

Application of Structural Equation Modeling in Measuring Owner-Occupiers' Satisfaction with Green Homes in China

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Abstract

Purpose: This study examines the factors influencing owner-occupiers' satisfaction with green homes in China, focusing on indoor environmental quality, smart home technology adoption, and perceived energy efficiency. Additionally, it investigates the mediating role of ease of use of green features and the moderating effects of government incentives and cultural attitudes toward sustainability.

Method: A quantitative research approach was employed, using a cross-sectional survey design. Data were collected from 184 owner-occupiers of green homes in urban China through an online questionnaire. Structural Equation Modeling (SEM) was conducted using SMARTPLS 4.0, following a two-step approach to evaluate the measurement and structural models.

Findings: The results indicate that indoor environmental quality, smart home technology adoption, and perceived energy efficiency positively influence owner-occupiers' satisfaction. Ease of use of green features significantly mediates these relationships, highlighting the importance of user-friendly sustainability features. Furthermore, government incentives and cultural attitudes toward sustainability moderate the impact of ease of use on satisfaction, reinforcing the role of external influences in shaping homeowner experiences.

Originality/Implications: This study advances the understanding of sustainable housing satisfaction by integrating technological, environmental, and behavioral perspectives. It offers practical insights for policymakers, real estate developers, and technology providers to enhance the usability and adoption of green home technologies, ensuring a more sustainable and satisfying residential experience.

Keywords: Green Homes, Owner-Occupiers' Satisfaction, Smart Home Technology, Energy Efficiency, Structural Equation Modeling.

Introduction

1. General Introduction of the Research Domain and Background Works

Sustainable housing has attracted significant global attention since issues related to climate change, energy use, and environmental sustainability have been rising steadily. Green houses, employing energy-saving technology, green materials, and sustainable designs, have been advocated for as a sustainable solution for minimizing environmental footprint and improving dwelling comfort

([Adetola Adewale et al., 2024](#)). Green housing is a term that encompasses various factors such as energy-efficient appliances, home automation systems, improved indoor environmental quality, and renewable energy, all of which are responsible for reducing carbon footprints and improving the health of the occupants ([Ali et al., 2023](#)). Governments, policymakers, and developers have been working towards green housing practices positively with incentives, laws, and technological innovations to promote sustainable living([Zhang et al., 2023](#)).

Despite higher green home adoption, among the most important research topics in influencing owner-occupier satisfaction, there remains a gap. Some of the influences on levels of satisfaction with green homes include perceived indicators of energy efficiency, indoor environmental quality, ease of use of green features, and adoption of smart home technologies ([Andikan Udofot et al., 2024](#)). Several scientific researches have assessed the determinants of green living satisfaction in residential conditions, emphasizing the role of technological innovation, cultural values, and economic incentives in the users' experience ([Aruta et al., 2023](#)).

More and more research has investigated the many determinants of satisfaction with green houses, and particularly determinants like indoor environmental quality, adoption of smart home technology, and perceived energy efficiency ([Chen et al., 2024](#)). Studies have confirmed that indoor environmental quality, such as air quality, natural light, thermal comfort, and sound level, plays a critical role in homeowner satisfaction ([Bielen et al., 2025](#)). Studies have consistently proved that improved air quality and ventilation result in an improved life experience and health, which improves resident satisfaction ([Joy Joshua, 2023](#)). Additionally, studies have proven that thermal comfort and improved lighting improves perceived value for green homes and promotes long-term residence.

Smart home technology use has also been a key satisfaction driver in sustainable housing studies. Application of automation systems, energy management systems, and networked appliances has immensely boosted convenience, security, and energy efficiency in green homes ([Christopher et al., 2023](#)). Research has established that home customers who employ smart thermostats, automatic lighting, and sensor-based energy control systems are more satisfied because they have greater control over their home ([Deng et al., 2023](#)). In addition, research has established that the simplicity of using such smart devices is paramount in deciding whether home customers fully utilize their advantages, thereby influencing the level of satisfaction ([Marikyan et al., 2023](#)).

Perceived energy efficiency is also a key driver of green home satisfaction since it is the perception by residents of how effective their homes are in reducing energy use without sacrificing comfort ([Park et al., 2024](#)). Empirical research has indicated that residents are more satisfied when they perceive their homes as energy-efficient since they save on utility bills and contribute to environmental conservation ([Hafez et al., 2023](#)). Further, studies have established that green feature ease of use mediates this relationship since easy-to-use technology leads to increased usage of energy-saving systems and increased satisfaction ([Liu et al., 2023](#)). Notwithstanding these findings, studies exploring government incentives and cultural beliefs' role in satisfaction within green housing are few and require additional research([Will & Renz, 2023](#)).

While previous research has shed light on the determinants of green home satisfaction, a number of research gaps still exist. To start with, while indoor environmental quality has been researched in depth within sustainable housing, few studies have investigated how it combines with ease of use of green features to influence overall homeowner satisfaction (Giles-Corti et al., 2023). Most past research has focused on isolated components of indoor environmental quality, such as air quality and thermal comfort, without examining the usability of systems maintaining these environmental variables (Zhang et al., 2023). An understanding of the part ease of use has in facilitating this relationship is necessary to develop easy-to-use green homes optimized for highest satisfaction.

Second, research on smart home technology adoption in green housing has largely been concerned with the direct effects of automation and energy management systems on satisfaction (Arul Selvan, 2024). However, few have examined the impact of government incentives on this relationship. Government subsidies also play a huge role in how much homeowners are willing to take up smart home technology, yet little empirical work is available regarding whether incentives will enhance or lower satisfaction with green home (Facchinetti et al., 2023). In addition, studies on how cultural attitudes toward sustainability affect homeowner satisfaction with the adoption of smart home technology are sparse (Gøthesen et al., 2023).

Third, while perceived energy efficiency is a strong predictor of homeowner satisfaction, the extent to which ease of use of energy-efficient features can mediate this relationship has not been fully examined (Wang & Shao, 2023). Homeowners may perceive that their homes are energy-efficient, but if the systems are difficult to operate and complex, satisfaction is lowered. Besides, attitude variations in the cultural context to sustainability can impact how homeowners behave with energy-saving technologies, and this is not an area extensively researched in prior literature (Papadakis & Katsaprakakis, 2023). This is necessary in order to address the gaps needed to develop an integrated understanding of green home satisfaction. Drawing on the gaps noted in the current research, the present research attempts to answer the following objectives:

1. To examine the impact of indoor environmental quality on owner-occupiers' satisfaction with green homes.
2. To investigate how smart home technology adoption influences owner-occupiers' satisfaction with green homes.
3. To analyze the role of perceived energy efficiency in shaping owner-occupiers' satisfaction with green homes.
4. To explore whether ease of use of green features mediates the relationship between indoor environmental quality, smart home technology adoption, perceived energy efficiency, and owner-occupiers' satisfaction.
5. To determine whether government incentives moderate the relationship between ease of use of green features and owner-occupiers' satisfaction.

6. To assess whether cultural attitudes toward sustainability moderate the relationship between ease of use of green features and owner-occupiers' satisfaction.

This study is significant on a number of levels. In the first instance, it contributes to the corpus of green home literature by understanding how certain key variables such as indoor environmental quality, smart home technology uptake, and perceived energy efficiency influence homeowners' satisfaction. Secondly, this study draws from previous work in incorporating ease of use as an intervening variable that highlights the value of usability as a determinant to realize full advantages of green components. Third, it sheds light on knowledge regarding the government incentives' moderating roles as well as the moderating role of cultural attitudes, providing useful implications for housing developers and policymakers. Finally, this study furnishes real estate practitioners, housing developers, as well as policymakers with practical insights in terms of identifying the key determinants of satisfaction, therefore informing better design and implementation of sustainable housing initiatives.

Literature Review

Indoor Environmental Quality and Owner-Occupiers' Satisfaction with Green Homes

Indoor environmental quality (IEQ) is an overall description of the environment in a residential place that affects occupants' comfort, health, and well-being. It has dimensions like thermal comfort, air quality, lighting, acoustics, and effectiveness of ventilation (Akhatova et al., 2024). In green homes, all of these are maximized as an integral objective because green homes aim to promote sustainability while ensuring high living standards (Ali et al., 2023). Unlike conventional houses, green houses integrate new building materials, effective energy systems, and environmental design concepts to enhance IEQ (Adedeji, 2023). Because residential satisfaction depends heavily on perceived comfort and well-being of the indoor climate of a house, IEQ is a key driver of homeowner satisfaction (Angel & Gregory, 2023). It not only impacts the physical well-being of the users but also contributes to their mental well-being by offering a cozy and aesthetically pleasing living condition.

