvement [29–31], cost and benefit calculation of retrofitting [32,33], and retrofitting risks [34,35]. They generally ignored the intention of the subject to participate at the micro level, thereby leading to the poor effectiveness of the intervention of macro policies. Lorraine Murphy pointed out that countries should formulate green retrofitting strategies in accordance with their own national conditions and regional characteristics [36]. China has a large number and a wide range of existing residential buildings. Different regions have their own unique building systems, living habits, building types and regional cultural characteristics. However, at present, no scholar has explored the differences in the intention toward green retrofitting between the eastern and western regions of China and different groups (educational level, income level, age, and occupation). The differences in the intention toward green retrofitting amongst these groups should be studied to properly select and cultivate market segmentation and accurately identify the target market. Therefore, exploring a set of research models that are suitable for Chinese residents is important in the study of residents' intention toward the green retrofitting of existing residential buildings in the unique context of China. The investigation using such models should help resolve the problem of the green retrofitting of many existing buildings and old 'stock' buildings that have been generated over time in China. This study focuses on urban residential buildings because residential buildings account for the vast majority of existing buildings.

To fill the research gap, this study explores the main factors that affect the intention of Chinese residents toward the green retrofitting of existing residential buildings. This work also evaluates whether significant differences exist between these main factors and the intention toward green retrofitting of residents in eastern and western China, as well as amongst different groups. The three reasons for China's status as an effective research laboratory are as follows. Firstly, China is the largest construction market in the world. With a large stock of existing buildings, the green retrofitting of existing buildings should significantly reduce the country's total energy consumption and greenhouse gas emissions. In this way, China may contribute to world sustainable development. Therefore, the results of the study can satisfy the urgent needs of the Chinese government to vigorously promote the green retrofitting of existing buildings. Second, China is the largest developing country in the world. The results of this study can be used as a reference for other developing countries to carry out the green retrofitting of existing housing. Third, most previous studies focused on green retrofitting technology without considering the subjective intention of residents toward retrofitting. Moreover, no scholar has studied the significant differences in the intention toward green retrofitting amongst residents in the eastern and western regions of China, as well as amongst different groups. In this work, these differences are analysed with multigroup structural equation modelling (SEM).

The remainder of this paper is organised as follows. Section 2 outlines the literature review and hypothesis development. Section 3 presents the methodology, data collection, and data processing. Section 4 provides the results, including model testing, effect analysis, and multigroup analysis. Section 5 discusses the critical factors and corresponding strategies. Section 6 presents the summary.

2. Literature Review and Hypothesis Development

2.1. Improved Modelling of Theory of Planned Behaviour (TPB)

In modern society, no simple one-to-one relationship exists between human behaviour and attitude. Behaviour is influenced by environment, experience, and psychological pressure. The theory of planned behaviour (TPB) is based on the study of the relationship between attitude and

behavior [37]. It explains the general decision-making process of individual behaviour from the point of view of information processing and the theory of expected value. It helps us understand how people control their actions and movements. Whether or not the target behaviour occurs can be explained and predicted by the intention and the perceived behavioural control (PBC) of the target behaviour. Intention also depends on attitude, subjective norms (SNs) and PBC. Not all behavioural intentions can eventually be translated into actual actions [38]. Whilst explaining the behaviour of people, the TPB can also explain some factors that cause people to change their original intentions or prevent them from acting, thereby enriching the understanding of how to change and correct a certain behaviour [39].

The TPB is widely favoured by researchers of social behaviour, and it has been successfully applied in many behavioural contexts, including dieting [40,41], choice of hotels [42,43], online shopping [44,45], and house rentals [46]. Moreover, most studies have confirmed that the TPB can significantly improve the explanatory and predictive power of research objects' behavior [39]. For example, on the basis of the TPB, Kautonen and other scholars predicted the entrepreneurial intention of the adult population in Austria and Finland and proved the correlation and robustness of the TPB [47]. Ajzen and Driver studied 68 college students to predict their behavioural intention toward leisure activities. They found that the leisure consciousness and economic ability of college students significantly impact behavioural intention and that the prediction results of the improved TPB modelling are relatively accurate [48]. Justin Paul expanded the TPB to include environmental concerns as the key variable in the marketing process and verified that such theory and its extended form can effectively predict the purchase intention of Indian consumers toward green products. The results also showed that extending the additional structure in the TPB improves the understanding of the formation of the purchase intention toward green products [49]. The results of the study by Yadav also showed the applicability of adding an additional structure to the TPB because doing so improves the predictive utility of the model (from 27.1 to 37%) [50].

The research results evidently show that the TPB has good generality and adaptability in the interpretation of individual intention. Many scholars have improved the TPB according to specific behaviour in empirical research. The research object of the current study is the intention toward the green retrofitting of existing residential buildings; such intention varies amongst individuals. Thus, this study attempts to expand the modelling of the TPB. Scholars have yet to consider the important variable of the cognition of green retrofitting as most studies focused on purchase intention toward green products and variables such as subjective knowledge [51] and policy incentives [46,51]. Berger believed that consumers' familiarity with green products and understanding of product quality directly affect their purchasing motivation [52]. Babin also explained that rich knowledge of product attributes facilitates an intelligent evaluation; thus, product attributes are the most important factor affecting consumers' purchase intent [53]. Policy factors (PFs) play an equally important role in promoting green consumption [54]. Therefore, on the basis of previous studies and research practice, the current study extends policy factors (PFs) and green retrofitting cognition (GRC) to the TPB and removes the variable of actual behaviour. This removal stems from the complicated measurement of residents' behaviour toward green retrofitting and the difficulty of selecting survey data. Moreover, shifting from residents' intention toward green retrofitting to actual behaviour is time consuming and thus restricts the tracking of the investigation. In theory, using behavioural intention as a dependent variable to study residents' intention toward green retrofitting is reasonable.

The expanded TPB modelling is shown in Figure 1.

