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Promoting Green Residential Buildings in China: Bridging the Gap between Design and Operation to Improve Occupants' Residential Satisfaction

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Abstract: While many studies have examined the supply of green residential buildings (GRBs), few have focused on the demand and living experience of them. This paper explores the antecedents of existing residents' repurchase intention and the effect of their residential satisfaction through a questionnaire survey in Sino-Singapore Tianjin Eco-city, China. Structural equation modeling was used to examine the role of proposed determinants. Multi-group analysis tested the moderating role of residential satisfaction. Results show that residents' satisfaction with respect to their homes in GRBs was heterogeneous with dissatisfied residents account for 55%. Residents' knowledge about GRBs, their environmental attitudes and perceived usefulness of GRB were key determinants of repurchase intentions but trust in relevant institutions was not. Residential satisfaction played a moderating role in predicting repurchase intentions. This study enlightens practitioners in both private and public sectors to improve occupancy experiences of existing residents and to understand the repurchase behaviors of existing customers, by bridging the gap between strong green design and construction and weak operation and maintenance of GRBs.

Keywords: green housings; residential satisfaction; homeowners; repurchase intentions; Sino-Singapore Tianjin eco-city; post occupancy evaluation; latent class cluster analysis

1. Introduction

Promoting green buildings is a key measure to achieve sustainability in the built environment [1]. Green residential buildings (GRBs), also are often referred to as green apartments, green estates or green homes, account for a substantial proportion (nearly 50%) of all green buildings in China. Promoting residential buildings with a green label and setting relevant GRB regulations in the residential building sector are seen as an effective way to boost environmental sustainability [2]. In the last decade, the Chinese government has focused mainly on the supply side of GRB projects, with policies mainly targeted at architecture, designers, developers, researchers and construction contractors. By contrast, policy practice and academic research have not paid sufficient attention to issues and problems of the demand for GRBs. The promotion of GRBs was therefore hindered by residents' low acceptance [3] or willingness to purchase [4], resulting in a mismatch between the production of GRBs and residents' demand [5].

GRBs have emerged as an important part of the built environment in China, but they have not been widely accepted by the public in many cities. The promotion of GRBs needs not only to attract prospective customers to GRB schemes, but also to encourage existing occupants to choose GRBs in

their future housing purchasing behaviors. Households (especially young couples) in Chinese cities seldom buy a dwelling and stay there for the rest of their lives. Families often sell their home after a few years and repurchase a bigger one in new residential areas, which provides a more comfortable living condition, better accessibility to public and commercial services such as schools, nurseries, medical centers, shops, restaurants, etc. Existing GRB homeowners often do the same and may also buy extra properties either as a second home or for the use of their offspring in the future when they grow up. Therefore understanding and motivating GRB residents' repeated purchase behavior and word-of-mouth advertising will promote the consumption of GRBs. Existing residents of GRBs may leave the GRB market due to unsatisfied living experiences. Occupant satisfaction plays an important role in repurchase intentions. Therefore, post occupancy evaluation (POE) in GRBs schemes can inform the policy makers to formulate new strategies to promote GRBs. It is therefore of strategic importance to obtain insights into residents' repurchasing intentions and to understand the factors that influence their decisions.

Although many studies have analyzed urban families' intention to purchase and willingness to pay for GRBs, few research projects have examined repurchase intentions of existing GRB occupants. Several predictors are found to have positive impacts on residents' purchase intentions or willingness to pay, such as residents' subjective knowledge [6], their trust in the relevant institutions/authorities that are responsible for the objects [7], residents' environmental attitudes [8] and perceived usefulness, which measures the degree to which a person believes that an object would enhance his or her benefits [9]. However, to the best of our knowledge, no studies focus on the repurchase intentions of residents who already have purchased or who have living experience in GRBs.

The paper aims to provide new evidence on residential satisfaction of GRBs in mainland China by addressing the following research questions: (1) What are the main factors that influence the repurchase intentions of GRB occupants? Can the influencing factors of purchase intentions for prospective GRB customers (residents who have not already bought GRB) identified in the current literature explain the repurchase intentions of existing customers? (2) What role does residential satisfaction play in repurchase decisions? We will also highlight the importance of repurchase behavior and word-of-mouth advertising in promoting GRBs.

The remaining part of the article is organized as follows: Section 2 presents the literature review and discusses the relationships of people's perceived usefulness of GRBs, their satisfaction levels and repurchase intention. Section 3 outlines the methodology and discusses the questionnaire design, data collection, reliability and validity test and data analysis method. Section 4 presents the results, and Section 5 discusses them and draws policy implications. Conclusions are summarized in Section 6.

2. Literature Review: Perceived Usefulness, Satisfaction and Repurchase Intention

Perceived usefulness is a typical independent variable (Davis' Technology Acceptance Model [10]) and has been widely used to explain consumers' purchase/repurchase decision-making and behaviors [11]. GRBs are supposed to be more advanced than conventional buildings in terms of: (1) Reducing waste and carbon emissions, hence they are environmentally friendly [1]; (2) conserving energy and resources, economically benefit stakeholders hence they are economically sustainable [12]; (3) improving social well-being in terms of comfort and health hence they are socially sustainable [13]. We assumed that the more positive residents perceive the usefulness of GRB, the more they will be likely to repurchase GRB.

H1: *Residents' perceived usefulness of GRBs has a positive impact on repurchase intentions (H1).*

Unfortunately, there are many barriers for residents to overcome before they realize any usefulness of GRBs. GRBs are public goods with externality [14], which refers to an unintended cost or benefit that is not part of the transactions made in the market [15]. For example, the reduced carbon emission effect of GRBs will benefit not only for its occupants who pay additional cost but also for other residents living nearby. Their occupants cannot perceive this usefulness of GRBs directly and vividly in the short

run. The extent to which the usefulness is perceived depends on residents' altruism, especially their views with respect to the growth of human societies, the fragility of nature's balance, the possibility of an ecological crisis and so on [16], which are reflected in people's environmental attitudes and knowledge. Previous studies have found that the perceived usefulness of green products is positively affected by knowledge about the green value of products [9] and environmental attitudes [8].