Empirical studies consistently validate the connection between IEQ and residential satisfaction. It has been proven through studies that enhanced indoor air quality, attained by utilizing non-toxic materials and effective ventilation systems, highly increases occupants' comfort and decreases health-related complaints like respiratory problems and allergies (Bielen et al., 2025). Likewise, studies of green building certification schemes, like LEED and BREEAM, indicate that residential buildings optimized for thermal comfort and daylighting lead to greater occupant satisfaction (Joy Joshua, 2023). The beneficial impacts of acoustic regulation, which reduces noise disturbance from the exterior, have also been found in earlier studies. Structural equation model (SEM)-based research has also established that IEQ parameters have direct and indirect effects on residential satisfaction, with thermal comfort and air quality tending to be the strongest predictors.

H1: Indoor environmental quality has a positive and significant impact on owner-occupiers' satisfaction with green homes

Smart Home Technology Adoption and Owner-Occupiers' Satisfaction with Green Homes

Smart home technology adoption is the incorporation of smart systems into homes to increase automation, energy efficiency, security, and overall convenience (Gøthesen et al., 2023). Smart home technology usually comprises smart thermostats, automated lighting, appliance remote control, energy management systems, and AI-driven climate control systems (Marikyan et al., 2023). In case of green homes, smart home technology has a significant role to play in maximizing the use of resources while enhancing the user experience (Nasr et al., 2024). These technologies allow homeowners to monitor and control energy consumption, minimize waste, and personalize their homes (Racha-Pacheco et al., 2023). With a seamless experience and ease of use, smart home technology has the capability to make homeowners more satisfied with their green home as an end result (Rock et al., 2022).

Empirical evidence suggests the significant influence of smart home technology uptake on housing satisfaction. Current evidence suggests that users of smart home systems are more content because of the convenience, security, and energy efficiency provided by the technologies (Sankar et al., 2023). Results show that the capacity to customize and automate home spaces according to one's preferences improves the homeowner's experience overall, hence confirming their feeling of control and comfort (Will & Renz, 2023). Besides, technology acceptance variables like ease of use perceived, usefulness perceived, and reliability of the system as determined via SEM-based studies were revealed to be excellent predictors of homeowner satisfaction (Park et al., 2025). With increasing adoption of technology, studies highlight ease of use and smooth integration as key factors in influencing residents' perceptions of the efficiency of green homes.

H2: Smart home technology adoption has a positive and significant impact on owner-occupiers' satisfaction with green homes

Perceived Energy Efficiency and Owner-Occupiers' Satisfaction with Green Homes

Perceived energy efficiency is the homeowners' assessment of the extent to which their home reduces energy usage while providing optimal performance and comfort (Arowoia et al., 2024). It is influenced by the home's design, quality of insulation, energy-efficient appliances, and use of renewable energy technologies like solar panels (Chen et al., 2024). Green homes are particularly designed to maximize energy efficiency through the use of passive design techniques, high-performance building envelopes, and intelligent energy management systems (Christopher et al., 2023). Home owners who perceive their homes as energy-efficient connect them to lower utility bills, improved comfort, and a reduced environmental footprint, all of which lead to higher levels of satisfaction (Deng et al., 2023). The financial and environmental advantages of green homes are among the primary drivers of house buyers, which also testifies to the significance of energy efficiency in the determination of homeowner satisfaction (Hafez et al., 2023).

Empirical works have consistently affirmed that perceived energy efficiency is the essential component of dwelling satisfaction. Energy-efficient houses studies confirm residents who feel they have enjoyed consequential energy savings remain satisfied with dwellings (Liu et al., 2023). Research using SEM attests that the homeowner's personal assessment of being energy efficient tends to directly correlate with homeowner satisfaction, especially coupled with tangible assets

such as saved money and planetary rewards (Ali et al., 2023). Furthermore, research has shown that energy-efficient products like well-insulated walls and intelligent climate control systems lead to increased comfort levels and improved interior living conditions.

H3: Perceived energy efficiency has a positive and significant impact on owner-occupiers' satisfaction with green homes

Ease of Use of Green Features as a Mediator

Ease of use of green features is the extent to which residents experience green systems and technology as being easy to use and incorporate into their daily life (Chen et al., 2024). Ease of use in green houses involves elements like automated ventilation systems, energy-efficient lighting, and smart thermostats, all which help enhance indoor environmental quality (IEQ) (Facchinetti et al., 2023). Although good-quality IEQ is the most important factor in improving occupant comfort, its effectiveness in shaping satisfaction also largely hinges on how easy it is to use these green features (Zhang et al., 2023). If occupants find it hard to control or adjust systems designed to maximize air quality, temperature, and light levels, the advantages of improved IEQ may be lost or even lead to dissatisfaction (Liu et al., 2023). Thus, ease of use is key to translating the benefits of IEQ into real homeowner satisfaction.

Empirical evidence attests to the fact that usability serves as an important mechanism through which environmental attributes influence overall satisfaction. Research has indicated that homeowners tend to value and use green features more when they are created with easy-to-use interfaces and entail little effort to maintain (Christopher et al., 2023). Previous research has shown that when air filtration systems, humidity controls, and natural lighting adjustments are intuitive and easy to use, occupants feel more comfortable, which leads to higher satisfaction with their residences (Ali et al., 2023). Structural equation modeling (SEM)-based research has established that usability is a strong mediating variable in the technological innovation-customer satisfaction relationship in many industries, including sustainable housing.

H4: Ease of use of green features mediates the relationship between indoor environmental quality and owner-occupiers' satisfaction with green homes

Smart home technology take-up encompasses the deployment of intelligent systems that deliver greater automation, efficiency, and convenience in domestic environments (Sankar et al., 2023). Yet, to what extent these technologies enhance owner-occupiers' satisfaction depends highly on how easy they are to use (Joy Joshua, 2023). Green home technologies, including smart energy meters, automated climate control, and sensor-based lighting, tend to be complex, demanding a degree of technological literacy (Racha-Pacheco et al., 2023). When these systems are felt to be too complex, their owners will be unable to utilize their full advantages, and hence they will create frustration instead of satisfaction (Park et al., 2025). In contrast, smart home technologies when made with intuitive interfaces and unified connectivity make the usability better, enabling homeowners to feel their benefits without too much effort (Akhatova et al., 2024). Therefore, ease of use is vital in making sure that smart home technologies become an aspect of better residential satisfaction.

Empirical studies have identified the usability factor as central to technology adoption. Research confirms that perceived ease of use is a key predictor of user acceptance and satisfaction with smart home systems(Marikyan et al., 2024). Technology adoption models, e.g., the Technology Acceptance Model (TAM), conclude that people will adopt and experience satisfaction from using smart technologies if they find them easy to use(Rock et al., 2022). Earlier research using SEM has also validated that ease of use strongly mediates the impact of technological characteristics on user satisfaction, supporting the fact that usability augments the advantages of automation.

H5: Ease of use of green features mediates the relationship between smart home technology adoption and owner-occupiers' satisfaction with green homes

Though energy-efficient residences provide both financial and environmental advantages, the degree to which these benefits occur in terms of homeowner satisfaction is found to be highly dependent on usability of the green technologies that are implemented to maximize energy efficiency(Papadakis & Katsaprakakis, 2023). Homeowners tend to underuse features perceived as complicated or troublesome to use, such as energy-saving technologies like programmable thermostats, solar panels, and energy-efficient appliances, thus diminishing their net effect on satisfaction(Wang & Shao, 2023). On the other hand, when energy-efficient equipment can be easily used and integrated into everyday life, they increase perceived as well as actual energy efficiency, which culminates in increased owner satisfaction(Chen et al., 2023).

Empirical work lends good support to the mediating effect of ease of use between energy efficiency and satisfaction. Evidence has indicated that if homeowners consider energy-saving technologies simple to use, they are likely to embrace energy-saving behaviors and value the benefits that follow(Christopher et al., 2023). Consumer studies of the adoption of sustainable technology have indicated that usability plays a central role in affecting perceived effectiveness and extended use of green amenities (Huda et al., 2024). SEM-based research has also established that ease of use is a mediator in many areas, connecting perceived technological effectiveness with positive user experiences.

