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Drivers of Adoption of Rooftop Innovations in Urban Southwestern Nigeria

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ABSTRACT

This study investigated the factors influencing the adoption of rooftop innovations in urban Southwestern Nigeria with the objective of enhancing adoption rates and improving performance outcomes in the study area. Primary data were collected using a structured questionnaire administered to 384 homeowners across Lagos, Ogun, Ondo, and Oyo States through a combination of purposive and snowball sampling techniques. A total of 305 completed copies of questionnaire were retrieved and found suitable for analysis. The questionnaire captured information on respondents' socio-economic characteristics, types and levels of rooftop innovations adopted, and factors influencing adoption decisions. Results indicated that aluminum long-span roofing constituted the highest share of rooftop innovation adopted, accounting for 24.8% among the respondents. Further analysis using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach revealed that effort expectancy to install the roof ($t = 2.879$; $p < 0.05$), hedonic motivation ($t = 5.545$; $p < 0.05$), and perceived price value of the roof ($t = 3.141$; $p < 0.05$) by the home owners had statistically significant effects on the adoption of rooftop innovations. These findings suggest that policies and market interventions aimed at simplifying installation processes, increasing perceived benefits, and reducing costs could substantially improve the adoption of rooftop innovations in urban Nigeria.

Keywords: Rooftop innovations, Structural equation model, Adoption of innovations, Unified Theory of Acceptance and Use of Technology, Urban Nigeria

INTRODUCTION

In recent years, the introduction of innovative rooftop technologies has become increasingly important in building construction, providing essential protection for residential, commercial, and industrial structures. Beyond their protective function, rooftops play a critical role in determining building performance, durability, and longevity. Dabara *et al.* (2018) estimated that rooftops account for approximately 20–30% of total building construction costs, highlighting their economic significance. At the global level, the roofing industry continues to expand, with projections indicating a market value of about $156 billion by 2030 (Katelyn, 2022).

The evolution of roofing materials, from traditional natural options such as bamboo, thatch, wood, clay, and asbestos shingles (Watson, 2021) to advanced technologies including solar roofs, green roofs, and high-performance polymer membranes such as Ethylene Propylene Diene Monomer (EPDM) rubber and polyurethane foam (Katelyn, 2022; Méndez *et al.*, 2023), reflects broader technological innovations in the construction sector. These innovations have expanded the role of rooftops beyond basic shelter to include improved energy efficiency, user comfort, and environmental sustainability (Adesogan, 2011). However, the successful diffusion of such innovations depends not only on their technical attributes but also on users' perceptions and behavioral intentions, as emphasized in technology adoption theories.

The Unified Theory of Acceptance and Use of Technology (UTAUT) hypothesis that individuals' adoption of new technologies is influenced by key constructs such as performance expectancy, effort expectancy, social influence, and facilitating conditions, with extensions of the model incorporating hedonic motivation and price value. These constructs provide a useful framework for understanding homeowners' decisions to adopt rooftop innovations, as roofing choices involve assessments of perceived usefulness, ease of installation and maintenance, cost implications, and experiential benefits. In the context of building technologies, adoption decisions are further shaped by users' interactions with technology within specific social, cultural, and economic environments (Popescu *et al.*, 2017).

In Africa, and particularly in Nigeria, the relevance of technology adoption theory is heightened by economic constraints, diverse climatic conditions, and infrastructural limitations that directly affect users' evaluations of rooftop innovations (Obada *et al.*, 2024). Many roofing materials available in the Nigerian market fail to meet recommended performance standards, often leading to premature deterioration and frequent roof failures. Moreover, roofing products developed for temperate or non-tropical climates may perform inadequately under Nigeria's environmental conditions, thereby influencing users' perceptions of performance expectancy and satisfaction (Nasir *et al.*, 2019). As a result, homeowners' adoption decisions are closely tied to the perceived effectiveness, affordability, and suitability of rooftop technologies for local conditions.

Despite the relevance of these theoretical constructs, existing studies on housing and construction technologies in Nigeria largely adopt a descriptive or Western perspective, with limited empirical application of established technology adoption frameworks such as UTAUT. Consequently, there remains a gap in understanding how key adoption factors—particularly effort expectancy, hedonic motivation, and price value—shape homeowners' adoption of rooftop innovations within the Nigerian context (Watson, 2021). Addressing this gap is essential for developing evidence-based strategies to promote the diffusion of appropriate rooftop technologies.