The second usefulness feature: Energy or resource saving, is also hardly perceived by households, especially in China [17]. The main property type in city is multi-family high-rise buildings, rather than detached buildings/semi-detached buildings or bungalow as found in western countries like the UK and US. Households have barely any control over the operation, maintenance or retrofitting of many energy consuming equipment in their dwellings. All of these are done by the government and property management companies. For example, winter heating is one of the main forms of household energy consumption. However, in north China, central heating is provided by the municipalities [18]. Residents pay for the heating bills based on their floor area rather than their actual energy consumption. Residents are not aware of the building's envelop and heat conservation performance, which may be one of the key merits of GRB design and operation, because they do not benefit from lower utility bills. Moreover, bad property management services may ruin the reputation of GRBs by leading a gap between the green design and operation. As for the third usefulness feature, it takes a considerable length of time to perceive the enhanced social well-being that GRBs provide in terms of health condition.

The usefulness features of GRBs are highly dependent on the performance of the relevant institutions/stakeholders (municipalities, property management companies, building energy performance evaluation parties, etc.) [19]. Therefore, the extent to which residents feel they can trust in these institutions' experience and expertise with GRBs will positively affect residents' perceived usefulness of GRBs, hence their repurchase intentions. We therefore assume that residents' trust in relevant institutions has positive impacts on the perceived usefulness of GRBs, and occupants' repurchase intention [20].

Therefore, we made the following assumptions:

Residents' perceived usefulness of GRBs is influenced by their subjective knowledge of GRBs (H2), trust in relevant institutions (H3) and their environmental attitudes (H4). These all have positive impacts on the perceived usefulness of GRBs.

Residents' repurchase intentions are influenced by their subjective knowledge of GRBs (H5), trust in relevant institutions (H6) and environmental attitudes (H7). These all have positive impacts on perceived usefulness of GRBs.

The role of satisfaction on repurchase intentions has been studied by many researchers. Some recognize satisfaction as one of the exploratory variables for repurchase intentions, in the context of online shopping [21], hotel service platforms [22] and so on. Satisfaction is an evaluation result of past experiences [23]. Researchers differentiate between satisfaction as experience-based and transaction-based [22,24]. Residential satisfaction reflects residents' POE of their GRBs so it is experience-based satisfaction. To date, occupant satisfaction surveys have been conducted mainly in western countries but have not been well documented in China's GRBs, and literature is inadequate in explaining GRB residents' repurchase intentions and answering whether residential satisfaction contributes to the promoting of GRBs.

Surveys are a commonly used method to collect occupants' satisfaction levels. They can provide information about how GRBs satisfy the occupants and meet their needs. It is an important way to assess the performance of GRBs from the perspective of their occupants [25], and to help improve the quality of GRBs. In addition, the feedback on the causes and effects of low-performance issues relating to GRBs can inform policymakers' planning and management of GRBs throughout their lifespans [26].

In this paper experience-based satisfaction was studied, namely post-purchase satisfaction rather than pre-purchase satisfaction and was based on residents' evaluation of post-occupancy experiences. The residential satisfaction here was an evaluation of their GRBs in the general sense, instead of measuring specific characteristics such as energy saving, environmental friendliness, etc. We argued

that the influence of overall residential satisfaction on repurchase intention of GRBs was not important enough to serve as determinants. Instead, it might play a moderating role between determinants and residents' repurchase intentions of GRBs, which means residents with different residential satisfaction features might cause heterogeneity among the coefficients.

Hypothesis: Residential satisfaction moderates the impacts of subjective knowledge, trust in relevant institutions and environmental attitudes and makes them different for different clusters of residents.

Based on the above hypothesis, we developed the research model shown in Figure 1.

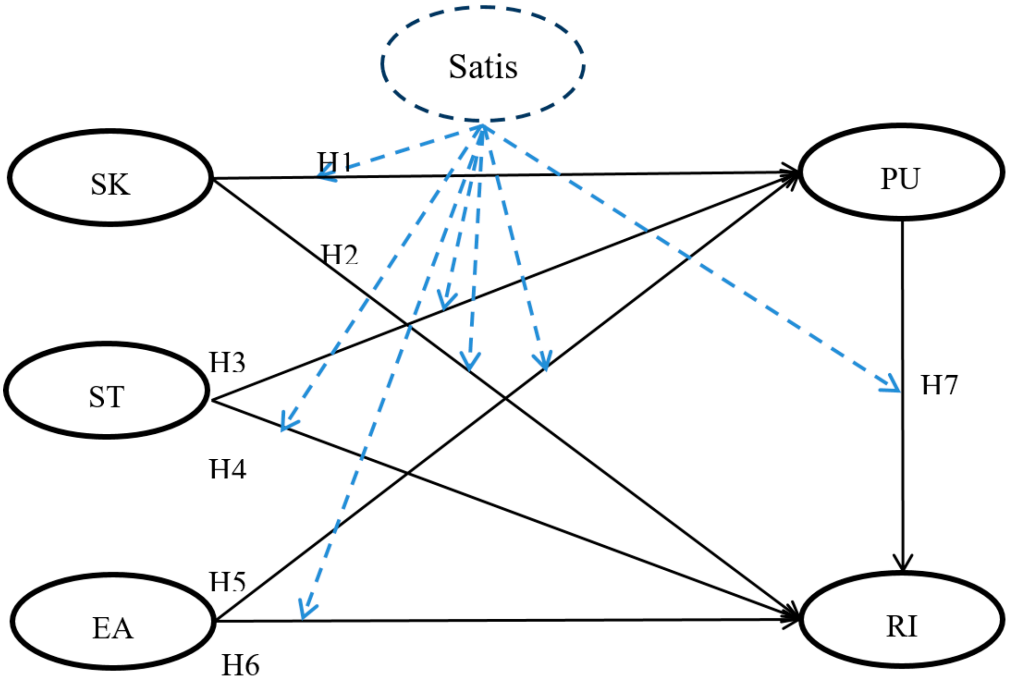

Figure 1. Theoretical framework. Note: SK: Subjective knowledge; ST: Social trust; PU: Perceived usefulness; EA: Environmental attitude; RI: Repurchase intention and Satis: Residential satisfaction.