H6: Ease of use of green features mediates the relationship between perceived energy efficiency and owner-occupiers' satisfaction with green homes

Government Incentives as a Moderator

Government incentives are monetary or policy-based support mechanisms extended by governments to promote the use of sustainable housing solutions(Joy Joshua, 2023). They can be in the form of tax credits, subsidies, low-interest loans, or grants to subsidize the financial burden of installing green technologies on residential real estate(Grimes et al., 2024). By reducing the cost of taking up energy-efficient solutions, government incentives are key in influencing consumer choice and making green housing more accessible(Bielen et al., 2025). But whether these incentives work or not does not entirely rely on monetary alleviation; it also combines with homeowners' exposure to green home technologies, specifically their simplicity of use(Angel & Gregory, 2023). If green features are easy to use and accompanied by government-sponsored

assistance, homeowners will be more inclined to maximize the use of these technologies, which will result in greater satisfaction with their green homes(Akhatova et al., 2024).

Empirical evidence has stressed the significance of state incentives to promote sustainability and ensure greater customer satisfaction with environmentally friendly housing(Park et al., 2025). Financial support systems have been observed in research studies to substantially improve the rate of use of green technology by reducing the costs involved and the perceived risk of installing the same(Will & Renz, 2023). Previous studies conducted under structural equation modeling (SEM) have established that government incentives enhance the relationship between user satisfaction and technology adoption since incentives instill a sense of security and green commitment(Ali et al., 2023). Also, according to studies, incentives have an increased effect when ease of use is high because homeowners are more confident in using the subsidized technologies to their maximum capacity.

H7: Government incentives moderates the relationship between ease of use of green features and owner-occupiers' satisfaction with green homes

Culture Attitudes toward Sustainability as Moderator

Cultural sustainability attitudes pertain to the common beliefs, values, and norms of a society concerning the responsibility for the environment and living sustainably(Aruta et al., 2023). Such attitudes influence the readiness of individuals to accept green practices and their perception of and interaction with green technologies(Chen et al., 2024). In societies in which sustainability is ingrained in the culture, people are ready to accept and value green house features even though they may demand effort to function(Giles-Corti et al., 2023). On the other hand, when environmental awareness is weaker in cultures, ease of use assumes a stronger role as a driver of satisfaction, as homeowners will be less willing to devote time and energy to learning and applying sustainable attributes(Huda et al., 2024). Thus, cultural orientation to sustainability can also act as a moderator, providing a context under which ease of use of green features has a stronger or weaker relationship with homeowner satisfaction(Tan et al., 2025).

Empirical work has proven that cultural values have a crucial impact on consumer attitudes toward sustainable homes. Studies have determined that members of environmentally conscious societies are more likely to have high levels of engagement with green technologies even when usability issues abound (Ali et al., 2023). SEM research has established that cultural sustainability orientation impacts perceived satisfaction with green attributes, with pro-environmental culture members deriving higher satisfaction from environmentally sustainable housing options (Rock et al., 2022). In addition, evidence shows that where green features are designed with user-friendliness in mind, satisfaction is universally high, but the size of this relationship varies as a function of cultural context.

H8: Cultural attitudes toward sustainability moderates the relationship between ease of use of green features and owner-occupiers' satisfaction with green homes

Theoretical Framework Supporting the Research

The theoretical foundation of this research draws on the Technology Acceptance Model (TAM) and the Stimulus-Organism-Response (SOR) model, both of which provide a structured explanation of the impact of technological, environmental, and psychological factors on owner-occupiers' satisfaction with green homes. TAM posits that perceived ease of use and perceived usefulness are the key factors that drive technology adoption and satisfaction. Usability of green features in green homes is a critical driver in shaping the overall satisfaction of owner-occupiers by reducing operating complexity and enhancing perceived value in smart home technology, indoor environmental quality, and energy efficiency (Huda et al., 2024). The SOR model, which describes the behavioral reactions of external stimuli in the environment, also confirms this relationship by indicating that energy efficiency, technological characteristics, and the quality of the indoor environment are the external stimuli influencing homeowners' perception (organism), thereby leading to satisfaction as a behavioral reaction (Vieira, 2013). In addition, moderating variables such as government policies and cultural notions of sustainability influence the strength of such relationships by determining people's motivation and willingness to embrace and apply green home features positively. Previous research has supported the effectiveness of government initiatives in fostering technology acceptance and environmental behavior, and cultural orientations have been observed to influence pro-environmental decision-making. (Umeora et al., 2025). By bringing these theoretical frameworks together, this research model identifies a complete picture of how technological usability, environmental quality, energy efficiency, and external factors work together to influence owner-occupiers' satisfaction with green homes. This conceptual framework of these relationships is presented in Figure 1.

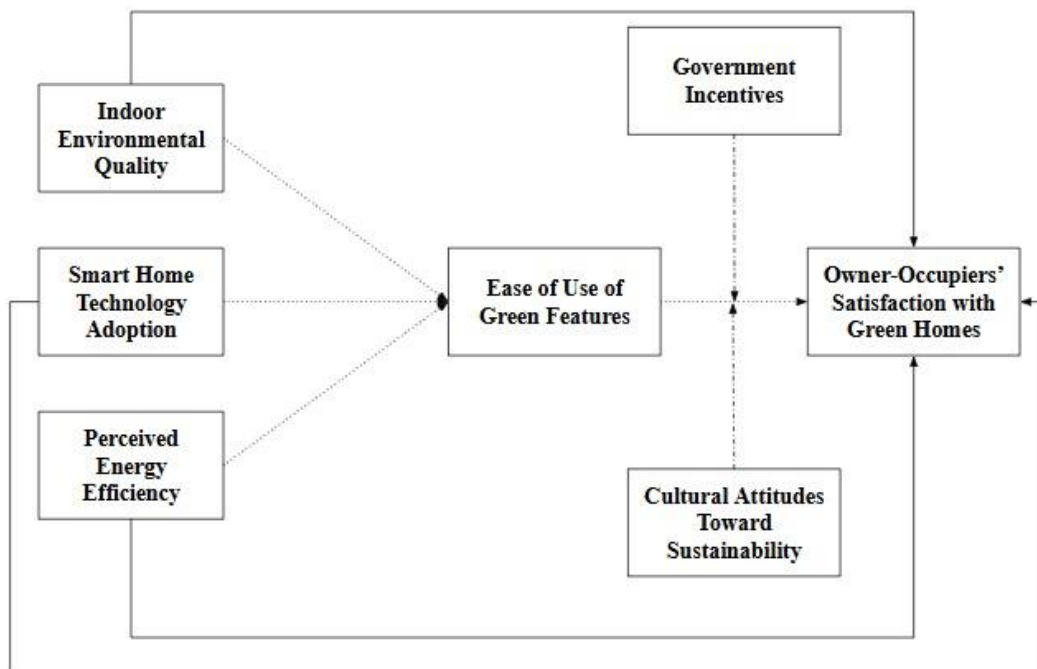


Figure 1: Conceptual Framework

Methodology

Population

The population targeted in this research were owner-occupiers of green houses in Chinese urban areas. They were chosen because they are directly benefiting from and facing the challenges of owning a green house, thus best placed to offer information on factors that determine their satisfaction. Green homes here are defined as residential structures that are built with environmentally friendly features like energy-efficient appliances, smart home systems, and high indoor environmental quality. The research targeted middle- to upper-income homeowners who had occupied their green homes for a minimum of six months, which was long enough to have enough experience to accurately measure their satisfaction levels.

Sample Size and Sampling Technique

The sample size for the study was 184 respondents, which is acceptable for SEM analysis with SMARTPLS, since previous studies recommend that a minimum of 150–200 cases is adequate for models with more than one construct and path relationships. The sampling method used was purposive sampling, where specific owner-occupiers meeting certain criteria were targeted, such as living in a certified green home and having at least a specified period of ownership. This technique was applied to guarantee the collection of answers from participants possessing pertinent experience within dealing with the green home amenities. A further snowball sampling strategy was then employed to attract more participants through the request from initial respondents that they refer suitable homeowners who belong to the same study category as themselves. It was this methodology that facilitated covering a wide, diverse range of green home owners from various regions of China.