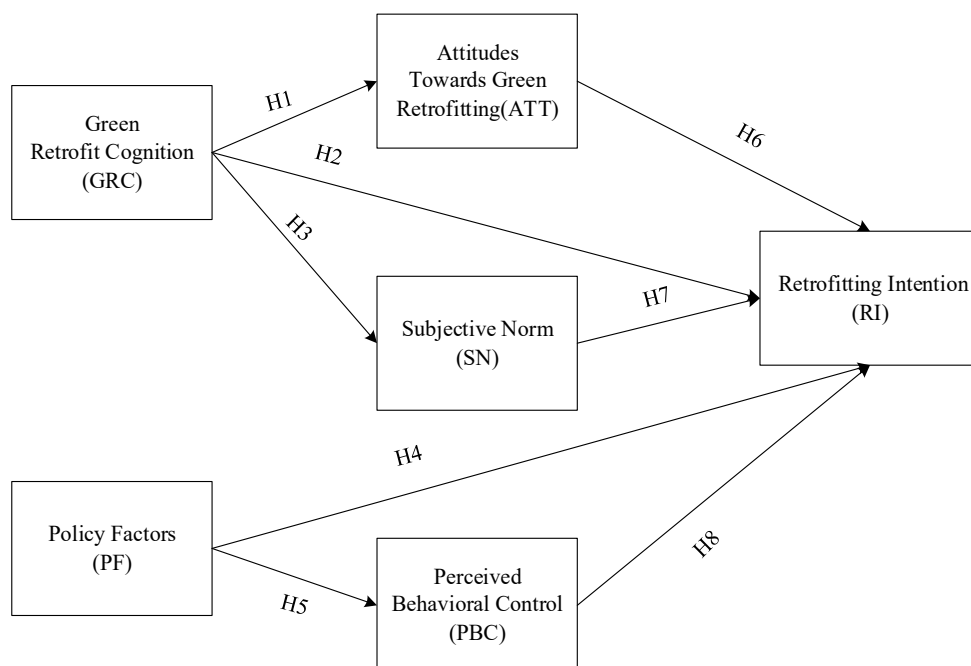


Figure 1. Theoretical model of green retrofitting intention for existing residential buildings.

2.2. Research Hypothesis

2.2.1. Relationship between Green Retrofitting Cognition and Behavioural Attitude, Subjective Norms, and Green Retrofitting Intention

Cognition is the information processing activity of individuals as they attempt to understand the objective world; it is the process of people's understanding of one thing [55]. At present, the concept of GRC is still vague. As a single concept, GRC is not commonly mentioned in the existing literature. Thus, its definition has not been unified, and it is generally combined with specific research objects. The specific definition of GRC refers to residents' perception of green retrofitting through their understanding of its process and products. It should include residents' overall perception of green retrofitting technology, retrofitting cost, and green retrofitting products. Follows and other scholars studied the purchase intention of products and concluded that consumers' perception of products positively affects their purchasing intention [56]. Chowdhury and other scholars studied the influencing factors of food purchase intention. Through a large number of experiments and questionnaires, they found that when consumers' understanding of nutrition knowledge is deep, they become inclined to purchase given products [57]. Biswas analysed the relationship between consumers' green consumption cognition and green product consumption. The author suggested that green consumption cognition is the driving force of green product consumption and is the reason for the premium value of green products; it influences consumers' attitude toward product selection [58]. This research indicates that consumers with certain product knowledge have sufficient understanding of the characteristics and attributes of products. They know how to evaluate products, and such knowledge influences the formation of consumers' cognitive and emotional attitudes or enhances consumers' perception of products to improve their purchasing intentions. In general, the current study holds that when consumers possess in-depth product knowledge, their product identification ability strengthens, and their cognition of product attributes is high. Under these conditions, judging emotions toward product value and preferences is favourable, and consumers tend to develop the intention to adopt green retrofitting.

In line with these generalisations, the following assumptions are made:

Hypothesis (H1). *GRC has a significant positive effect on behavioural attitude.*

Hypothesis (H2). *GRC has a significant positive effect on green RI.*

Hypothesis (H3). *GRC has a significant positive effect on SNs.*

2.2.2. Relationship between Policy Factors and Green Retrofitting Intention and Perceived Behavioural Control

PFs refer to the direct control, intervention or encouragement of policies on micro economic subjects at the government level; they are considered important external variables affecting environmental behaviour [54]. The green retrofitting of existing residential buildings has external economy, and government intervention is a good solution [59]. The removal of tax incentives and subsidies affects the sustainable development of existing buildings [60]. On the contrary, the government's financial or policy incentive guarantee affects stakeholders' action to implement green retrofitting projects in existing buildings [61]. At present, most studies are based on the perspective of direct government intervention. Zhang and other scholars conducted a study on the intention of Chinese young consumers to purchase green housing. They found that the government's incentives exert a significant positive influence on PBC and the intention to purchase and that these incentives largely affect purchase intention [51]. Zheng and other scholars studied the behaviour of Chinese youth in adopting rented housing, and their results showed that policy incentives exert a significant positive impact on PBC [46]. The current analysis indicates that the popularisation and application of the green retrofitting of existing residential buildings in society are not dependent on the strong guidance and policy encouragement of the government. Therefore, the government's implementation of incentive measures not only effectively improves the determination of residents to carry out green retrofitting but also promotes the formation of residents' intention to carry out green retrofitting. Therefore, the following assumptions are drawn:

Hypothesis (H4). *PFs have a significant positive impact on green RI.*

Hypothesis (H5). *PFs have a significant positive impact on PBC.*

2.2.3. Relationship between Behavioural Attitude, Subjective Norms, Perceived Behavioural Control, and Green Retrofitting Intention

Behavioural attitude refers to an individual's intention to carry out a particular behaviour in a given situation, as well as this individual's comprehensive evaluation of a particular behaviour (including positive or negative evaluation) [62]. In this study, behavioural attitude refers to the behavioural intention of residents to carry out the green retrofitting of existing residential buildings. It is the comprehensive evaluation of residents' green RI. PBC is the degree to which an individual perceives the ease or difficulty of performing a particular behaviour. It reflects an individual's perception of factors that promote or hinder the execution of a behaviour. The connotation of PBC includes two factors, namely, self-efficacy perception and control power. The former refers to the confidence of the individual in their ability to complete the behaviour, that is, self-efficacy; the latter refers to the degree of control of the individual to the resources required to complete the capacity [63]. SNs mainly refer to the external pressure generated by individuals when they perform a particular act. When the positive SN is strong, it is likely to generate the intention to promote the behavior [64,65]. In the process of forming green RI, the persuasion of the government, social network, friends, and family represents SNs that affect RI. A review of the literature reveals that most studies showed that behaviour, SNs and PBC significantly influence behavioural intention. For example, Yang and other scholars studied the sustainable consumption intention of Chinese consumers in the 'Double 11 Shopping Festival'. Their results showed that attitude, SNs, and PBC exert significant positive effects on sustainable consumption intention [45]. Maichum and other scholars studied the intention of Thai consumers to purchase green products, and their results also showed that attitudes, SNs and PBC have significant positive effects on the intention to purchase green products [66]. Mufidah [67], Zheng [46], Vermeir [68], Kim [69], and

other scholars used the TPB or extended the TPB to study related problems in different areas; however, they concluded that attitude, SNs, and PBC exert significant effects on intention. On the basis of this analysis, the current study contends that residents' attitudes and SNs significantly affect their green RI. Moreover, the green RI of residents is affected by the control of willpower, that is, PBC. On the basis of this analysis, the following assumptions are drawn:

Hypothesis (H6). *Behavioural attitude has a significant positive effect on green RI.*

Hypothesis (H7). *SNs have a significant positive effect on green RI.*

Hypothesis (H8). *PBC has a significant positive effect on green RI.*

3. Methodology

3.1. Structure Equation Model (SEM)

Structural equation models (SEM)s have been widely used in many fields of research since the 1980s, such as social sciences, management, and behavioral sciences, and psychology [70]. SEM is used to analyze the relationship between observed variables and latent variables, and to identify the path relationship between latent variables [71]. This method has played an excellent role in identifying key indicators and factors. For example, Shen et al. adopted SEM to analyze the most important factor that influences the passenger satisfaction with urban railway transit in China [72]. Ju identify the impact factors of the logistics service supply chain for sustainable performance by SEM [73]. In order to compensate for the shortcomings of traditional statistical methods, SEM has been widely used in the field of multivariate data analysis. Therefore, the hypotheses in this study were analyzed by SEM. The AMOS 21.0 software was adopted for applying SEM during the research process.