Therefore, this study applies the UTAUT framework to assess the factors influencing the adoption of rooftop innovations in Southwestern Nigeria, with the objective of providing a context-specific framework to support their effective and sustainable adoption.

LITERATURE REVIEW

Types of Rooftop Innovations

Innovation being described as the introduction of new ideas, methods, or products perceived novel (Rogers, 2003) has continued to have a significant impact on various materials used in the production of roofs. Materials such as thermosetting plastics, modified bitumen, shingles, stone, tiles to photovoltaic roofs, and non-combustible materials have evolved due to technological advancements aimed at improving energy efficiency, durability, and environmental sustainability. Modern rooftop innovations are commonly classified by colour according to their environmental functions. For instance, green roofs incorporate vegetation for environmental and thermal benefits while cool or white roofs use reflective coatings to reduce heat absorption. Also, black roofs integrate photovoltaic technology for solar energy generation while blue roofs are designed for rainwater collection and management (Chung & Park, 2016; Cascone, 2019). The traditional rooftop materials include slate roofs, valued for durability and fire resistance; tile roofs made from baked clay or concrete; metallic roofs such as zinc and aluminium, which are widely used in tropical regions because of their affordability and ease of installation; concrete roofs known for structural strength; and bitumen roofs appreciated for waterproofing properties (Aasin, 2008; Adesogan, 2011). Other roof types include asbestos roofs, which provide cooling benefits but pose health risks, and shingles roofs made from wood, asphalt, fiberglass, or ceramic materials (Adesogan, 2011).

Adoption of Innovations

The need to know the factors responsible for an individual's acceptance and use of new technologies and innovation has led to the theory on technology adoption and innovation diffusion (Tamilmani *et al.*, 2021). The emergence of this theory has also witnessed the collection of methodologies assessing various new technologies and innovations based on types, users, abode, acceptance time and task performed across sectors (Tamilmani *et al.*, 2021). The adoption and diffusion-related issues are examined by theories such as the Technology Acceptance Model, Diffusion of Innovation (DoI), Theory of Planned Behaviour (TPB), and Task Technology Fit (TTF) theory (Kapoor *et al.*, 2014). Similarly, Venkatesh *et al.* (2012) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT) from the survey of eight adoption models, which was later updated to UTAUT2 (Tamilmani *et al.*, 2021).

The combined theory of adoption and application of the technology model is used in this study to explain the factors influencing the adoption of rooftop innovations. The constructs are performance expectation, effort expectancy, social influence, facilitating condition, hedonic motivation, habit, and Price Value. Grajales *et al.* (2020) adopted a technological acceptance model to study the elements that influence the acceptance of vegetated roofs in horizontal real estate. The study observed that landscaping duties temperature, energy, economic factors, and quality of life are the main factors influencing the adoption of vegetated roof technology. Also, Chen *et al.* (2019) showed that the factors influencing the adoption of roofs made of greenery in Chinese towns were the high cost of installing and maintaining green roofs. The lack of adequate incentives for city developers is another factor hindering the adoption of roof technology (Keeley, 2004; Chen *et al.*, 2019; Burszta-Adamiak and Fiakiewicz, 2019).

In Nigeria, Ezema *et al.* (2015) showed that the high cost of adopting and administering green roof technology is a major reason why city developers do not adoption the technology in Lagos. The study agreed with the findings of Shiah (2011), Chen *et al.* (2019), Keeley (2004), and Burszta-Adamiak and Fiakiewicz (2019). Other factors reported by Ezema *et al.* (2015) are the absence of government support and incentives, as well as ignorance of green roof technology.