Data Collection

Information was gathered from a standardized web-based questionnaire disseminated through numerous digital media outlets, such as social media networks, online neighborhood communities, and business real estate forums. The questionnaire was constructed based on a five-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree), to quantify major constructs of indoor environmental quality, adoption of smart home, perceived energy efficiency, convenience of using green features, government incentives, cultural attitudes, and owner-occupiers' satisfaction. The questionnaire was sent in both Mandarin and English to provide accessibility to a wider respondent group. In order to improve response validity, screening questions were added at the start of the survey to validate eligibility so that only certified green home owner-occupiers were included. A total of 220 responses were collected initially, but after data cleaning and elimination of incomplete or inconsistent responses, 184 valid responses were used for analysis.

Data Analysis

The data collected were processed using Partial Least Squares Structural Equation Modeling (PLS-SEM) within SMARTPLS 4.0, a sophisticated statistical tool with the ability to handle complex models with latent variables. The two-step analysis involved assessing construct reliability, convergent validity, and discriminant validity via measurement model evaluation. Internal consistency was confirmed using Cronbach's alpha and composite reliability, while Average

Variance Extracted (AVE) was used to determine convergent validity. Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio were used for discriminant validity. After ensuring a valid and reliable measurement model, the assessment of the structural model was conducted to test the hypothesized hypotheses. Path coefficients, R^2 , and effect sizes (f^2) were considered in order to look at the significance and strength of relationships. Bootstrapping using 5,000 resamples was also employed to verify the statistical significance of the moderating, mediating, and direct effects. The results presented constituted empirical evidence for the advocated relationships, and they demonstrated the prominent role played by environmental quality, adoption of smart technology, energy efficiency, and external factors in determining owner-occupiers' satisfaction with green homes.

Results

Table 1 and Figure 2 shows the assessment of the measurement model, with outer loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) evaluated for each construct. All measurement items' outer loadings are greater than 0.70, which guarantees their sufficiency in capturing the corresponding latent constructs. Strong internal consistency among constructs is reflected by Cronbach's alpha ranging between 0.803 and 0.891. Composite reliability (CR) measures all range above 0.85, indicating strong reliability. Furthermore, the AVE measures all are above 0.50, thereby verifying convergent validity. Indoor environmental quality (AVE = 0.753), ease of use of green features (AVE = 0.742), and cultural attitudes toward sustainability (AVE = 0.738) particularly show strong validity. These findings together show that the measurement items validly measure the intended latent variables, and this supports the validity of subsequent structural model analysis.

Table 1: Variables reliability and validity

	Items	Outer Loading	Cronbach's Alpha	CR	AVE
Cultural Attitudes Toward Sustainability	CAS1	0.860	0.823	0.894	0.738
	CAS2	0.874			
	CAS3	0.844			
Ease of Use of Green Features	EUGF1	0.858	0.826	0.896	0.742
	EUGF2	0.870			
	EUGF3	0.855			
Government Incentives	GI1	0.699	0.813	0.877	0.642
	GI2	0.865			
	GI3	0.872			
	GI4	0.755			
Indoor Environmental Quality	IEQ1	0.853	0.891	0.924	0.753
	IEQ2	0.871			
	IEQ3	0.873			
	IEQ4	0.874			

Owner-Occupiers' Satisfaction	OCS1	0.835	0.885	0.916	0.685
	OCS2	0.858			
	OCS3	0.817			
	OCS4	0.822			
	OCS5	0.805			
Perceived Energy Efficiency	PEE1	0.832	0.803	0.870	0.627
	PEE2	0.784			
	PEE3	0.789			
	PEE4	0.760			
Smart Home Technology Adoption	SMTA 1	0.849	0.849	0.898	0.687
	SMTA 2	0.840			
	SMTA 3	0.802			
	SMTA 4	0.824			
	SMTA 5	0.824			

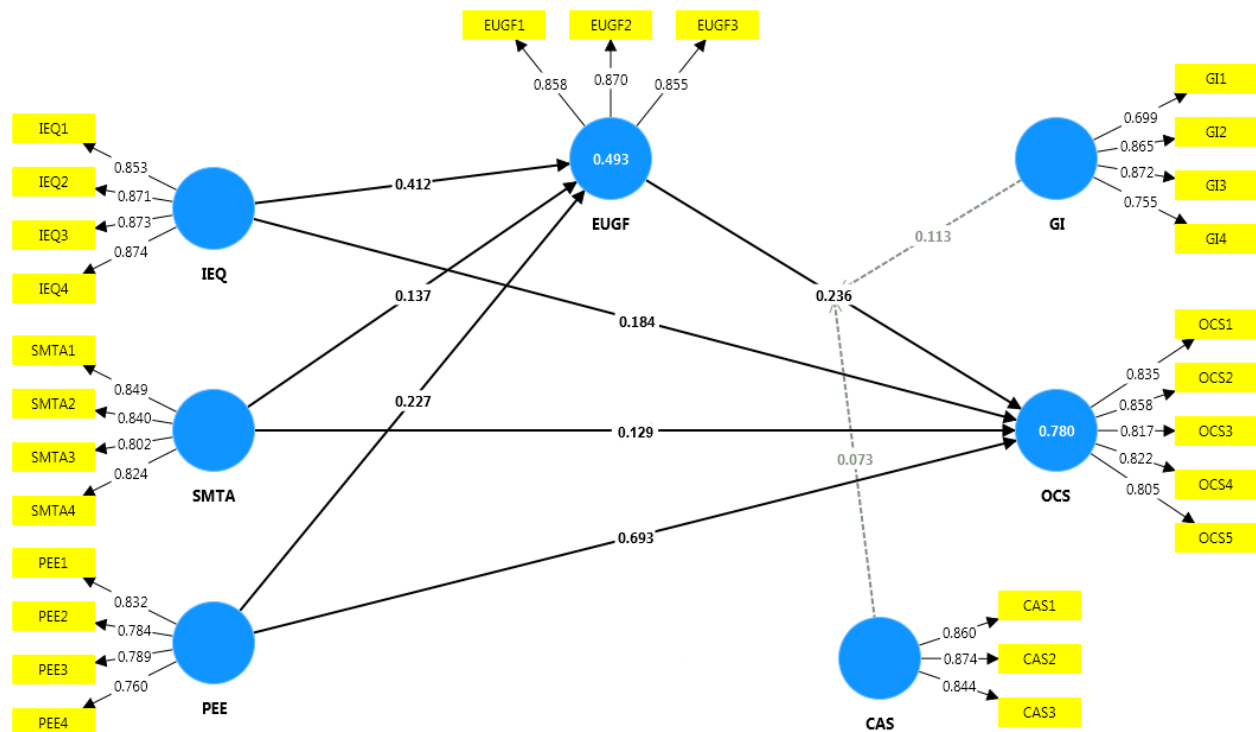


Figure 2: Measurement Model

Table 2 shows the Heterotrait-Monotrait (HTMT) ratio of correlations, a very strict test for discriminant validity. The HTMT values should be less than 0.85 to ensure that constructs are different from each other. The findings show that the majority of HTMT values are still below the

cut-off point, with the exception of smart home technology adoption and indoor environmental quality (0.916) and owner-occupiers' satisfaction and perceived energy efficiency (0.846), which are close to the upper limit. These results indicate that although there exist strongly correlated constructs, they nonetheless possess adequate differences to pass discriminant validity test. Overall, the results assert that the constructed variables truly signify distinct constructs as they uphold the model robustness.

Table 2: Discriminant Validity (HTMT)

	CAS	EUG F	GI	IEQ	OCS	PEE	SMT A
Cultural Attitudes Toward Sustainability							
Ease of Use of Green Features	0.732						
Government Incentives	0.533	0.781					
Indoor Environmental Quality	0.658	0.776	0.678				
Owner-Occupiers' Satisfaction	0.597	0.790	0.684	0.716			
Perceived Energy Efficiency	0.580	0.707	0.601	0.752	0.711		
Smart Home Technology Adoption	0.594	0.739	0.611	0.916	0.741	0.846	

Table 3 shows the R-square values, which measure the explanatory power of the model. The R² for owner-occupiers' satisfaction is 0.780, meaning that 78% of owner-occupiers' satisfaction variance is explained by its predictors. This is a high explanatory power, indicating that indoor environmental quality, adoption of smart home technology, perceived energy efficiency, and ease of use of green features have a significant influence on satisfaction. Further, the R² for owner-occupiers' satisfaction with green features is 0.493, indicating that 49.3% of its variance is captured by the pertinent independent variables. The Q² values that evaluate the model's predictive relevance attest to its stability, where Q² for owner-occupiers' satisfaction is 0.719 and for ease of use of green features is 0.478. In addition, the Standardized Root Mean Square Residual (SRMR) measure of 0.072 shows a good fit for the model since it is less than the suggested limit of 0.08. These results confirm the predictive ability of the structural model and that it offers valid information regarding owner-occupiers' satisfaction with green homes.