3.2. Scale Design

The questionnaire used in this study mainly includes the following seven sections: demographic characteristics and regional distribution, GRC, PFs, behavioural attitude, SNs, PBC, and the intention toward the green retrofitting of existing residential buildings. The measurement items of the latent variables are mainly based on the TBP and the maturity scale in green building and other fields, along with the current research topic. The items were optimised following consultations with three experts from various universities. The literature research indicated that most questionnaires on attitude measurement adopt a five-point Likert scale. However, an increasing number of scholars have begun to use a seven-point Likert scale. The research of Lubke and Muthen [74] suggested that a seven-point scale is suitable to reduce the excessive skewness of data. Therefore, except for demographic characteristics and regions, all other variables in the current study adopted a seven-point Likert scale. The interviewees rated the degree of their agreeableness with the subject according to their true feelings, with the score of 7 indicating 'completely agree' and the score of 1 indicating 'completely disagree'.

This study requires multigroup SEM to analyse different groups. Hence, all demographic variables in the questionnaire, except occupation, are dichotomous. The demographic variables included sex, age, monthly family income, educational level, and occupation. For age, family income, and education level, the following classification was performed after consulting the experts and literature: 35 years old and below = 1 = low age and over 35 years old = 2 = high age (people over 18 years of age were selected as research objects); monthly family income of 3500 yuan or less = 1 = low income level and monthly family income of 3500 yuan or more = 2 = high income level; bachelor's degree and below = 1 = low education level and bachelor's degree and above = 2 = high education level. The five major occupational categories are as follows: enterprise personnel = 1, government personnel = 2, self-employed = 3, student = 4 and unemployed = 5. In the regional variable, 1 represents 'east', and 2 represents 'west'.

Prior to the formal investigation, a pre-investigation using a small sample was carried out on old residential areas. The pre-investigation involved graduate students and office workers around Chengdu, Sichuan Province. Data collection was mainly carried out on the spot, particularly at the entrance and exit locations of each community to improve the speed of questionnaire collection and the extensiveness and flexibility of data collection. The quality of the questionnaire was guaranteed by scheduling the survey time during weekends because most people work under tight hours from Monday to Friday, and the interviewees might not have sufficient time to answer the questionnaire at will. As a result, the survey was set to 10–11 November 2018. A total of 80 questionnaires were sent out. Excluding missing data and contradictory questionnaires, 66 valid questionnaires were collected, and the effective recovery rate of the questionnaire was 82.5%. In accordance with the collected questionnaire data on small samples, the reliability and validity of the sample data were analysed. The final questionnaire was formed after eliminating the unreliable indices and modifying the expression of individual questions, as shown in Table 1.

Table 1. Research questionnaire on intention toward green retrofitting of existing residential buildings.

Dimensions	Question Items	Sources
ATT	I think the green retrofitting of existing residential buildings is conducive to the protection of the environment.	[51,66]
	I think the green retrofitting of existing residential buildings is conducive to improving the quality of living.	
	I think the green retrofitting of existing residential buildings is worth it.	
	I have a positive attitude toward the green retrofitting of existing residential buildings.	
SN	The green retrofitting of existing residential buildings can be supported by families.	[40,66]
	Friends and relatives carry out the green retrofitting of existing residential buildings.	
	The media vigorously advertise the green retrofitting of existing residential buildings.	
	The government vigorously promotes the green retrofitting of existing residential buildings.	
PBC	I have sufficient funds for the green retrofitting of existing residential buildings.	[45,46]
	I think I have the ability to carry out the green retrofitting of existing residential buildings in the future.	
	I have sufficient time and energy for the green retrofitting of existing residential buildings.	
	The policy incentive strengthens my determination to retrofit existing residential buildings.	
GRC	The green retrofitting of existing residential buildings accords with the concept of sustainable development.	[56–58]
	Green retrofitting can increase the value of housing rental and sale.	
	The green retrofitting technology for existing residential buildings is mature, and the green materials are safe and reliable.	
	Green retrofitting entails low cost.	
	Green retrofitting can improve the performance of existing residential buildings and extend the life of buildings.	
	The period of the green retrofitting of existing residential buildings is short, and retrofitting is convenient.	
PF	The residential environment after green retrofitting is comfortable and entails low energy consumption and low operating cost.	[54,59,61]
	If the government can provide appropriate economic subsidies according to the green retrofitting area, then I am willing to carry out the green retrofitting of existing residential buildings.	
	If the government issues tax incentives for green retrofitting, then I am willing to carry out the green retrofitting of existing residential buildings.	
	If the government introduces a preferential policy on loan interest rates for green retrofitting, then I am willing to carry out the green retrofitting of existing residential buildings.	
	If the government rewards residents for carrying out the green retrofitting of existing residential buildings, then I am willing to carry out the green retrofitting of existing residential buildings.	
	If the government can arrange green retrofitting professionals to provide technical and program support, then I am willing to carry out the green retrofitting of existing residential buildings.	
RI	I would like to actively recommend to friends the green retrofitting of existing residential buildings.	[46,51]
	I am willing to carry out the green retrofitting of existing residential buildings.	
	In the future, I will carry out the green retrofitting of existing residential buildings because it is conducive to the sustainable development of the society.	

ATT, Attitudes Toward Green Retrofitting; SN, Subjective Norms; PBC, Perceived Behavioural Control; GRC, Green retrofitting cognition; PF, Policy factors; RI, Retrofitting Intention.

3.3. Data Collection

In conducting a scientific analysis of the theoretical model constructed in this study, the provinces that could fully represent the eastern and western regions should be fully considered when selecting samples from the east and west. Differences in the level of development were found. Shandong Province, Jiangsu Province, and Fujian Province were selected to represent the east. Sichuan Province, Guizhou Province, and Guangxi Zhuang Autonomous Region were selected to represent the west. In Figure 2, blue represents the eastern region, and yellow represents the western region. The data collection was mainly performed through field interception research, and small tokens were given to the respondents. The investigation period was from 20 November 2018 to 30 January 2019. A total of 600 questionnaires (100 in each province) were sent out, and 543 were recovered. A total of 507 valid questionnaires were collected by excluding the questionnaires with inconsistent and incomplete answers and those with answers showing evident regularity. The effective recovery rate of the questionnaire was 84.5%. Of all the questionnaires collected, 268 questionnaires were from the eastern region, and 239 were from the western region. Table 2 presents the demographic characteristics of the respondents.