3. Methodology

3.1. Case Study and Sampling Site

Since we focused on residents who had already purchased or who were living in GRBs, the Sino-Singapore Tianjin Eco-city (hereafter referred to as the Eco-city) was selected as the sampling site. The eco-city is an international cooperation project between China and Singapore located 45 km from Tianjin inner city and 150 km from Beijing city. The vision behind its construction was the establishment of a thriving city that is socially harmonious, environmentally friendly and resource efficient. Designed to be practical, replicable and scalable, the Eco-city is meant to demonstrate the determination of both countries to create a model city that will showcase sustainable development. One of the key performance indexes (KPI) is the proportion of green buildings. All buildings in the Eco-city must meet green building label standards, including all commercial buildings and residential buildings. There are about 50,000 residents now living in the Eco-city, whose families have already bought GRBs.

The Eco-city celebrated its 10-year anniversary in 2018, coinciding with the 10-year anniversary of China Green Building Label projects. However, to date there has been no research offering deep insights into residential satisfaction, both within the Eco-city and beyond the Eco-city in China. Although residential satisfaction in the Eco-city will mainly reflect performance of GRBs in the operation phase,

it will also affect the future demand for GRBs and thus needs to be taken into consideration when designing GRB projects.

3.2. Sampling and Data Collection

The online survey was conducted among adult residents in the Eco-city from July to November 2017. With the help of the local government and the Green Building Research Centre of the Eco-city, we gained access to the Eco-city's internal social media platforms. Via these platforms, residents were informed about the objectives and background of the survey. Residents who were interested in the study were encouraged to click on a hyperlink and fill out the questionnaire. To encourage participation, a reward was offered (a voucher of 10 CNY) to those who completed the survey.

The online questionnaire was divided into three parts: Part 1 investigated residential satisfaction with their GRBs using 23 specific items (Table 1), with a five-point Likert scale to quantify their level of satisfaction (1 = very dissatisfied, 2 = dissatisfied, 3 = neutral, 4 = satisfied, 5 = very satisfied). They were designed on the basis of a literature review and drawn from related studies on residential satisfaction. In part 2, five latent variables (subjective knowledge, social trust, perceived usefulness, environmental attitude, repurchase intention) identified in the literature were measured using 18 items with a five-point Likert scale (1=strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The design of the scales was based on the study of Liu et al. [27]. Part 3 collects residents' social-economic information such as age, gender, income, etc.

Table 1. Eco-city residential satisfaction level on specific items.

Category	Item	Mean	Std. Dev	Skewness	KurtOsis
Indoor environment quality	Room soundproofing	2.72	1.34	0.13	−1.2
	Natural lighting	3.94	1.07	−0.83	0.02
	Indoor ventilation	3.92	0.99	−0.82	0.49
	Indoor air quality	3.61	1.05	−0.47	−0.13
	Thermal comfort in summer	3.61	1.05	−0.52	−0.03
	Thermal comfort in winter	3.96	1.01	−0.84	0.34
Outdoor environment	Greening	3.46	1.34	−0.47	−0.83
	Cleanliness	3.37	1.33	−0.42	−0.92
	Outdoor noise	3.09	1.36	−0.16	−1.06
	Outdoor air movement	4.12	0.95	−1.12	1.2
	Drainage system	3.66	1.24	−0.74	−0.29
Quality of building and facilities	Quality of architecture	2.9	1.26	−0.08	−0.93
	Thermal and insulation performance of envelop	3.41	1.14	−0.45	−0.32
	Airtightness of windows	3.26	1.28	−0.4	−0.85
	Quality of power supply facilities	3.39	1.22	−0.46	−0.63
Environment friendliness	Energy saving of public areas such as corridors, staircases, etc.	3.44	1.27	−0.53	−0.62
	Publicity about energy conservation and environmental protection	2.98	1.38	−0.14	−1.2
Operation and Maintenance	Property management	2.59	1.41	0.23	−1.3
	Facility Maintenance	2.79	1.37	0.05	−1.19
Convenience	Accessibility to public transportation	3.6	1.1	−0.41	−0.39
	Traffic layout design and management within the Eco-city	3.29	1.33	−0.4	−0.87
	Availability of shopping, catering and leisure facilities	3.95	1.07	−0.96	0.54
	Accessibility to public amenities	2.78	1.31	0.08	−1.06

Several strategies were taken to secure the quality of the sample. First, three screening questions were designed to rule out unqualified participants: (1) Do you live in the Eco-city? (2) What is your age? (3) What is the name of your community? People who answered "no" to the first question, or indicated that they were less than 18 years old would get a pop-up "thank you" message and the

online questionnaire will be ceased. If a respondent's residence (according to the answer for the third question) was not located in the Eco-city, his or her returns would be ruled out from the survey.

A total of 1656 people opened the questionnaire link, after careful checks, 630 returned questionnaires were valid (38%). We examined the standard deviations of 18 items measuring five latent variables, and questionnaires with a standard deviation of 0 were also excluded (namely each person's score for all the 18 items was the same one, like 1 or 5) since these respondents' answers may not be truthful and objective. The final number of questionnaires left for further analysis was 365.