Table 3: R-square statistics Model Goodness of Fit Statistics

	R-square	R-square adjusted	Q2	SRMR
Ease of Use of Green Features	0.493	0.490	0.478	0.072
Owner-Occupiers' Satisfaction	0.780	0.776	0.719	

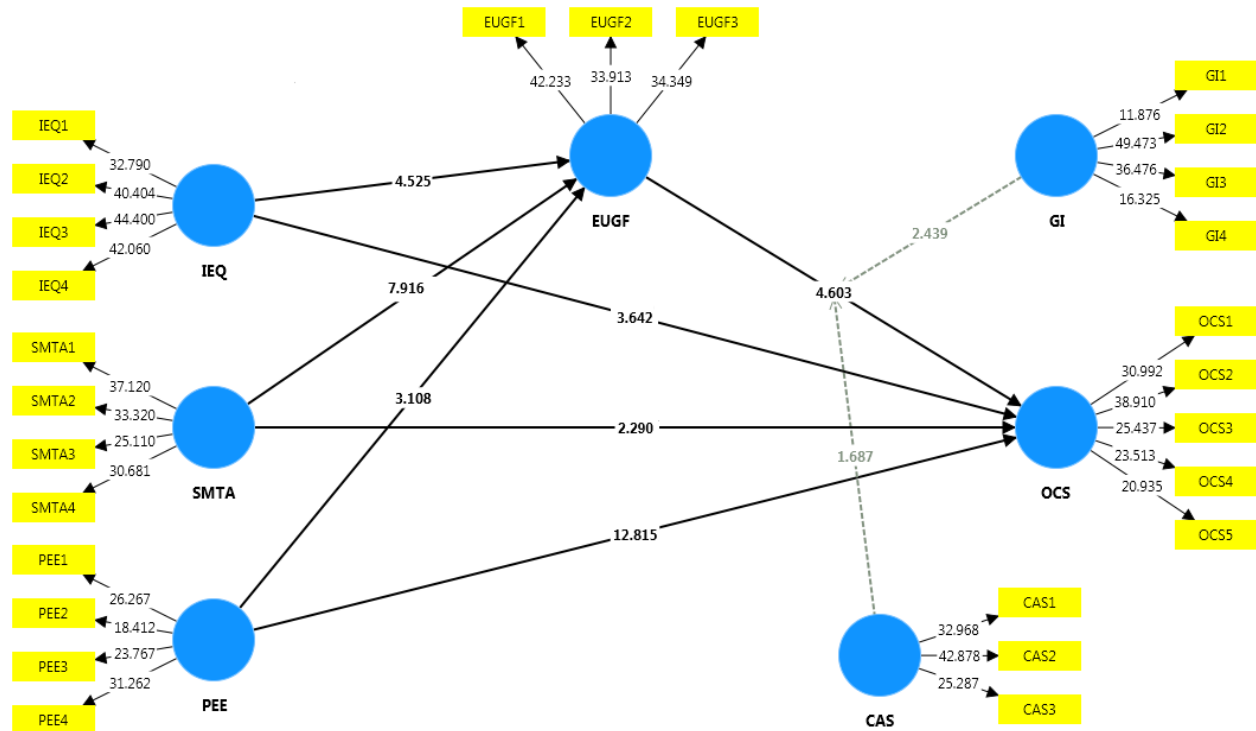


Figure 3: Structural Model for Path Analysis

Table 4 and Figure 3 shows the direct path analysis, which considers the effect of the main independent variables on owner-occupiers' satisfaction with green homes. The findings are consistent with all three hypotheses concerned with direct effects being statistically significant, as seen from their p-values ($p < 0.05$) and high t-values. Indoor environmental quality has a strong positive influence ($\beta = 0.184$, $t = 3.642$, $p = 0.000$), indicating that better indoor environmental quality leads to increased owner satisfaction. Likewise, the adoption of smart home technology also has a strong positive influence ($\beta = 0.129$, $t = 2.290$, $p = 0.000$), indicating that the adoption of smart home features increases satisfaction levels. The best predictor in this study is perceived energy efficiency, with a β value of 0.693, $t = 12.815$, and $p = 0.000$, meaning that energy efficiency is the top determinant of satisfaction. These results highlight the relevance of maximizing indoor environmental parameters, encouraging intelligent home technologies, and enhancing energy efficiency in order to maximize the overall quality of life for occupants in green homes.

Table 4: Direct Path Analysis

	β	t value	p value
Indoor environmental quality has a positive and significant impact on owner-occupiers' satisfaction with green homes	0.184	3.642	0.000
Smart home technology apotion has a positive and significant impact on owner-occupiers' satisfaction with green homes	0.129	2.290	0.000

Perceived energy efficiency has a positive and significant impact on owner-occupiers' satisfaction with green homes	0.693	12.815	0.000
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Table 5 displays the findings of the mediation analysis, examining if ease of use of green features mediates the associations between major predictors and satisfaction among owner-occupiers. The findings are in line with the fact that ease of use of green features has a significant mediating effect in all three associations, as indicated by statistically significant β values and p-values less than 0.05. In particular, usability strongly mediates the association between indoor environmental quality and satisfaction ($\beta = 0.097$, $t = 3.248$, $p = 0.001$), suggesting that green home environment which is well-designed and easy to use will bring about satisfaction. Likewise, the mediation effect of smart home technology adoption to satisfaction is also significant ($\beta = 0.032$, $t = 2.331$, $p = 0.016$), which indicates that smart home technology that is easy to use enhances user interaction, and thus satisfaction. Finally, ease of use also mediates the relationship between perceived energy efficiency and satisfaction ($\beta = 0.054$, $t = 2.348$, $p = 0.009$), with the implication that energy-efficient attributes need to be easy to use in order to achieve maximum benefits. These results indicate that ease of use and accessibility of green home attributes help increase the efficacy of environmental and technological innovations for enhancing occupant satisfaction.

Table 5: Mediation Analysis

	β	t value	p value
Ease of use of green features mediates the relationship between indoor environmental quality and owner-occupiers' satisfaction with green homes	0.097	3.248	0.001
Ease of use of green features mediates the relationship between smart home technology adoption and owner-occupiers' satisfaction with green homes	0.032	2.331	0.016
Ease of use of green features mediates the relationship between perceived energy efficiency and owner-occupiers' satisfaction with green homes	0.054	2.348	0.009

Table 6 shows the moderation analysis, examining the impact of government incentives and culture towards sustainability in mediating the effect between ease of use of green features and owner-occupiers' satisfaction. The results suggest that government incentives exert a significant positive moderating effect ($\beta = 0.113$, $t = 2.439$, $p = 0.007$), suggesting policy backing and economic incentives reinforce the effect of easy-to-use green features on satisfaction. This implies that if green features are encouraged by government incentives, users tend to view them as beneficial and worthwhile, hence increased satisfaction. Cultural beliefs concerning sustainability also significantly moderate the relationship ($\beta = 0.073$, $t = 1.687$, $p = 0.046$), implying that social and individual values concerning sustainability affect the degree to which ease of use leads to satisfaction. These findings suggest that encouraging positive attitudes towards sustainability and

offering government incentives can further augment the beneficial impacts of easy-to-use green home features, ultimately resulting in greater satisfaction levels among owner-occupiers.

Table 6: Moderation Analysis

	β	t value	p value
Government incentives moderates the relationship between ease of use of green features and owner-occupiers' satisfaction with green homes	0.113	2.439	0.007
Cultural attitudes toward sustainability moderates the relationship between ease of use of green features and owner-occupiers' satisfaction with green homes	0.073	1.687	0.046

Discussion

The transition to sustainable housing is now a global imperative, driven by the need to reconcile human development with nature conservation. Green homes are now a feasible option, integrating energy-saving technologies, home automation technologies, and ecological designs to enhance living standards while reducing environmental effects. However, green home success is also not only restricted to its ecological implications, it mostly depends on the satisfaction of homeowners, amongst other considerations such as indoor environmental quality, intelligent technology usage, perceived energy efficiency, and useability of green features. This research provides empirical evidence into such intricate interlinkages of such factors and throws light into the way green houses can be tuned for sustainability purposes as well as for the use experience. By validating the influential role of such variables on satisfaction, the study emphasizes that it is not just a matter of designing technologically sophisticated green homes but also an effort to see that they get user-friendly, accessible, and backed by policy measures.