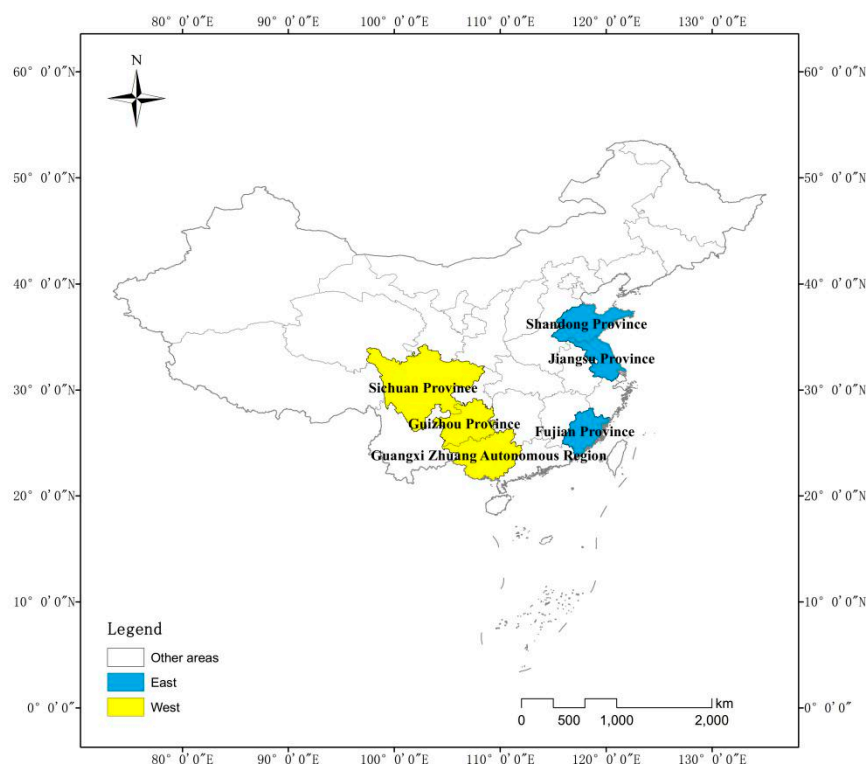


Figure 2. Distribution of data sources.

From the perspective of gender ratio, the ratio of male to female was approximately equal, with females being slightly greater in number. In terms of age, 59.96% of the respondents were over 35 years old; this percentage is relatively consistent with the proportion of respondents published in China's statistical yearbook in 2017. In terms of education level, 54.83% of the respondents earned bachelor's degrees and below; this percentage is consistent with China's basic national conditions in which the proportion of individuals receiving higher education is relatively low. In terms of monthly family income, 61.74% of the respondents earned over 3500 yuan. The high cost of green retrofitting and the high proportion of high-income groups are in line with the reality. In terms of occupation, enterprise personnel and government personnel were dominant at 54.24%. These groups have their own independent source of income and can decide whether to carry out the green retrofitting of

existing residential buildings. The demographic variables indicate that the research sample has a wide range and good representativeness.

Table 2. Descriptive statistics of demographic variables.

Variable	Variable Definition	Frequency	Percentage (%)
Sex	Male	239	47.14
	Female	268	52.86
Age	35 years old and below	203	40.04
	Over 35 years old	304	59.96
Education Level	Bachelor's degree and below	278	54.83
	Bachelor's degree and above	229	45.17
Family Monthly Income	3,500 yuan and below	194	38.26
	More than 3500 yuan	313	61.74
Occupational Categories	Enterprise personnel	133	26.23
	Government personnel	142	28.01
	Self-employed	58	11.44
	Student	71	14.00
	Individual business	56	11.05
	Others	47	9.27

3.4. Data Verification

3.4.1. Reliability Analysis

At present, members of the academe generally use the Cronbach's alpha coefficient to test the reliability of data. The Cronbach's alpha coefficient ranges from 0 to 1, and values close to 1 indicates great correlation and high consistency between question items and measured variables. In the current work, SPSS 20.0 was used for the reliability analysis, and the overall reliability of the scale was determined to be 0.918. The reliability analysis results of each latent variable are shown in Table 3. The Cronbach's alpha coefficient of each latent variable was above 0.7, indicating the questionnaire's good reliability and high consistency.

Table 3. Results of reliability and convergence validity tests.

Dimensions	Reliability Test	Convergent Validity Test	
	Cronbach's α coefficient	AVE	CR
GRC	0.842	0.573	0.832
PF	0.821	0.608	0.845
ATT	0.849	0.631	0.849
SN	0.905	0.706	0.905
PBC	0.841	0.588	0.843
RI	0.756	0.519	0.733

AVE, Average Variance Extracted; CR, Critical Ratio.

3.4.2. Validity Test

The validity test is mainly divided into convergent validity test and discriminant validity test. At present, the values of composite reliability (CR) and average variance extracted (AVE) are commonly used to test convergent validity. Generally, the CR value should be greater than 0.6, and the AVE value should be greater than 0.5. In the current work, AMOS 21.0 was used to test the convergent validity of the AVE and CR values. The specific results of the convergent validity test are shown in Table 3.

As shown in Table 3, the AVE value of each latent variable was greater than 0.5, and the CR values were greater than 0.7. Therefore, the questionnaire showed good convergent validity.

Generally, a model's discriminating validity mainly depends on whether the square root of the AVE value of each variable is greater than the correlation coefficient between variables. If the square root of the AVE value is greater than the correlation coefficient between variables, then the model has good discriminant validity. Table 4 shows that the square root of each variable's AVE is greater than the correlation coefficient between the variables. Thus, the discriminant validity of the questionnaire was deemed satisfactory.

Table 4. Results of discriminant validity test.

Latent Variable	GRC	PF	ATT	SN	PBC	RI
GRC	0.756					
PF	0.677	0.779				
ATT	0.580	0.531	0.794			
SN	0.44	0.390	0.315	0.840		
PBC	0.369	0.400	0.258	0.239	0.767	
RI	0.233	0.592	0.479	0.397	0.360	0.721

The reliability and validity analysis of these questionnaires obtained good results. Thus, the next step of SEM analysis can be carried out.