METHODOLOGY

This study adopts a quantitative approach in the research design and employs a survey method for the collection of primary data. A set of questionnaire, was used to elicit information from the homeowners. The study was carried out in Nigeria's Southwestern geopolitical zone. Four representative States were purposively selected because they constitute the core business areas in Southwestern Nigeria which further aided the concentration of urban cities in the region. The States selected are Lagos, Ogun, Ondo, and Oyo States. For instance, Lagos State, which is home to an estimated 24 million people, has 20 Local Governments and 37 Local Council Development Areas (Oloko *et al.*, 2022). The sample for this study are the house owners (referred to as homeowners). Purposive sampling technique supported with snowballing technique were used in the selection of respondents for the study. The sample size of the respondents was determined using the Cochran formula. Cochran (1977) developed a formula to calculate a representative sample for proportions as:

$$n_0 = \frac{z^2 pq}{e^2}$$

where:

n_0 = is the sample size
z = is the selected critical value of the desired confidence level
p = is the estimated proportion of an attribute that is present in the population
q = $1-p$
e = is the desired level of precision

The calculation required for sample size for this study is as follows: p = 0.5 and hence q =1-0.5 = 0.5; e = 0.05; z =1.96

$$\text{So, } n_0 = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} = 384.16 = 384$$

A sample size of three hundred and eighty-four (384) homeowners were adopted for the study. Statistical analyses were conducted to identify patterns and relationships between variables. Descriptive statistics, such as frequencies and percentages, and inferential statistics were employed to provide insights into adoption patterns in the roof technology industry.

Conceptual Framework, Study Variables and Measurements

The study's conceptual framework is presented in Figure 1. The framework is adapted from Venkatesh *et al.* (2012). This was used in assessing the adoption of rooftop innovations in Southwestern Nigeria.

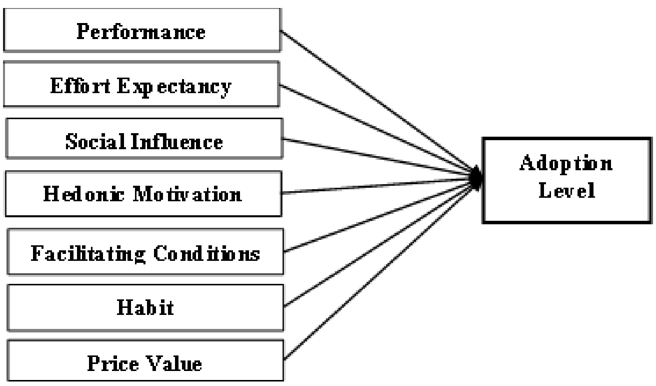

Figure 1: Conceptual framework of Rooftop Innovation Adoption in Southwestern Nigeria

The figure shows that the independent variable will be captured by factors such as performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value and habit, influenced the adoption of rooftop innovations.

Level of Adoption of Rooftop Innovations

The types of roofs adopted by respondents in the study area were identified, and the level of their adoption was captured using a five (5) point Likert scale to determine the extent of adoption of different types of roof technological innovations. The types of roofs to be identified include solar shingle roofs, recycled steel roofs, green roofs, blue roofs, cool roofs, black roofs, stone-coated metal roof tiles, aluminium long span, aluminium step-tiles, clay roofs, concrete roofs, and asbestos roofs. On the Likert scale, 1 = have not used the roof at all; 2 = used the roof for 1-3 buildings; 3 = used the roof for 3-5 buildings; 4 = used the roof for 5-7 buildings; and 5 = used the roof for 8-10 buildings.

Factors Influencing Rooftop Innovations Adoption

Factors that may influence the adoption of rooftop innovations in this study comprise seven (7) variables and a total of twenty-eight (28) items that were measured on a Likert scale. Performance expectancy, which measures the degree to which the users believe in the expected performance of the type of roof technology adopted, was captured using four (4) items where respondents were asked to indicate the level of their expectation on a 5-point Likert scale. Effort expectancy measures the degree of ease efforts expected with the installation and maintenance of the roof technology. This was captured using four (4) items where respondents were asked to indicate the level of their expectation on a 5-point Likert rating scale. Also, social influence which captures the level of importance users give to other people's opinion of them for using the roof technology was measured with three (3) items where respondents were asked to indicate the level of their influence on a 5-point Likert scale.