The skewing and kurtosis for all item values were between −2 and +2. This was considered acceptable to prove normal univariate distribution [28]. Since we chose the maximization likelihood estimation method (required that the data follow a multivariate normal distribution), a multivariate normality test was conducted. We used Mardia's Test to check whether the multivariate skewing and kurtosis indicated a multivariate normal distribution [29]. The value of Mardia's coefficient 89.2 indicated that the data did not follow a multivariate normality distribution [30]. Through calculating the Mahalanobis distance, 20 samples with observations farthest from the centroid were considered outliers and dropped. After dropping the outliers, the Mardia's coefficient was 47.1, which was less than the threshold of 49.1 as suggested in the literature [31]. There are 345 valid samples left.

Male residents accounted for 47.5% of the valid respondents (Table 2). Adult residents falling within the age categories of 19–30, 31–40 and 41 years old and above accounted for about 35.4%, 53.9% and 10.8%, respectively. Residents with an average monthly income of 5000–10,000 Chinese Yuan accounted for the largest share (42.6%). By 2017, most of the residents (63.2%) had been living in the Eco-city GRB for less than two years, followed by those who had moved in about 3–4 years ago (30.7%).

Table 2. Sample demographics (N = 345).

Variables	Group	Frequency	Percentage (%)
Gender	Male	164	47.5
	Female	181	52.5
Age (year)	19–30	122	35.4
	31–40	186	53.9
	41–60	34	9.9
	>60	3	0.9
Income (CNY)	0	22	6.4
	0–5000	124	35.9
	5001–10000	147	42.6
	10001–20000	39	11.3
	>20,000	13	3.8
Duration of residence (year)	1–2	218	63.2
	3–4	106	30.7
	5–6	21	6.1
Ownership	Private	306	88.7
	Rent or others	39	11.3
Estates	Jiaheyuan	48	13.91
	Hongshuwan	24	6.96
	Hechangyuan	23	6.67
	Meiyunyuan	20	5.80
	Kangqiaojun	20	5.80
	Others	210	60.86
Total	/	345	100

The 345 respondents lived in 35 residential estates (most of them are high-rise buildings) within the Eco-city. One estate was developed as a public housing project, named Hechangyuan and included

23 respondents (6.67%). The other 34 residential estates were all commercial residential buildings, home to 322 of the respondents (93.33%). The estate Jiaheyuan had the largest share (13.91%) of residents.

3.3. Analytic Tools

Structural Equation Modeling (SEM) was used to examine the role of proposed determinants. The heterogeneity of residential satisfaction towards their GRBs was analyzed by Latent Class Cluster Analysis (LCCA). Multi-group analysis [32] tested the moderating role of residential satisfaction by examining the invariance of different groups identified by the LCCA.

In LCCA, latent class means unobservable or invisible segments of given samples. Cases within the same latent class are homogeneous while cases in different latent classes are different from each other in some ways [33]. There are two important assumptions for LCCAs: (1) Residents are heterogeneous [33]. This is also different from traditional methods like the multi-nominal logit or ordinal logit model, in which people's preferences are assumed to be homogeneous and (2) local independence assumption. The observed items are conditionally independent of each other given an individual score on the latent variables [33]. In latent variable models, constructs are what scholars are mainly concerned with, while observed variables are collected and studied to figure out the underlying factors, which can explain why the observed items are related to another [34]. In this sense, LCCA is very similar to factor analysis, and the difference is the unobservable variable for latent class analysis, which is categorical instead of continuous in a factor analysis.

4. Results

4.1. Residential Satisfaction

4.1.1. Distribution of Satisfaction Levels

Residents' item-based residential satisfaction levels are shown in Table 1. Negative skewness values indicate that the mass of the distribution was concentrated on the right (>3). Most of the skewness values in Table 1 were negative except for property management (0.23), room soundproofing (0.13), accessibility to public amenities (0.08) and facility maintenance (0.05), indicating that majority of the respondents tended to be satisfied with most items except for the above four aspects. Outdoor air movement had the highest mean score (4.12), followed by thermal comfort in winter (3.96), availability of shopping, catering and leisure facilities (3.95), indoor natural lighting (3.94) and ventilation (3.92). Most mean scores were lower than 4, almost no aspect met residents' expectations. This indicates residents' neutral-to-satisfied attitude with these items. Even worse, six of these items had mean scores lower than 3, indicating that residents were generally dissatisfied with these six aspects, including property management (mean = 2.59), room soundproofing (mean = 2.72), accessibility to public amenities (mean = 2.78), facility maintenance (mean = 2.79), quality of building (mean = 2.90), publicity about energy conservation and environmental protection (mean = 2.98). Inferred from the mean scores of 345 samples, residents showed a low satisfaction level with their GRBs in the Eco-city. However, individual residents' satisfaction level might differ among different groups of residents.

4.1.2. Heterogeneity of Residents' Satisfaction

It is important to understand prototypes of residents and developing tailored interventions [35], so, heterogeneity of residents' satisfaction was examined by LCCA, using LatentGold 4.5 software (Statistical Innovations Inc. Belmont, MA, US) [36]. Respondents were classified into different clusters using 23 specific residential satisfaction items. To simplify the analysis, respondents' response patterns were regrouped according to their scores of satisfaction. Respondents with the score of 1 and 2 were grouped together as pattern A: Dissatisfaction, those with the score of 4 and 5 were grouped as pattern C: Satisfaction, leaving those with the score of 3 as pattern B: Neutral ones.

In the first step to determine the number of clusters, we estimated six different models, which specified the cluster number from 1 to 6, respectively. These models were estimated using maximum likelihood estimation and the results are shown in Table 3.

Table 3. Latent class model estimation results.