4. Results

Variables such as behavioural attitude and SNs cannot be directly measured. Hence, in multiple regression, independent and dependent variables should be measurable, and neither independent variables nor dependent variables can produce regression coefficients. Moreover, many factors influence green RI intention, and the relationships amongst the influencing factors are complex, hence the difficulty in identifying them using multiple regression analysis. SEM can make up for the deficiency of multiple regression methods and deal with the complex relationship amongst multiple potential variables simultaneously. Therefore, SEM was selected for analysis.

4.1. Structural Modelling Test

Through the establishment of a theoretical model and the measurement indices of the potential variables, this study initially fitted the theoretical model with the statistical analysis data software AMOS 21.0. The fitting results showed that the path H2 ($\beta = 0.136$, $p > 0.05$), where GRC points to RI, did not reach the significance level; thus, path H2 was deleted. The chi-square degree of freedom ratio was $2.818 < 3$, IFI was 0.891, TLI was 0.887, CFI was 0.854, RMSEA was 0.087, RMR was 0.053, and AGFI was 0.901. It was basically close to the fitting index, but it did not reach the ideal value. Hatcher [75] pointed out that the fitting indices of modelling cannot easily satisfy fitting standards during the first attempt due to data deviation or modelling problems. Therefore, the modelling was modified several times according to the modification index (MI) value provided by AMOS. The absolute fit index, value-added fit index, and contracted fit index of the modified model satisfied the standard. The modified path coefficient is shown in Figure 3, and the model fitting index is shown in Table 5.

The modified modelling path coefficients are shown in Table 6.

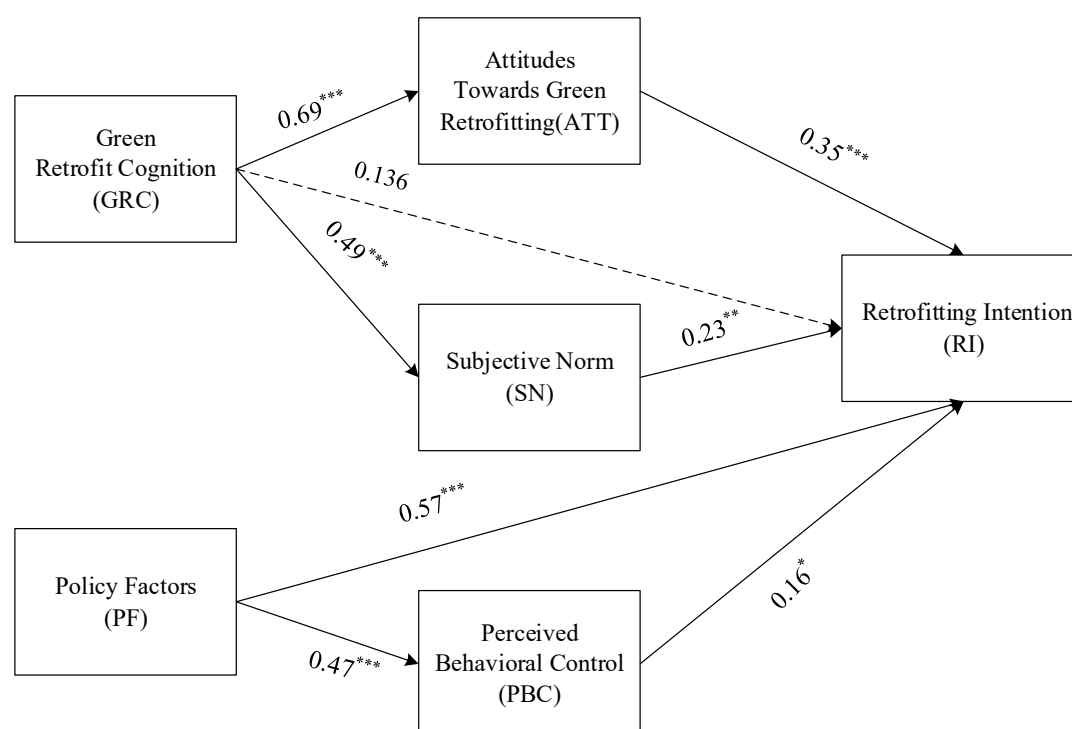


Figure 3. Modified modelling of green retrofitting intention for existing residential buildings (standardised path coefficient). Note: * denotes 0.05 significance level, ** indicates 0.01 significance level, and *** represents 0.001 significance level.

Table 5. Model fitting indices.

Statistical Test Quantity	Adaptation Standard	Before Model Correction	Model Adaptation Judgment	After Model Revision	Model Adaptation Judgment
Absolute fit index					
RMR	<0.05	0.053	No	0.041	Yes
RMSEA	<0.08	0.087	No	0.066	Yes
GFI	>0.9	0.897	No	0.913	Yes
AGFI	>0.9	0.901	Yes	0.917	Yes
Value-added fit index					
IFI	>0.9	0.891	No	0.925	Yes
TLI	>0.9	0.887	No	0.907	Yes
CFI	>0.9	0.854	No	0.918	Yes
Simple fit index					
PGFI	>0.5	0.687	Yes	0.713	Yes
PNFI	>0.5	0.733	Yes	0.768	Yes
PCFI	>0.5	0.845	Yes	0.859	Yes
CN	<3	2.818	Yes	2.705	Yes

RMR, Root Mean Square Residual; RMSEA, Root Mean Square Error of Approximation; GFI, Goodness-of-Fit Index; AGFI, Adjusted Goodness-of-Fit Index; IFI, Incremental Fit Index; TLI, Tucker-Lewis Index; CFI, Comparative Fit Index; PGFI, Parsimonious Goodness Fit Index; PNFI, Parsimonious Normative Index; PCFI, Parsimonious Comparative Fit Index; CN, CMIN/DF.

The calculation results are summarised in Table 7 to further explore the direct effects, indirect effects, and total effect amongst the potential variables. Amongst the five latent variables—GRC, PFs, behavioural attitude, SNs, and PBC—PF (0.645) had the greatest impact on the green RI for existing residential buildings. PFs not only directly affect green RI for existing residential buildings but also indirectly affect the green RI for existing residential buildings through PBC. The indirect effect equalled 0.075, indicating that every 1 percentage point increase in PF increased the green RI for existing residential buildings by 0.075 percentage point. GRC (0.354) exerted no significant direct influence

on green RI, but it indirectly influenced green RI through behavioural attitude and SNs. The indirect influence effect equalled 0.354, indicating that every 1 percentage point increase in GRC increased the green RI for existing residential buildings by 0.354 percentage points. Behavioural attitude (0.350) and SNs (0.230) had the second greatest impact on green RI for existing residential buildings, followed by PBC (0.160).

Table 6. Modelling path coefficients.