The empirical results confirm that indoor environmental quality has a positive and significant impact on owner-occupiers' satisfaction with green homes (H1). The result is in line with previous research emphasizing the importance of air quality, thermal comfort, natural light, and sound reduction in determining residential satisfaction. Past studies have invariably shown that better indoor air quality, resulting from good ventilation systems and low-emission materials, enhances occupants' comfort and health, leading to increased satisfaction (Umeora et al., 2025). Thermal comfort, including effective heating and cooling systems, has also been reported to be a major predictor of residents' satisfaction with green homes (Liu et al., 2023). Our study's validation of this assumption shows that owner-occupiers place a lot of emphasis on the indoor climate in their dwelling, which favors the need for developers and planners to prioritize top-notch indoor environment in green home developments.

The study also concluded that the integration of smart home technology has an important and significant impact on the satisfaction of owner-occupiers with green homes (H2). This attests to the new literature citing the growing utility of technology and automation in households. Smart home technologies, such as energy-saving lighting systems, climate control systems, and security

systems based on IoT, universally enhance the ease of use, efficiency, and security of green homes (Facchinetti et al., 2023). Different researches have proven that home owners adopting intelligent technologies have enhanced control over the homes, and this translates into higher comfort and satisfaction (Huda et al., 2024). Acceptance of the above assumption also points towards the importance of the integration of technology in green houses, as current homeowners more so expect seamless automation and smart handling of the dwellings. In addition, these findings show that aside from the energy efficiency and savings benefits of smart technologies, their ease of use and ability to personalize user experiences have a significant role in shaping levels of satisfaction.

In addition, the results confirmed that the satisfaction of owner-occupiers with green houses is significantly and positively affected by perceived energy efficiency (H3). This is in line with previous research that demonstrates that energy-efficient homes provide numerous benefits including reduced bills, reduced carbon emissions, and enhanced environmental consciousness, that tend to contribute to higher household satisfaction (Hafez et al., 2023). Homeowners residing in houses with green credentials and who perceive their homes as being energy-efficient tend to report greater satisfaction that their investment is in line with financial and environmental benefits, confirming overall satisfaction with their homes. The strong association between perceived energy efficiency and satisfaction implies the importance of effective communication by developers and regulators regarding energy saving and sustainability benefit. Unless homeowners become cognizant or realize immediate advantages from their energy-efficient attributes, their satisfaction is threatened despite the fact that the house actually is efficient (Liu et al., 2023). Such evidence warrants explicit labeling, in-home real-time energy monitors, and homeowner education programs in order for homeowners to become conscious of and to appreciate the energy efficiency of their homes.

Moreover, this research confirmed the mediation role of the ease of use of green features in the indoor environmental quality and owner-occupiers' satisfaction relationship (H4). The results indicate that indoor environmental quality has a direct impact on satisfaction, while perceived ease of use of green features has an impact on this relationship. This is consistent with earlier studies that have established usability as a key determinant of effective take-up and long-term use of sustainable housing technologies (Joy Joshua, 2023). Provided homeowners are able to use green features like air purification systems, high-end insulation regulators, or automatically controlled shading devices easily, they will likely utilize them effectively, thereby enhancing their overall satisfaction (Umeora et al., 2025). This highlights the importance of intuitive design, simple-to-use interfaces, and low maintenance requirements in green home technology. If indoor environmental quality features are too complex or require significant manual adjustments, residents may find it hard to take full advantage of their potential benefits, potentially decreasing their levels of satisfaction.

The study attested that the usability of green attributes mediates the effect of the adoption of smart home technology on owner-occupiers' satisfaction with green homes (H5). This observation is consistent with earlier research noting the significance of usability to smart technologies' uptake and performance within domestic contexts (Angel & Gregory, 2023). Although smart home

technology provides a wide range of advantages such as energy efficiency, security, and automation, the degree to which homeowners feel at ease using and interacting with these features has a direct impact on their overall satisfaction. There have been numerous studies highlighting that once homeowners find smart home systems easy to operate and intuitive, they tend to incorporate them into their lives and gain full benefit from their functionality (Chakraborty et al., 2023). The embracing of this hypothesis highlights the role of simple-to-use interfaces, uncluttered connectivity, and strong customer support towards creating a good smart home experience. Home owners with difficulties managing complex or unseamly integrated smart home systems will get frustrated and become disconnected, hence the diminution of the favorable impact of technology uptake on satisfaction. This result indicates that policymakers and builders should be concerned not just with technological innovation but also with the fact that these technologies are accessible to and easy to use by a broad array of customers.

The findings also confirmed the hypothesis that the ease of use of green features mediates between perceived energy efficiency and satisfaction among owner-occupiers in green homes (H6). Though energy efficiency has been increasingly seen as one of the determining factors of satisfaction in green homes (Arowoia et al., 2024), homeowners' ability to easily control and monitor energy-saving features is just as important a factor in defining their overall experience. Previous studies have shown that even when houses are constructed with high-end energy-efficient systems, their efficiency is a function of how effectively users can interact with them (Hafez et al., 2023). If smart meters, solar panel controllers, or heating and cooling automation are too complex, homeowners will not be able to use them effectively, resulting in disappointing satisfaction even though they are efficient. The embracing of this hypothesis implies that streamlining the function of green features can dramatically amplify the perceived advantages of energy efficiency. Developers should focus on crafting user-friendly energy management systems with immediate feedback and automatic functions for residents to make sound decisions regarding energy usage.

In addition, the study upheld that government incentives moderate the ease of employing green features and owner-occupiers' satisfaction with green dwellings (H7). This evidence aligns with studies that stress the significance of policy support in the adoption and application of sustainable housing (Christopher et al., 2023). Government incentives in the form of tax credits, subsidies, and rebates may also render green houses more appealing by decreasing the cost and motivating homeowners to adopt green lifestyles. There has been research to show that homeowners are more likely to adopt and use green technologies if they feel they have tangible economic gains from government policy (Chen et al., 2024). This acceptance has the function of bringing in the spotlight policy actions towards magnifying the reinforcing effect of usability on satisfaction. Even if green features are user-friendly, homeowners may still be hesitant to use them if the upfront cost is perceived to be too much. Government incentives narrow this gap by lowering the cost of green technologies, which enhances broader participation and satisfaction.

Finally, the study established that cultural beliefs on sustainability moderate the relationship between usability of green features and satisfaction of owner-occupiers with green houses (H8). This supports the literature in emphasizing social norms and awareness on the environment as

factors on sustainable action. Attitudes of culture contribute significantly to homeowners' attitudes toward green living, with implications as to whether sustainability is seen as a requirement or extra indulgence. Existing literature has shown that in those societies that have highly developed pro-environmental beliefs, homeowners will more likely support and enjoy green attributes with increased usability-satisfaction link (Zhang et al., 2023). The validity of this hypothesis implies that even if green features are made user-friendly, their ability to increase satisfaction hinges on cultural orientations toward sustainability. In highly environmentally conscious communities, residents are more likely to incorporate green practices into their daily routine, resulting in a greater appreciation for user-friendly green features.

The general acceptance of all four hypotheses also points to the need for a holistic strategy towards green home construction that incorporates environmental quality, technology, usability, policy support, and cultural factors. Indoor environmental quality, adoption of smart home features, and perceived energy efficiency directly influence satisfaction but are boosted greatly when green features are highly usable. In addition, government incentives and cultural perceptions are outside moderators that influence how homebuyers appreciate and engage with green technology. These implications indicate that effective green housing approaches must go beyond technological innovations and also take the human factor into consideration, allowing sustainable homes to be energy-efficient as well as user-friendly and acceptable to families. In the future, developers, policy makers, and environmentalists have to work together to design green living spaces that are innovative as well as practical, promoting long-term involvement in sustainable housing alternatives. Through examining the technical, behavioral, and policy aspects of green home take-up, this research opens up the prospect for a future when sustainability and happiness go hand-in-hand, strengthening the long-term viability of sustainable residential developments.