Furthermore, facilitating conditions which measure the degree to which users believe that the infrastructure of an organisation supports and facilitates the use of the roof technology they adopted, were measured with four (4) items where respondents were asked to indicate the level of their belief on a 5-point Likert scale. Similarly, hedonic motivation, which measures the degree of pleasure and fun users derive from using a particular roof technology, was captured with two (2) items where respondents were asked to indicate the level of motivation on a 5-point Likert scale. Price value measuring the perception of values and exchange of information between users based on the benefits achieved in relation to monetary costs in the use of roof technology adopted was captured with three (3) items where respondents were asked to indicate the level of perception on a 5-point Likert scale, and habit captures the frequency and capability of users to act automatically through technology use learning derived from the roof technology, and measured with four (4) items where respondents were asked to indicate the level of their learning on a similar 5-point Likert scale.

Model Specification

The research adopted a structural equation model (SEM) to describe the interrelationship among the constructs and their items. The structural equation model consists of the measurement and the structural models (Eboli and Mazzulla, 2012).

The structural equation model is represented below: The effect of influencing factors on the level of adoption of rooftop innovations

$$ARI = \alpha_0 + \alpha_1 PE + \alpha_2 EE + \alpha_3 SI + \alpha_4 FC + \alpha_5 HM + \alpha_6 H + \alpha_7 PV + e \qquad (1)$$

Where:

ARI	=	Adoption of Rooftop Innovations
α_0	=	Constant term
SAT	=	Customer Satisfaction
PE	=	Performance Expectancy
EE	=	Effort Expectancy
SI	=	Social Influence
FC	=	Facilitating Condition
HM	=	Hedonic Motivation
H	=	Habit
PV	=	Price Value
$\alpha_1 ... \alpha_7$	=	Parameter coefficient
e	=	error term

RESULTS AND DISCUSSION

Analysis of the Socio-demographical Characteristics of the Respondents

Table 1 presents the socio-demographical characteristics of the homeowners. It revealed that the majority (68.5%) of the homeowners were males, while females accounted for 31.5%. Similarly, to the characteristics of the homeowners and users, the majority (65.6%) were older than 40 years, while above two-thirds (70.2%) were university degree holders. The table shows that 18.4% of the homeowners had a background in engineering, 31.8% had a background in sciences, and 7.5% had a background in Arts. On the other hand, social science, management, humanities, and education accounted for 17.4%, 14.4%, 8.5%, and 2.0%, respectively. With regards to monthly income, the majority (48.9%) earn below N200,000 per month, and less than 10% earn more than N200,000 per month.

Types of Rooftop Innovations Adopted

Table 2 revealed that aluminum long span was adopted by the majority of homeowners which accounted for 24.8%, this was followed by 13.0% who adopted aluminum step tiles. About 11.8% adopted recycled steel roof, 7.6% adopted asbestos/cement, 6.0% adopted galvanised metal roof, 5.7% adopted cool/white roof and 5.4% adopted black roof aluminum step tiles, 5.1% adopted concrete roof, 7.6% adopted asbestos/cement roof, 4.5% adopted solar shingles roof, 3.9% adopted clay while 3.6% adopted green roof and stone coated roof respectively.

Factors Influencing Adoption of Rooftop Innovation in Southwestern Nigeria

Table 3 indicated that ranked first among the factors influencing the adoption of rooftop innovations among homeowners/users was habit (mean = 4.32), closely followed by performance expectancy (mean = 4.30) and facilitating condition (mean = 4.14). Others include price value (mean = 4.08), hedonic motivation (mean = 4.05), and social influence (mean = 4.06) while effort expectancy has the lowest mean score of 3.84 on the scale of 5 points. This suggest that Homeowners place more emphasis on ease of use and convenience. Understanding these perspectives can help developers and manufacturers tailor their products to better meet the needs and expectations of rooftop users, ultimately leading to increased adoption and

Table 1: Socio-demographic Characteristics of the Respondents

Survey	Classification	Homeowners (n=305)
Gender	Male	209(68.5)
	Female	96(31.5)
Age of Respondent	Below 30 years	14(4.6)
	30-39 years	91(29.8)
	40-49 years	53(17.4)
	50-59 years	107(35.1)
	60 years and above	40(13.1)
Highest education attained	Primary education	2(0.7)
	Secondary education	17(5.6)
	OND	26(8.5)
	HND	33(10.8)
	B.Sc./B.Tech.	214(70.2)
	Ph.D	13(4.3)
Educational background	Engineering	56(18.4)
	Science	97(31.8)
	Art	23(7.5)
	Social sciences	53(17.4)
	Management science	44(14.4)
	Humanity	26(8.5)
	Education	6(2.0)
Average monthly income (Naira)	less than 50,000	15(4.9)
	50,000-199,000	149(48.9)
	100,000-199,000	75(24.6)
	200,000-299,000	39(12.8)
	300,000-399,000	8(2.6)
	400,000-499,000	9(3.0)
	500,000 and above	10(3.3)