Hypothesis	Path			Standardised Path Coefficient	S.E.	C.R.	P	Results
H1	ATT	←	GRC	0.693	0.079	8.965	***	Supported
H2	RI	←	GRC	0.136	0.107	1.432	0.074	Unsupported
H3	SN	←	GRC	0.490	0.096	7.276	***	Supported
H5	PBC	←	PF	0.467	0.123	5.438	***	Supported
H7	RI	←	SN	0.233	0.050	3.203	**	Supported
H4	RI	←	PF	0.567	0.129	5.264	***	Supported
H8	RI	←	PBC	0.160	0.067	2.015	0.044	Supported
H6	RI	←	ATT	0.346	0.076	4.345	***	Supported

S.E., Standard Error; Note: * means $p < 0.05$, ** means $p < 0.01$ and *** means $p < 0.001$.

Table 7. Direct effects, indirect effects, and total effects amongst latent variables.

Hypothesis	Path			Direct Effects	Indirect Effects	Total Effects
H1	ATT	←	GRC	0.69	—	0.690
H2	RI	←	GRC	—	0.354	0.354
H3	SN	←	GRC	0.49	—	0.490
H4	RI	←	PF	0.57	0.075	0.645
H5	PBC	←	PF	0.47	—	0.470
H6	RI	←	ATT	0.35	—	0.350
H7	RI	←	SN	0.23	—	0.230
H8	RI	←	PBC	0.16	—	0.160

4.2. Multigroup SEM Analysis

ANOVA can analyse the differences in cognitive level between different groups on a certain (or a certain) variable, but it cannot evaluate the effects and differences between different variables. Multigroup SEM makes up for the deficiency of ANOVA in this respect. Therefore, multigroup SEM was adopted in the current work to analyse the differences in demographic characteristics and regional variable influences on each path.

4.2.1. Multigroup SEM Analysis Based on Demographic Characteristics

AMOS 21.0 was used to simulate the data, and the calculation results were sorted, as shown in Table 8. The CFI value was between 0.902 and 0.951 and was thus higher than the modelling adaptation standard value of 0.90. The PNFI value was between 0.584 and 0.796 and was thus higher than the standard value of 0.5. The RMSEA values were between 0.034 and 0.071 and were thus lower than the standard value of 0.008. Therefore, the results of multigroup SEM can be in good agreement with observed data.

Table 8. Estimation results of multigroup structure equation model (SEM) based on demographic characteristics.

Path	Sex		Age	
	Male	Female	Low Age	High Age
H1	0.69 ***	0.774 ***	0.433 **	0.619 ***
H3	0.642 ***	0.982 ***	0.329 *	0.351 *
H4	0.75 ***	0.163	0.312 *	0.614 ***
H5	0.69 ***	0.653 ***	0.637 ***	0.479 **
H6	0.307 **	0.283 **	0.513 ***	0.076
H7	0.09	0.365 **	0.446 **	0.109
H8	0.593 ***	0.507 ***	0.106	0.211

Path	Occupational Categories					
	Enterprise Personnel	Government Personnel	Self-Employed	Student	Individual Business	Others
H1	0.448 **	0.562 ***	0.102	0.473 **	0.167	0.094
H3	0.521 ***	0.601 ***	0.091	0.125	0.053	0.044
H4	0.462 **	0.533 ***	0.149	0.218	0.326 *	0.068
H5	0.339 *	0.341 *	0.061	0.118	0.079	0.135
H6	0.497 **	0.433 **	0.221	0.353 *	0.307 *	0.116
H7	0.364 *	0.449 **	0.102	0.227	0.045	0.213
H8	0.445 **	0.675 ***	0.137	0.054	0.102	0.193

Path	Per Capita Monthly Family Income		Education Level	
	Low Income Level	High Income Level	Low Level of Education	High Level of Education
H1	0.223	0.729 ***	0.107	0.455 **
H3	0.161	0.549 ***	0.464 ***	0.553 **
H4	0.402 **	0.633 ***	0.359 *	0.448 **
H5	0.397 *	0.641 ***	0.313 *	0.366 *
H6	0.104	0.472 **	0.202	0.471 **
H7	0.116	0.344 *	0.488 **	0.219
H8	0.203	0.679 ***	0.235	0.606 ***

Note: * means $p < 0.05$, ** means $p < 0.01$ and *** means $p < 0.001$.

In terms of gender, significant differences were noted between H4 (male ($\beta = 0.75$, $p < 0.001$), female ($\beta = 0.163$, $p > 0.001$)) and H7 (male ($\beta = 0.09$, $p > 0.05$) and female ($\beta = 0.365$, $p < 0.001$)). In terms of age, significant differences were noted between H6 (low age ($\beta = 0.513$, $p < 0.001$), high age ($\beta = 0.076$, $p > 0.001$)) and H7 (low age ($\beta = 0.446$, $p < 0.001$), high age ($\beta = 0.109$, $p > 0.001$)). As for the occupational categories, only enterprise personnel and government personnel exerted a significant influence and showed no significant difference; the other groups had significant differences in different paths. With regard to the per capita monthly family income, only H4 (low income level ($\beta = 0.402$, $p < 0.001$), high income level ($\beta = 0.633$, $p < 0.001$)) and H5 (low income level ($\beta = 0.397$, $p < 0.001$), high income level ($\beta = 0.641$, $p < 0.001$)) showed a significant difference but not in other paths. As for the level of education, H1 (low education level ($\beta = 0.107$, $p > 0.05$), high education level ($\beta = 0.455$, $p < 0.01$)) and H6 (low education level ($\beta = 0.202$, $p > 0.05$), high education level ($\beta = 0.471$, $p < 0.01$)) presented a significant difference.

4.2.2. Multigroup SEM Analysis Based on Samples from East and West

AMOS 21.0 was used to simulate the data, and the calculation results were sorted, as shown in Table 9. In accordance with the model adaptation standard, the CFI value was between 0.911 and 0.987 and was thus greater than the standard value of 0.90). The PNFI value was between 0.602 and 0.822 and was thus greater than the standard value of 0.5. The RMSEA values were between 0.027 and 0.069 and were thus lower than the standard value of 0.08. Therefore, the results of multigroup SEM can be in good agreement with observed data.

Table 9. Estimation results of multigroup SEM based on samples from east and west.

Hypothesis		Path		West	East
H1	ATT	←	GRC	0.503 **	0.746 ***
H3	SN	←	GRC	0.252	0.416 **
H4	RI	←	PF	0.631 ***	0.429 **
H5	PBC	←	PF	0.625 ***	0.433 **
H6	RI	←	ATT	0.173	0.577 **
H7	RI	←	SN	0.068	0.628 ***
H8	RI	←	PBC	0.212	0.812 ***

Note: * means $p < 0.05$, ** means $p < 0.01$ and *** means $p < 0.001$.

The multigroup analysis results show that only H1 (west ($\beta = 0.503$, $p < 0.01$), east ($\beta = 0.746$, $p < 0.001$)), H4 (west ($\beta = 0.631$, $p < 0.001$), east ($\beta = 0.429$, $p < 0.01$)) and H5 (west ($\beta = 0.625$, $p < 0.001$), east ($\beta = 0.433$, $p < 0.01$)) had a significant influence and no significant difference. All other paths had significant difference.