Conclusion

This research delivers a complete view of the decisive factors affecting the satisfaction of owner-occupiers with green dwellings, stressing the importance of indoor environmental quality, the adoption of smart home technology, and perceived energy efficiency in influencing home experiences. It is proven that these factors play a direct role in contributing to satisfaction but even more so when green home components are made to be easy to use, strengthening the need for user-focused sustainability innovations. Additionally, government support and cultural orientations towards sustainability are significant moderators, proving that support from outside and cultural norms have a significant impact on influencing positive attitudes and long-term uptake of green housing. These findings have theoretical and practical contributions to the study of sustainable housing, technology uptake, and environmental psychology, with significant implications for policymakers, developers, and researchers. Although the research identifies some limitations, including geographical boundaries and self-reported data, it also leaves the door open for future research to investigate other psychological, technological, and demographic influences on sustainable housing satisfaction. In the future, a holistic strategy that incorporates policy assistance, technology, and behavioral understanding will be critical in ensuring the large-scale uptake of green homes. As the call for sustainable living grows, making sure that green housing

options are not only eco-friendly but also easy to use, cost-effective, and culturally acceptable will be the key to creating a more sustainable and rewarding living experience for generations to come.

Implications

The results of this research provide significant practical implications for various stakeholders, such as policymakers, real estate developers, technology vendors, and homeowners. To begin with, the strong influence of indoor environmental quality, smart home technology uptake, and perceived energy efficiency on homeowner satisfaction emphasizes the importance of developers focusing on these factors in green home design and construction. Maintaining optimal indoor air quality, daylighting, acoustics, and thermal comfort can improve the quality of living, while marrying smart home technology with user-friendly interfaces can optimize their use and acceptability. In addition, the research also identifies the ease of use as being critical in the magnification of green feature benefits, where developers are encouraged to emphasize intuitive design, unobtrusive automation, and concise instructions to support user adoption. Government incentives moderator function suggests that policymakers need to continue offering economic support, tax benefits, and subsidies to encourage utilization of green housing, particularly by minimizing the initial cost hindrances that might discourage prospective consumers. Cultural values towards sustainability also play a vital function in deciding homeowner satisfaction, which requires public consciousness campaigns, community outreach programs, and sustainability sensitization educational programs. By addressing both behavioral and technological facets, this research provides a map for maximizing long-term success for green housing ventures so that green initiatives are framed as concrete improvement in residential life. Ultimately, a collaborative strategy between stakeholders—where innovation, usability, incentives, and promotion of culture take precedence—can drive mass adaptation of green houses toward a sustainable and user-centered future in residential life.

This study makes significant theoretical contributions by advancing existing theories on sustainability, technology adoption, and user satisfaction within household settings. By confirming the impacts of indoor environmental quality, smart home technology adoption, and perceived energy efficiency on owner-occupiers' satisfaction with green homes, this study advances the theoretical foundation of environmental psychology and sustainable housing frameworks. It extends the Technology Acceptance Model (TAM) and Expectation-Confirmation Theory (ECT) by describing how not only the presence of green home characteristics but also user-friendliness plays a decisive role in satisfying the users. The findings confirm the assertion that usability is indeed a core mediating process, emphasizing the importance of green home technologies being developed with user experience in mind if they are to deliver the most out of them. Additionally, the study includes moderating factors such as government incentives and cultural attitudes, creating new insight into how external forces influence the success of green housing adoption. This expands Institutional Theory, suggesting that policy-driven incentives play a crucial role in encouraging sustainable behavior. Furthermore, the finding that cultural attitudes are a valid moderator is also according to Socio-Technical Systems Theory, which focuses on the interdependence between human conduct, technology, and environmental factors. By bringing together these theoretical models, this study provides a more comprehensive understanding of

green home adoption and satisfaction, paving the way for future research to explore other psychological and behavioral factors that influence sustainable housing choices.

Limitations and Future Directions

Although this research presents useful information about the determinants of owner-occupiers' satisfaction with green homes, it is not flawless. One key limitation is geographic scope, given that the research was carried out within China, which has peculiar environmental policies, cultural orientations, and market dynamics that might not be fully representative of other markets. Future research may replicate this study in other nations with varying regulatory systems and cultural attitudes toward sustainability to increase the external validity of the results. The study also mostly used self-reported data, which can be prone to social desirability bias and subjective definitions of green home attributes. Even though structural equation modeling (SEM) was utilized to confirm the findings' robustness, longitudinal studies that follow homeowner satisfaction through time would give more insight into how perceptions change as a result of longer exposure to green home technologies. Another limitation is the failure to account for demographic diversity, including differences in income levels, education, and generational tastes, which may affect how various homeowner segments view and engage with green home attributes. Future studies might use segmentation analyses to examine whether satisfaction levels differ across various socio-economic and demographic segments.

Furthermore, although this research tested the ease of use mediation and the government incentives and cultural attitudes moderation effects, other psychological and behavioral dimensions may further explain green home satisfaction. Future work may investigate constructs like environmental awareness, perceived cost-benefit compromise, and habitual behavior, potentially affecting the tendency to adopt sustainable housing options. Also, new smart technologies like home automation based on artificial intelligence, energy trading based on blockchain, and biophilic design concepts might transform the face of green homes in the not-too-distant future. Examining how these innovations interface with homeowner satisfaction would give us significant insight into the next-generation sustainable housing paradigms. Also, qualitative research tools like in-depth interviews or ethnographic studies might offer support for quantitative research by tabulating detailed opinions around homeowner experiences and decision-making. Last but not least, future research could investigate the role of peer influence and community participation, since sustainable living is typically influenced by social networks and shared environmental behaviors. Addressing these and broadening research avenues, researchers can towards a more comprehensive and dynamic understanding of drivers of satisfaction and long-term take-up of green housing.

References

- [1] Adedeji, I. (2023). Nigerian Urbanization and the Significance of Affordable Housing. *Journal of Service Science and Management*, 16(03), 351-368. <https://doi.org/10.4236/jssm.2023.163020>

- [2] Akhatova, A., Derkenbaeva, E., van Leeuwen, E., Kranzl, L., Halleck Vega, S., & Hofstede, G. J. (2024). Who invests in energy retrofits? Mining Dutch homeowners' data. *Energy Policy*, 189. <https://doi.org/10.1016/j.enpol.2024.114132>
- [3] Ali, A. H., Kineber, A. F., Elyamany, A., Ibrahim, A. H., & Daoud, A. O. (2023). Modelling the role of modular construction's critical success factors in the overall sustainable success of Egyptian housing projects. *Journal of Building Engineering*, 71, 106467. <https://doi.org/https://doi.org/10.1016/j.jobe.2023.106467>
- [4] Angel, S., & Gregory, J. (2023). Does housing tenure matter? Owner-occupation and wellbeing in Britain and Austria. *Housing Studies*, 38(5), 860-880. <https://doi.org/10.1080/02673037.2021.1912714>
- [5] Arowoia, V. A., Moehler, R. C., & Fang, Y. (2024). Digital twin technology for thermal comfort and energy efficiency in buildings: A state-of-the-art and future directions. *Energy and Built Environment*, 5(5), 641-656. <https://doi.org/10.1016/j.enbenv.2023.05.004>
- [6] Arul Selvan, M. (2024). IoT-Integrated Smart Home Technologies with Augmented Reality for Improved User Experience. *Journal of Science Technology and Research (JSTAR)*, 5(1), 389-394.
- [7] Aruta, G., Ascione, F., Bianco, N., Iovane, T., Mastellone, M., & Maria Mauro, G. (2023). Optimizing the energy transition of social housing to renewable nearly zero-energy community: The goal of sustainability. *Energy and Buildings*, 282, 112798. <https://doi.org/https://doi.org/10.1016/j.enbuild.2023.112798>
- [8] Bielen, L., Van den Broeck, K., Versele, A., & Breesch, H. (2025). Evaluating Housing Quality, Energy Performance, Indoor Environment, and User Satisfaction in Renovated Locked-In Owner-Occupied Homes in Belgium. *Buildings*, 15(4). <https://doi.org/10.3390/buildings15040588>
- [9] Chakraborty, A., Islam, M., Shahriyar, F., Islam, S., Zaman, H. U., & Hasan, M. (2023). Smart Home System: A Comprehensive Review. *Journal of Electrical and Computer Engineering*, 2023(1), 7616683. <https://doi.org/https://doi.org/10.1155/2023/7616683>
- [10] Chen, W., Alharthi, M., Zhang, J., & Khan, I. (2024). The need for energy efficiency and economic prosperity in a sustainable environment. *Gondwana Research*, 127, 22-35. <https://doi.org/https://doi.org/10.1016/j.gr.2023.03.025>
- [11] Chen, Y., Ren, Z., Peng, Z., Yang, J., Chen, Z., & Deng, Z. (2023). Impacts of climate change and building energy efficiency improvement on city-scale building energy consumption. *Journal of Building Engineering*, 78, 107646. <https://doi.org/https://doi.org/10.1016/j.jobe.2023.107646>
- [12] Vikram, M. P., Bakli, C., Thakur, A. K., Ma, Y., Ma, Z., Xu, H., Cuce, P. M., Cuce, E., & Singh, P. (2023). Renewable energy potential towards attainment of net-zero energy buildings status – A critical review. *Journal of Cleaner Production*, 405, 136942. <https://doi.org/https://doi.org/10.1016/j.jclepro.2023.136942>
- [13] Deng, Z., Chen, Y., Yang, J., & Causone, F. (2023). AutoBPS: A tool for urban building energy modeling to support energy efficiency improvement at city-scale. *Energy and Buildings*, 282, 112794. <https://doi.org/https://doi.org/10.1016/j.enbuild.2023.112794>
- [14] Facchinetti, G., Petrucci, G., Albanesi, B., De Marinis, M. G., & Piredda, M. (2023). Can Smart Home Technologies Help Older Adults Manage Their Chronic Condition? A Systematic Literature Review. *Int J Environ Res Public Health*, 20(2). <https://doi.org/10.3390/ijerph20021205>