Model	LL	BIC (LL)	AIC (LL)	Npar	L^2
1-cluster model	−7734.61	15738.03	15561.23	46	11601.86
2-cluster model	−6657.27	13857.99	13500.54	93	9447.177
3-cluster model	−6356.68	13531.45	12993.36	140	8845.996
4-cluster model	−6206.57	13505.89	12787.15	187	8545.788
5-cluster model	−6084.72	13536.82	12637.44	234	8302.073
6-cluster model	−6006.55	13655.14	12575.11	281	8145.744

Note: LL: Log-likelihood. BIC: Bayesian Information Criteria. AIC: Akaike Information criteria. Npar: Number of parameters. L^2 indicates the amount of the association among the variables that remain unexplained after estimating the model.

Akaike information criterion (AIC) and Bayesian information criterion (BIC) are popular criteria for deciding the optimal number of clusters [37]. Results showed the AIC values decreased with an increasing number of clusters, the minimum BIC value occurred for the 4-cluster model, suggesting that it was an appropriate model. The relative change of AIC and BIC values decreased sharply from the 1-cluster model to the 2-cluster mode but only slightly afterwards, indicating the 2-cluster model was better. Considering the parsimony and interpretability principles, we chose the 2-cluster model.

Profile output of the 2-cluster model is shown in Table 4. The numbers in the first row show the classification probabilities, also known as cluster size, indicating that 55% of the respondents belonged to cluster 1 and cluster 2 contained 45% of the respondents.

Table 4. Profile output of 2-cluster model.

Item	Response	Cluster 1	Cluster 2
Cluster Size	/	0.55	0.45
Room soundproofing	Dissatisfaction	0.67	0.15
	Neutral	0.26	0.23
	Satisfaction	0.07	0.62
Natural lighting	Dissatisfaction	0.18	0.01
	Neutral	0.26	0.13
	Satisfaction	0.56	0.86
Indoor ventilation	Dissatisfaction	0.11	0.01
	Neutral	0.38	0.07
	Satisfaction	0.51	0.93
Indoor air quality	Dissatisfaction	0.18	0.03
	Neutral	0.46	0.19
	Satisfaction	0.36	0.78
Thermal comfort in summer	Dissatisfaction	0.18	0.03
	Neutral	0.46	0.18
	Satisfaction	0.35	0.79
Thermal comfort in winter	Dissatisfaction	0.13	0.00
	Neutral	0.32	0.12
	Satisfaction	0.55	0.88
Greening	Dissatisfaction	0.37	0.00
	Neutral	0.35	0.22
	Satisfaction	0.28	0.78

Table 4. *Cont.*

Item	Response	Cluster 1	Cluster 2
Cleanliness	Dissatisfaction	0.44	0.00
	Neutral	0.33	0.15
	Satisfaction	0.23	0.85
Outdoor noise	Dissatisfaction	0.43	0.13
	Neutral	0.38	0.24
	Satisfaction	0.19	0.63
Outdoor air movement	Dissatisfaction	0.07	0.01
	Neutral	0.28	0.06
	Satisfaction	0.64	0.93
Drainage system	Dissatisfaction	0.27	0.01
	Neutral	0.34	0.13
	Satisfaction	0.39	0.86
Quality of architecture	Dissatisfaction	0.57	0.04
	Neutral	0.38	0.31
	Satisfaction	0.05	0.65
Thermal and insulation performance of envelop	Dissatisfaction	0.29	0.01
	Neutral	0.51	0.15
	Satisfaction	0.19	0.84
Airtightness of windows	Dissatisfaction	0.44	0.04
	Neutral	0.33	0.17
	Satisfaction	0.24	0.79
Quality of power supply facilities	Dissatisfaction	0.38	0.01
	Neutral	0.39	0.14
	Satisfaction	0.23	0.85
Energy saving of public areas such as corridor, staircase, etc.	Dissatisfaction	0.34	0.02
	Neutral	0.4	0.14
	Satisfaction	0.26	0.84
Publicity of energy conservation and environmental protection	Dissatisfaction	0.56	0.07
	Neutral	0.31	0.2
	Satisfaction	0.13	0.73
Property management	Dissatisfaction	0.75	0.13
	Neutral	0.21	0.25
	Satisfaction	0.04	0.62
Maintenance of public facilities	Dissatisfaction	0.66	0.06
	Neutral	0.27	0.29
	Satisfaction	0.07	0.65
Accessibility to public transportation	Dissatisfaction	0.19	0.04
	Neutral	0.4	0.29
	Satisfaction	0.4	0.66
Traffic layout design and management within the Eco-city	Dissatisfaction	0.38	0.05
	Neutral	0.35	0.24
	Satisfaction	0.27	0.71
Availability of shopping, catering and leisure facilities	Dissatisfaction	0.12	0.02
	Neutral	0.26	0.19
	Satisfaction	0.62	0.78
Accessibility to public utilities	Dissatisfaction	0.63	0.11
	Neutral	0.26	0.36
	Satisfaction	0.11	0.54

The lower part shows the conditional probabilities, which summed to 1 within each variable and showed the differences in response patterns to distinguish clusters. For example, respondents in cluster 2 had a 62% chance of responding that they were satisfied with room soundproofing. By comparison, respondents in cluster 1 had only 7% probability of responding that they were satisfied. Instead, they were more likely to be dissatisfied, with a probability of 67%. Generally, residents in cluster 2 were more likely to be satisfied with all of the 23 aspects but residents in cluster 1 tended to be negative or neutral towards the operational performance in most aspects. Therefore, we named cluster 1 as the dissatisfied group, and cluster 2 as the satisfied group. The two-group classification was used to further examine the moderating role of residential satisfaction.

Residents' social demographic features of the two groups are shown in Table 5. A chi-square test was conducted to examine their independence. Results showed ownership might play a role to explain the classification of the two groups ($p = 0.002$), people who lived in the rent dwellings were more likely to be grouped into the satisfied group. No statistical differences were found between the two groups in terms of gender, age, income and duration of living.