5. Discussion

PFs (0.645) had the greatest impact on green RI for existing residential buildings, followed by GRC (0.354), behavioural attitude (0.350), and SNs (0.230). PBC (0.160) had the smallest impact, but GRC was confirmed to have no direct and significant impact on green RI.

5.1. Effects of Behavioural Attitude, Subjective Norms and Perceived Behavioural Control on Green Retrofitting Intention

Behavioural attitude, SNs, and PBC in relation to green retrofitting showed direct and significant effects on green RI. The results validate the importance of behavioural attitude, SNs, and PBC in predicting residents' green RI. This conclusion is consistent with most research results, such as those on street food supply [76], food safety [77], green product purchase [66], and green consumption [49]. Only a few studies have reached inconsistent conclusions. For example, Zhang's research showed that PBC exerts no significant effect on purchase intention toward green building [51]. We consider two reasons behind the difference in results. On the one hand, consumers have the autonomy to decide whether or not to purchase products or services. Zhang's research used young Chinese consumers as the research samples. Whether this group is able to purchase green buildings is largely determined by their parents and not by the young consumers themselves. By contrast, the sample in the current study can decide whether or not to carry out the green retrofitting of existing residential buildings. On the other hand, a large gap exists in the cost between purchase and retrofitting. Purchasing new green buildings requires large funding, whereas the green retrofitting of existing residential buildings entails a relatively low cost [78]. Residents who lack large consumption funds can decide whether or not to carry out green retrofitting. These factors contribute to the differences in the results of the current work and those of other studies.

5.2. Impact of Policy Factors on Green Retrofitting Intention

PFs showed the greatest impact on green RI. The promotion and application of the green retrofitting of existing residential buildings in society cannot be separated from the vigorous guidance and policy encouragement of the government. The green retrofitting of existing residential buildings is still in its infancy in China. Through the government's incentive policy, most residents can obtain additional economic income to compensate for the cost of green retrofitting. Hence, such policy greatly improves the enthusiasm of residents toward green retrofitting. This result accords with the findings of Mickaityte [79], Baek [80], and other scholars. The government's financial support, loan preferential policies, and tax preferential policies are important driving forces for the green retrofitting of buildings. Therefore, to achieve and promote the large-scale retrofitting of existing residential buildings, the Chinese government should formulate a combination of economic incentive policies and actively guide residents in carrying out the green retrofitting of existing residential buildings. In this study, PFs were mainly measured by five variables: economic subsidies, tax preferences, loan interest rate discount, technical program support for green retrofitting, and direct reward for retrofitting behaviour. The results of the model operation suggest that the top three influencing factors of government policy are as follows: economic subsidies, whose standard factor load and average value were 0.91 and 5.88, respectively; loan interest rate discount, whose standard factor load and average value were 0.87 and 4.79, respectively; and direct reward for retrofitting behaviour, whose standard factor load and average value were 0.72 and 5.03, respectively. Most residents attach great importance to direct government subsidies, loan interest rate discount, and direct rewards, probably because the green retrofitting of residential buildings in China is still in the initial stage of exploration and only a few incentives, such as subsidies for green retrofitting at the government level, are available. These incentives are insignificant relative to the cost of green retrofitting. Government financial subsidies seem to be the most attractive to the majority of residents. For example, the local government of Hong Kong has subsidised residents to implement green residential retrofitting, thereby proving the suitability of government-led green retrofitting of existing residential buildings [80]. This incentive has significantly increased the intention of residents toward green retrofitting. This conclusion echoes similar findings by Bon-Gang Hwang [81]. However, because of China's large number of existing residential buildings, all types of subsidies inevitably bring serious financial burden to the government. The government alone cannot make up for the large financial gap related to green retrofitting. Therefore, using a market mechanism to promote green retrofitting whilst reducing financial burden is necessary. This requirement may be met with a tripartite cooperation model based on government, social capital and residents. Moreover, integrating tripartite objectives and social, economic and environmental benefits is a sensible option. Property management and heating companies are the best partners. Property management companies provide economic subsidies for potential residents who are inclined to carry out green retrofitting. In the operation stage after green retrofitting, these subsidies can be obtained by reducing the maintenance costs of daily equipment and facilities in the community. In summary, financing via public-private partnership can realise the effective combination of social and government capital and thereby make enterprises the main body of retrofitting investment. By realising the cost sharing and benefit sharing of financial funds by enterprises and residents involved in green retrofitting projects, the market-oriented operation of green retrofitting may be promoted.

5.3. Impact of Green Retrofit Cognition on Green Retrofitting Intention

Beyond the expectation of this study, GRC had no direct and significant impact on green RI. This study did not confirm the view of Bartels [82] and Tan [83]. We speculate that the reason is mainly due to the different properties of the research objects. The aforementioned authors studied conventional household products with low purchase cost and repeatability. However, green retrofitting entails substantial costs and is disposable. For the purchase of expensive products, we believe that consumers are rational. Thus, they will not have the intention to carry out green retrofitting because they have a certain degree of awareness. They will also consider whether or not they have the corresponding

economic strength and other factors. Although the perception of green retrofitting had no direct significant impact on green RI, it had an indirect impact on green RI through behavioural attitude and SNs, which are only second to government PFs. Hence, GRC plays a crucial role in promoting residents' intention to carry out green retrofitting. GRC was mainly measured by seven variables, namely, conformity to sustainable development, rental and sale value, retrofitting technology, retrofitting cost, residential performance after retrofitting, retrofitting convenience, and operating cost. The top three cognitive effects on green retrofitting were as follows: retrofitting cost, whose standardised factor load was 0.94; operating cost, whose standardised factor load was 0.85; and improvement of rental and sale value, whose standardised factor load was 0.79.

The results suggest that most residents attach great importance to the cost of green retrofitting, the improvement of housing value, and the subsequent operating cost. In essence, economic considerations remain the primary concern of residents. This research also confirms the view of Mark Dowson [84] and Jagarajan [85]. The average value of GRC in the current work was 4.32, which indicated that most of the residents had a low level of GRC, similar to previous research conclusions [86]. Therefore, if the Chinese government aims to succeed in the green retrofitting of large and extensive stock housing, then it must publicise relevant information on green retrofitting through necessary measures to make residents agree with green retrofitting. With an improved awareness of green retrofitting of existing buildings, residents can directly and effectively understand the connotation and advantages of green retrofitting. Residents may also realise that existing residential buildings not only have high energy consumption and high cost but also cause serious pollution, which adversely affects the environment and people's physical and mental health.