- [15] Giles-Corti, B., Foster, S., Lynch, B., & Lowe, M. (2023). What are the lessons from COVID-19 for creating healthy, sustainable, resilient future cities? *NPJ Urban Sustain*, 3(1), 29. <https://doi.org/10.1038/s42949-023-00107-y>
- [16] Gøthesen, S., Haddara, M., & Kumar, K. N. (2023). Empowering homes with intelligence: An investigation of smart home technology adoption and usage. *Internet of Things*, 24. <https://doi.org/10.1016/j.iot.2023.100944>
- [17] Grimes, A., Smith, C., O'Sullivan, K., Howden-Chapman, P., Le Gros, L., & Dohig, R. K. (2024). Housing Tenure and Subjective Wellbeing: The Importance of Public Housing. *Applied Research in Quality of Life*. <https://doi.org/10.1007/s11482-024-10369-y>
- [18] Hafez, F. S., Sa'di, B., Safa-Gamal, M., Taufiq-Yap, Y. H., Alrifay, M., Seyedmahmoudian, M., Stojcevski, A., Horan, B., & Mekhilef, S. (2023). Energy Efficiency in Sustainable Buildings: A Systematic Review with Taxonomy, Challenges, Motivations, Methodological Aspects, Recommendations, and Pathways for Future Research. *Energy Strategy Reviews*, 45. <https://doi.org/10.1016/j.esr.2022.101013>
- [19] Huda, N. U., Ahmed, I., Adnan, M., Ali, M., & Naeem, F. (2024). Experts and intelligent systems for smart homes' Transformation to Sustainable Smart Cities: A comprehensive review. *Expert Systems with Applications*, 238, 122380. <https://doi.org/https://doi.org/10.1016/j.eswa.2023.122380>
- [20] Joy Joshua, M. (2023). Factors Influencing Transformation of Prototype Public Housing in Northern Nigeria. *Covenant Journal of Research in the Built Environment*, 13(1). <https://journals.covenantuniversity.edu.ng/index.php/cjrbe/article/view/3930>
- [21] Liu, Z., Wang, W., Chen, Y., Wang, L., Guo, Z., Yang, X., & Yan, J. (2023). Solar harvest: Enhancing carbon sequestration and energy efficiency in solar greenhouses with PVT and GSHP systems. *Renewable Energy*, 211, 112-125. <https://doi.org/https://doi.org/10.1016/j.renene.2023.04.133>
- [22] Marikyan, D., Papagiannidis, S., & Alamanos, E. (2023). Cognitive Dissonance in Technology Adoption: A Study of Smart Home Users. *Inf Syst Front*, 25(3), 1101-1123. <https://doi.org/10.1007/s10796-020-10042-3>
- [23] Marikyan, D., Papagiannidis, S., F. Rana, O., & Ranjan, R. (2024). Working in a smart home environment: examining the impact on productivity, well-being and future use intention. *Internet Research*, 34(2), 447-473. <https://doi.org/10.1108/INTR-12-2021-0931>
- [24] Nasr, I. B., Abaidi, I., & Thomas, L. (2024). Home Sweet Smart Home: Enhancing Consumer Valuation and Purchase Intention of Smart Home Technologies (SHTs) for Societal Value. *Information Systems Frontiers*, 26(6), 1997-2025. <https://doi.org/10.1007/s10796-024-10563-1>
- [25] Papadakis, N., & Katsaprakakis, D. A. (2023). A Review of Energy Efficiency Interventions in Public Buildings. *Energies*, 16(17). <https://doi.org/10.3390/en16176329>
- [26] Park, G.-R., Park, H., & Kim, J. (2025). Late homeownership and life satisfaction among older adults: an examination of long-term effects and gender differences. *Journal of Housing and the Built Environment*. <https://doi.org/10.1007/s10901-025-10188-z>
- [27] Park, G.-R., Seo, B. K., & Kim, J. (2024). Moderating Effects of Housing Tenure Change on the Longitudinal Relationship Between Housing Relocation and Life Satisfaction. *Journal of Happiness Studies*, 25(7), 90. <https://doi.org/10.1007/s10902-024-00805-z>

- [28] Racha-Pacheco, P., Ribeiro, J. T., & Afonso, J. (2023). Architecture towards Technology—A Prototype Design of a Smart Home. *Buildings*, 13(7). <https://doi.org/10.3390/buildings13071859>
- [29] Rock, L. Y., Tajudeen, F. P., & Chung, Y. W. (2022). Usage and impact of the internet-of-things-based smart home technology: a quality-of-life perspective. *Univers Access Inf Soc*, 1-20. <https://doi.org/10.1007/s10209-022-00937-0>
- [30] Sankar, S. M. U., Dhinakaran, D., Kavya, T., Priyanka, S., & Oviya, P. P. (2023, 14-16 March 2023). A Way for Smart Home Technology for Disabled and Elderly People. 2023 International Conference on Innovative Data Communication Technologies and Application (ICIDCA),
- [31] Tan, S., Guo, S., Wu, Y., Zhang, T., Tang, J., & Ji, G. (2025). Achieving Broadband Microwave Shielding, Thermal Management, and Smart Window in Energy-Efficient Buildings. *Advanced Functional Materials*, 35(8), 2415921. <https://doi.org/https://doi.org/10.1002/adfm.202415921>
- [32] Umeora, C. O., Okoye, B. S. A., Odiaka, M. I., Nnamani, M. O., & Chike-Ikemefuna, C. (2025). NEXUS BETWEEN PHYSICAL CONDITIONS OF HOUSING UNITS AND RESIDENTS' SATISFACTION IN PRIVATE HOUSING ESTATES IN ENUGU METROPOLIS, NIGERIA. *Journal of Environmental Management and Safety*, 16(1), 9. <https://cepajournal.com/index.php/jems/article/view/536>
- [33] Vieira, V. A. (2013). Stimuli–organism–response framework: A meta-analytic review in the store environment. *Journal of Business research*, 66(9), 1420-1426.
- [34] Wang, L., & Shao, J. (2023). Digital economy, entrepreneurship and energy efficiency. *Energy*, 269, 126801. <https://doi.org/https://doi.org/10.1016/j.energy.2023.126801>
- [35] Will, S., & Renz, T. (2023). My Home is My Burden? Homeownership, Financial Burden and Subjective Well-Being in a Unitary Rental Market. *Applied Research in Quality of Life*, 18(5), 2227-2257. <https://doi.org/10.1007/s11482-023-10184-x>
- [36] Zhang, B., Zhang, Y., Li, J., Song, Y., & Wang, Z. (2023). Does the energy efficiency of buildings bring price premiums? Evidence from urban micro-level energy data. *Renewable and Sustainable Energy Reviews*, 181, 113315. <https://doi.org/https://doi.org/10.1016/j.rser.2023.113315>