Table 5. Social demographic and chi-square test of two groups.

Variables	Category	Frequency (G1: Dissatisfied Residents)	Frequency (G2: Satisfied Residents)	Sig.
Gender	Male	86	78	0.278
	Female	106	75	
Age (year)	19–30	70	52	0.167
	31–40	106	80	
	41–60	16	18	
	>60	0	3	
Income (CNY)	0	9	13	0.487
	0–5000	73	51	
	5001–10,000	83	64	
	10,001–20,000	19	20	
	>20,000	8	5	
Duration (year)	1 or 2	116	102	0.386
	3 or 4	62	44	
	5 or 6	14	7	
Ownership	Private	181	125	0.002
	Rent or others	11	28	

However, the two groups of residents showed differences on some psychological factors, especially for the trust in relevant institutions. Table 6 shows the results of independent sample T test. Satisfied residents (Group 2) tended to have higher level of trust than dissatisfied ones.

Table 6. Mean difference of psychological factors between two groups.

Variable	Mean Difference (G1–G2)	Mean (G1)	Mean (G2)	Sig.
SK1	−0.214	3.94	4.16	0.029
SK2	−0.119	4.08	4.20	0.204
SK3	−0.359	3.95	4.31	0.000
TRU1	−0.630	3.57	4.20	0.000
TRU2	−0.663	3.50	4.16	0.000
TRU3	−1.037	2.76	3.80	0.000
NEP1	0.158	4.41	4.25	0.108
NEP2	0.063	4.52	4.46	0.440
NEP3	−0.025	4.61	4.63	0.730
NEP4	0.054	4.58	4.53	0.483
NEP5	0.027	4.48	4.46	0.749
PU1	−0.259	4.12	4.38	0.006
PU2	−0.114	4.40	4.51	0.153
PU3	−0.119	4.08	4.20	0.221
PU4	−0.183	4.33	4.52	0.026

4.2. Model Estimation

4.2.1. Reliability and Validity of the Measure Model

To test the reliability and validity of the measure in part 2 of the questionnaire, confirmatory factor analysis (CFA) is conducted. Validity is the extent to which a measurement tool measures what it claims to measure, namely the accuracy of a measurement tool [38]. Specifically, convergent validity refers to the degree that two measures of constructs that theoretically should be related, are in fact related and discriminant validity tests, whether concepts or measurements that are not supposed to be related are actually unrelated [39]. The results (Table 7) showed that all item loadings were greater than 0.55, meeting the suggested range of 0.5 or above in the literature [40–42]. The composite reliabilities for constructs ranged from 0.82 to 0.96, indicating good composite reliability. In order to establish construct validity, the measurement tools must demonstrate both convergent validity and discriminant validity [43]. Convergent validity was tested using the average variance extracted (AVE). The threshold value for AVE was 0.5 [40], the higher the better. The AVE values also indicated a good convergent validity of the measurement.

Table 7. Composite reliability and convergent validity of the measures.

Construct	Item	Standardized Factor Loading	Composite Reliability	Average Variance Extracted
Subjective knowledge	SK1	0.65	0.82	0.60
	SK2	0.78		
	SK3	0.90		
Trust	TRU1	0.85	0.87	0.69
	TRU2	0.94		
	TRU3	0.69		
Perceived Usefulness	PU1	0.73	0.86	0.61
	PU2	0.85		
	PU3	0.68		
	PU4	0.86		
EA	EA1	0.55	0.85	0.54
	EA2	0.71		
	EA3	0.83		
	EA4	0.81		
	EA5	0.73		
Repurchase intention	RI1	0.92	0.96	0.89
	RI2	0.97		
	RI3	0.94		

Discriminant validity was tested by comparing squared AVEs and correlation coefficients [40]. The square root of AVE for each construct was greater than its correlations with any other constructs (Table 8), indicating acceptable discriminant validity.

Table 8. Constructs' correlations and square roots of the average variance extracted (AVE).

Variables	SK	EA	TRU	PU	RI	AVE
SK	**0.77**					0.60
EA	0.30	**0.73**				0.54
TRU	0.50	0.14	**0.83**			0.69
PU	0.70	0.52	0.47	**0.78**		0.61
RI	0.49	0.61	0.34	0.67	**0.94**	0.89

Note: 1. SK: Subjective knowledge; TRU: Social trust; PU: Perceived usefulness; EA: Environmental attitude; RI: Repurchase intention. 2. The diagonal elements are the square roots of AVEs instead of correlation coefficients, correlation coefficients among the six constructs are presented below the diagonal.

4.2.2. Group Invariance

Multi-group comparison was conducted between the satisfied group and the dissatisfied group to test group invariance of the measurement weights and structural weights. Three models were developed: Model A was an unconstrained model without any constraints. In Model B we assumed that the measurement weights in the two different groups were equal. Model C assumed that in addition to the measurement weights, the structural weights in the two groups were equal. The three models were estimated and all were identified as having an acceptable model fit.

Nested model comparison outputs (Table 9) proved the group invariance of measurement weights. The p value was 0.486, indicating non-significant differences between model A and model B [44]. However, the null hypothesis of equal structural weights (Model C) was rejected with the p value of 0.045, that is, the structural weights varied when residential satisfaction heterogeneity was considered, indicating the possible moderating role of residential satisfaction.

Table 9. Nested model comparisons.