After retrofitting, existing residential buildings may be recognised as green, environmentally friendly, and energy saving. The effect is strengthened through intuitive data comparison. For example, pilot projects involving small-scale green retrofitting may be conducted, and typical demonstration projects involving the green retrofitting of residential buildings may be developed. In addition, the living experience of residents after green retrofitting, the comparison of building energy consumption before and after the retrofitting, and the reduction degree of water and electricity bills may be highlighted. The positive impact on people who increasingly pursue a healthy and comfortable environment at the present stage should be strengthened to enhance their awareness and improve their intention toward green retrofitting. The residents may then be guided to improve their green RI for existing residential buildings.

5.4. Multigroup Analysis

The results of the multigroup analysis showed no significant difference in gender, except for H4 and H7. In terms of age, only H6 and H7 showed a difference, probably because the low age groups easily accept new things and are relatively emotional. Although high age groups focus on environmental protection, their inherent ideas hinder their acceptance of new things. Thus, low age groups are particularly willing to participate in green retrofitting. The findings are consistent with those of Magnusson MK [87].

From the perspective of occupational categories, only enterprise personnel and government personnel did not have significant differences, whereas the other groups showed differences. We speculate that the main reason is that the income of enterprise personnel and government personnel is stable; they have easy access to national green retrofitting policies and a high degree of cognition of green retrofitting policies relative to other groups. In terms of the per capita monthly family income, significant differences were observed in other paths, except for H4 and H5. We speculate that the main reason is that low income groups do not have additional income to allow their families to undergo green retrofitting. Therefore, the intention of low-income groups to carry out green retrofitting greatly depends on the strength of government policy support. On the contrary, groups with high family income are likely to accept green retrofitting because they expect improved life experience through green retrofitting. This conclusion further validates the viewpoint of Doling, John [88]. Therefore, to

enable low income groups to participate in green retrofitting, the Chinese government should launch a green retrofitting incentive plan for low income groups, which may include providing high subsidies and low loan interest rates to allow all income groups to enjoy equal opportunities for green retrofitting.

In terms of education level, differences were noted between H1, H6, H7, and H8. We assume that the main reason is that the income of the group with a high educational level, as well its awareness of green retrofitting, is higher to some extent than that of the group with a lower educational level. To reflect the social status brought about by a high level of education and obtain a sense of satisfaction, the group with a high level of education is likely to accept green retrofitting. This conclusion is consistent with that of Ritter, Agata M [89].

From the perspective of region, no differences were found in H1, H4, and H5, but the remaining paths were different. We speculate that the result may be due to the eastern region being economically developed; hence, people's income level and overall quality of life here are relatively high. The pilot of 'resource-saving and environmentally friendly society' is mainly concentrated in the eastern region. Therefore, residents in the eastern region have high GRC and are likely to accept green retrofitting. By contrast, the economy in the western region is relatively weak, and the income level of the local people is not generally high. As a result, residents in the western region have no additional economic income to subsidise the high cost of green retrofitting. To enable the residents in western regions to participate in green retrofitting, the government can provide substantial economic subsidies to families with low incomes in western regions. In addition, the effects of retrofitting can be vigorously publicised in the community, and the operating cost before and after retrofitting can be compared using a direct diagram to increase residents' awareness of green retrofitting costs and clarify that the operating cost after retrofitting can completely make up for the cost of retrofitting.

5.5. Research Limitations

The study has several limitations that need to be addressed in future research. The expanded TPB model seems to be the appropriate framework for predicting the intention of residents to retrofit existing residential buildings. However, future research will need to inspect whether this extended TPB model can be used to predict other green consumption behaviours. Furthermore, the variable of behaviour was not considered in this study because the measurement of residents' green retrofitting behaviour is complicated and selecting the survey data is difficult. Moreover, shifting from residents' intention toward green retrofitting to actual retrofitting behaviour requires a substantial amount of time. Future research can extend the variables to improve the predictability of actual retrofitting behaviour by investigating actual behaviour. At the same time, the research on the relationship between intention and behaviour is achieved through field visits and household surveys. The data in this study were all collected in the Chinese context. As a result of differences in national environment and policies, whether the conclusions of this work are applicable to other countries has yet to be confirmed. Thus, green retrofitting cases in other countries or regions should be considered in follow-up studies.

6. Conclusions and Implications

The green retrofitting of existing residential buildings has become an important breakthrough for the construction industry to achieve sustainable development and has been upgraded to the national strategic level. The greening of existing houses improves the performance of existing houses and extends the life of buildings. The strategy is equally important in urban renewal. Therefore, green transformation is advantageous in promoting economic and social sustainable development.

The purpose of this study is to explore the intention of residents toward the green retrofitting of existing residential buildings in the context of China. On the basis of theoretical modelling construction, data were obtained through questionnaire survey in eastern (Shandong, Jiangsu, and Fujian) and western (Sichuan, Guizhou, and Guangxi Zhuang Autonomous Region) regions. On the basis of the survey data obtained, the influencing factors and mechanism of residents' green retrofitting of existing residential buildings were analysed. The study concluded that the extension of PFs

and GRC into the TPB can effectively predict the green RI of residents. Green RI can be predicted directly or indirectly by behavioural attitude, SNs, PBC, GRC, and PFs. PFs had the greatest impact on the intention toward green retrofitting, followed by GRC, behavioural attitude, SNs, and PBC. Demographic characteristics (gender, age, monthly family income, education level and occupation) and regional variables (eastern, western) showed significant differences in terms of the impact of different hypothetical paths. Furthermore, the research methods and ideas of this study can be further expanded. In the future research, the value-belief norm theory and theory of planned behaviour can be integrated to study the public environment participation behaviour, and the differences in the path of the statistical variables in the model can be compared by SEM and multi-group analysis, such as marital status and the number of family members.

This study provides three main contributions. First, the TPB is applied to residents' intention toward the green retrofitting of existing residential buildings. The study not only enriches the application scope of the TPB but also provides a new approach to the study of residents' green retrofitting behaviour. Second, a multigroup analysis method is used to test and discuss different groups and regions; this method is conducive to the segmentation of the green retrofitting market and the selection and cultivation of a precise target market. Finally, a model of Chinese residents' intention toward the green retrofitting of existing residential buildings is constructed. This model identifies the key factors affecting the intention toward green retrofitting to deepen residents' understanding and support for the green retrofitting of existing residential buildings. At the government level, relevant policies can be formulated in accordance with the conclusions of this study to promote green retrofitting and social sustainable development.

Several policy implications are put forward according to the empirical analysis. First, the government should increase financial subsidies for residents to encourage the retrofitting of existing residential buildings. Second, the green retrofitting consciousness of social masses should be improved to expand the green retrofitting of existing residential buildings. Finally, the green retrofitting of existing residential buildings is beneficial to urban renewal and social sustainable development. Therefore, the government should vigorously promote the green retrofitting of existing residential buildings.

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