Assumption	Model	DF	CMIN	p	NFI	IFI	RFI	TLI
Assuming model A to be correct	Model B	13	12.518	0.486	0.003	0.003	−0.003	−0.003
Assuming model B to be correct	Model C	7	14.397	**0.045**	0.003	0.003	0.001	0.001

4.2.3. Moderating Role of Residential Satisfaction

For further analysis, the proposed model was estimated respectively for the whole sample, dissatisfied group (Group 1) and satisfied group (Group 2). The results show that one hypothesis was rejected (H6 a) in Group 1 and three were rejected (H3b, H5b and H6b) for Group 2 (Table 10). Specifically, for dissatisfied residents, trust in the relevant authorities had only weak indirect impact ($\beta = 0.06$) on repurchase intention (through its direct impact on perceived usefulness). By contrast, trust in the relevant authorities had no direct or indirect impact on satisfied residents' repurchase intentions. Moreover, subjective knowledge had no direct impact on repurchase intentions. Even without trust in the relevant authorities, the modified model got a higher exploratory power of 60% for the satisfied group compared to 55% for the dissatisfied group.

Table 10. Hypothesis test.

Hypotheses	Whole Sample: N = 345 (SMC = 0.55)		Group 1: Dissatisfied Residents: N = 192 (SMC = 0.55)		Group 2: Satisfied Residents: N = 153 (SMC = 0.60)	
	Estimate	p	Estimate	p	Estimate	p
H1: PU→RI	0.40	***	0.27	**	0.63	***
H2: SK→PU	0.41	***	0.38	***	0.42	***
H3: TRU→PU	0.13	**	0.15	**	0.12	0.108
H4: EA→PU	0.46	***	0.49	***	0.40	***
H5: SK→RI	0.05	0.376	0.14	**	-0.14	0.152
H6: TRU→RI	0.06	0.149	0.10	0.057	0.08	0.256
H7: EA→RI	0.52	***	0.64	***	0.36	**

Note: *** $p < 0.001$, ** $p < 0.01$.

The standardized effects of explanatory variables on repurchase intentions are shown in Table 11. A 1000 times bootstrap (percentile method) results showed all effects were significant ($p = 0.01$). A pairwise comparison of structural weights indicated that residential satisfaction moderated the paths from (1) perceived usefulness to repurchase intentions, (2) trust in relevant institutions to perceived usefulness and (3) subjective knowledge to repurchase intentions. Specifically, satisfaction strengthens the effect of perceived usefulness on repurchase intentions, weakens (even eliminated) the effect of trust in the relevant institutions on perceived usefulness and subjective knowledge's impact on repurchase intentions.

Table 11. Standardized effects of explanatory variables.

Group	Variable	Direct Effect				Indirect Effect				Total Effect			
		TRU	SK	EA	PU	TRU	SK	EA	PU	TRU	SK	EA	PU
G1	PU	**0.19**	0.49	0.37	0.00	0.00	0.00	0.00	0.00	0.19	0.49	0.37	0.00
	RI	0.00	**0.19**	0.41	**0.30**	0.06	0.15	0.11	0.00	0.06	0.34	0.52	0.30
G2	PU	**0.00**	0.57	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.33	0.00
	RI	0.00	**0.00**	0.30	**0.57**	0.00	0.33	0.19	0.00	0.00	0.33	0.49	0.57

The standardized total effects show that: (1) The impact of trust in the relevant institutions on repurchase intentions is negligible, for both satisfied and dissatisfied residents. Specifically, trust in the relevant institutions is not a determinant in the model explaining satisfied residents' repurchase intentions. Even for dissatisfied residents, trust in the relevant institutions plays only a small indirect role in repurchase intentions via its direct impact on perceived usefulness; (2) compared to the dissatisfied group, subjective knowledge and environmental attitude contributes slightly less in determining the repurchase intentions of the satisfied group; and (3) perceived usefulness of GRBs plays a far more important role in predicting the repurchase intention of satisfied residents than it did for dissatisfied residents.

5. Discussion and Implication

Results showed that, as we assumed early, residential satisfaction played a moderating role in predicting existing residents' repurchase intention. It strengthened the effect of perceived usefulness on repurchase intention, and weakened (even eliminated) the impact of trust on perceived usefulness of GRBs and the impact of knowledge on repurchase intentions. Repurchase intentions of satisfied residents' were affected mainly to the perceived usefulness of their dwellings in GRBs and had nothing to do with trust in relevant institutions.

The eco-city residents' trust in relevant institutions was found to have negligible impact on repurchase intentions. This differs from a study among residents who did not have any direct experience of life in GRBs [27], where trust is a determinant of purchase intentions. This could be explained by the function of trust, a psychological state [45] or belief [46] that addresses uncertainty or risk, especially when people have no knowledge or experience. As people who do not live in the

Eco-city have no experience of life in GRBs, their decisions to buy GRBs can be based only on indirect resources like trust in the relevant institutions. Once direct experiences become available and can assist in the decision-making of Eco-city residents, the role of trust in the relevant institutions will weaken and become less important.

By contrast, perceived usefulness of GRBs plays an important role, and its impact on repurchase intentions is far greater for satisfied residents than that for dissatisfied ones. As durable goods, residential buildings are unique and people put special emphasis on residential buildings' practical use. In addition, residential buildings are post-experience goods [47], which means it is difficult to know the quality of the green performance and other characteristics before residents move in. When making purchase or repurchase decisions, this feature poses difficulties for other residents. Since the Eco-city residents already have occupancy experiences in GRBs, they prefer to rely on the perceived usefulness of GRBs based on their own direct and subjective occupancy experiences, instead of relying on indirect sources such as trust. Satisfied occupancy experience will strengthen the perceived influence of usefulness on repurchase intentions. This is the reason why the total effect of perceived usefulness substantially surpasses the impact of other determinants for satisfied residents.

Subjective knowledge and environmental attitudes were found to predict the repurchase intentions of the Eco-city residents (existing customers of GRBs). It was also the case for the purchase intentions of residents who had no purchase or living experience (prospective GRBs customers), revealed by a previous study [27]. The two determinants showed stable influences not only on purchase and repurchase intentions alike, but also among different groups within the Eco-city residents. Their influences did not vary between the satisfied and dissatisfied groups. Better understanding of GRBs will help enhance residents' acceptance, and will be reflected in purchase or repurchase decisions or behaviors. Purchasing dwellings in GRBs is a pro-environmental behavior, and environmental attitudes are undeniable and implicit predictors.

In general, residents had a low level of residential satisfaction with their GRBs in the Eco-city, which was designed to be green and was supposed to provide better occupancy experience. Weak operation and maintenance have led to poor performance of the GRBs, hence residents' low level of satisfaction. Dissatisfied occupancy experience will ruin the reputation of green buildings. As existing customers, if residents' loyalty cannot be established and secured, repurchase intentions and word-of-mouth advertising are impossible. The residents of the eco-city will switch back to conventional buildings and they will not recommend GRBs to family and friends.

The findings in the present article highlight the importance of (1) stimulating the demand for GRBs as well as stimulating the production of GRBs, and (2) improving existing residents' occupancy experiences and motivating the repurchase behaviors of existing customers and purchase intentions of prospective customers, by bridging the gap between good design and weak operation.

Currently, the production of GRBs in China is driven mainly by mandates or incentives from governments, rather than residents' demand. Governments are "pushing" GRBs upon residents through its "visible hand". This may not be a sustainable way to promote GRBs. Once mandates and incentives are cancelled, GRBs may slump in supply. In addition, governments' top-down approach [48] to promoting GRBs overlooks residents' occupancy needs and may result in complaints, or even resistance.

The Chinese governments' promotion of GRBs is suffering from many barriers, both for prospective purchasers and existing customers. The root problem is residents' perceived usefulness of GRBs. Therefore, enhancing the perceived usefulness of GRBs must be the absolute priority, starting with enhancing residents' knowledge and environmental attitudes. To enhance residents' knowledge, policymakers need to devote continuous and substantial efforts towards cultivating residents with GRB-related knowledge and pro-environmental attitudes. Such an attitude and associated behavior change can reduce household emission [49].

The launching of information and publicity programs is essential. Lack of information is the main global barrier for promoting of GRBs [50]. As public goods, information relating to GRBs was

under-produced in the market [51]. Governments can facilitate in providing information and assisting households in their decision-making processes. Information campaigns can cultivate knowledgeable residents and other key stakeholders, and also help monitor the operation of the buildings and give feedback to other stakeholders. In addition, on-site publicity schemes can equip residents with knowledge and skills, and therefore promote green behavior within buildings, which is an effective practice of demand side management of carbon emission reduction [52]. This will help make green communities function in a more sustainable way [53,54]. If the merits of GRBs are fully realized through occupancy experience, repurchase intentions will be enhanced, and potential demand will rise. Furthermore, the public with increased green awareness can demand more green investment elsewhere [55] and thus can indirectly contribute to the environment protection.

Better operation and maintenance of GRBs could be improved by (1) establishing institutions to promote wide coordination and collaboration of designers/developers and parties responsible for building operation and maintenance. The mismatch between green design and green operation is usually caused by misalignment of key stakeholders' interests in different building phases. Designers and developers are the main stakeholders for the design and initial certification of GRBs. They are not stakeholders after the green label is conferred and the building is put into use so they have no motivation to connect the green design with good performance in operation phrase. (2) Roles of responsible authorities as supervisors should also be strengthened by effective enforcement of related regulations. Developing an assessment system for property management company performance would help rule out bad property management companies and improve the performance of GRB in the operation phase.

Due to some limitations, however, these findings should be cautiously interpreted. First, the methodology we adopt is subjective measurement of GRBs performance via surveys, it is not clear how the selected responses are meaningful without objective and quantitative comparison with building characteristics and experimental verification of actual building performance. Second, though we have covered residents from 35 residential communities in GRB projects, they are all located within the Eco-city in Tianjin. This location's limited representativeness should be noted so as not to generalize the conclusions about other populations and cities. Third, examination of the moderating role in this study is exploratory rather than confirmed. Therefore, further studies with similar hypotheses and larger sample sizes are expected.

6. Conclusion

In this article, we conducted a survey in the Eco-city, where all residential buildings had been certified and conferred with green building labels, to investigate residential satisfaction and repurchase intention. The results showed that GRBs in the Eco-city did not completely satisfy their occupants in a general sense. They showed heterogeneity in satisfaction levels, with 45% of residents satisfied with most aspects, and 55% either neutral or dissatisfied. Empirical analysis elucidated the determinants of repurchase intentions, including subjective knowledge, environmental attitudes and perceived usefulness, which were the determinants discussed in previous studies [27]. But trust in the relevant institutions, a determinant of purchase intentions, was found to have no impact on repurchase intention of GRBs. Residential satisfaction was found to play a moderating role by strengthening the effect of perceived usefulness of GRBs on repurchase intentions, weakening (even eliminating) the impact of trust on the perceived usefulness and the impact of knowledge on repurchase intentions.

The paper contributes to the literature by: (1) adding empirical evidence about the residential satisfaction of GRBs, in particular, in mainland China, which has not been well-documented in literature. (2) Highlighting the importance of maintenance and operating as well as designing of GRBs in a good way to retain existing customers and motivate their repeated purchasing behaviors. Moreover, we highlight the importance of motivating repurchase behavior among existing residents, especially their word-of-mouth advertising, through improving residential satisfaction. Practically, findings in this study enlighten GRB stakeholders in their decisions or policies making. We highlight the presently

unsustainable way of promoting GRBs by motivating production but not devoting enough effort towards stimulating demand. This is also the first survey of GRB residents' post occupancy experience in the Tianjin Eco-city during its 10 years anniversary. Our examination of their satisfaction reveals a typical problem for GRBs in China: A missing link between green design and green operation, within and beyond the Eco-city [17]. The study suggests implications for practice and policy development, including collecting and disseminating information about GRB residential satisfaction, promoting coordination and collaboration among stakeholders, including designers and operators, comprehensive standards of GRBs.

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