Figures in parentheses are percentages

Table 2: Types of Rooftop Innovations (Multiple response analysis)

Variables	Homeowners	
	Frequency (n=305)	Percentage
Aluminum long span	82	24.8
Aluminum step tiles	43	13.0
Asbestos/Cement	25	7.6
Black roof	18	5.4
Clay	13	3.9
Concrete roof	17	5.1
Cool/white roof	19	5.7
Galvanized metal roof	20	6
Green roof	12	3.6
Recycled steel roof	39	11.8
Solar shingles roof	15	4.5
Stone coated roof	12	3.6

satisfaction among users. By considering these factors, businesses can gain valuable insights into consumer preferences and make informed decisions to drive success in the market. The major factors influencing the adoption of rooftop innovations among homeowners and users, as revealed by the findings of this study, are habit, performance expectancy, facilitating conditions, price value, hedonic motivation, and social influence. These findings suggest that individuals are more likely to adopt rooftop innovations if they are already in the habit of trying new technologies or if they believe that the innovations will perform well. Additionally, having the necessary resources and support in place, such as easy access to installation services, can also increase adoption rates. The perceived value of the price, the

Table 3: Breakdown of Factors Influencing the Adoption of Rooftop Innovations among Homeowners/users

Factors	Strongly agree F (%)	Agree F (%)	Somewhat Agree F (%)	disagree F (%)	Strongly Disagree F (%)	Mean
Performance Expectancy *(PE)*						**4.32**
• I am convinced that the roof used will add value to the building *(PE1)*	169(55.4)	80(26.2)	46(15.1)	0(0.0)	10(3.3)	4.30
• Using the roof enables me to follow the trend in global housing standard *(PE2)*	156(51.1)	119(39.0)	11(3.6)	17(5.6)	2(0.7)	4.34
• I am sure and confident that innovations in the roof will optimize housing standard *(PE3)*	163(53.4)	95(31.1)	26(8.5)	14(4.6)	7(2.3)	4.29
• Using innovative roofs will improve cooling in a building *(PE4)*	157(51.5)	116(38.0)	25(8.2)	0(0.0)	7(2.3)	4.36
Effort Expectancy *(E)*						**3.84**
• I think technologically innovative roofs are easy to install *(E1)*	44(14.4)	205(67.2)	43(14.1)	10(3.3)	3(1.0)	3.91
• Living/working under a technologically innovative roof is not characterized by stress *(E2)*	87(28.5)	59(19.3)	83(27.2)	74(24.3)	2(0.7)	3.51
• I think working under a technologically innovative roof will be easy for me *(E3)*	240(78.8)	4(1.3)	21(6.9)	32(10.5)	8(2.6)	4.43
• The use of technologically innovative roofs reduces the cost, time and effort associated with conventional roofing system *(E4)*	73(23.9)	125(41.0)	0(0.0)	97(31.8)	10(3.3)	3.50
Social Influence *(S)*						**4.06**
• The installation/use of technologically innovative roofs gives me a higher social status *(S1)*	147(48.2)	66(21.6)	43(14.1)	42(13.8)	7(2.3)	4.00
• People who are important to me recommend me use/install technologically innovative roofs *(S2)*	115(37.7)	66(21.6)	33(10.8)	68(22.3)	23(7.5)	3.60
• My friends and family value the use/installation of technologically innovative roofs *(S3)*	155(50.8)	120(39.3)	11(3.6)	17(5.6)	2(0.7)	4.34
• In general, people that are close to me support the use of technologically innovative roofs *(S4)*	162(53.1)	95(31.1)	26(8.5)	14(4.6)	8(2.6)	4.28
Facilitating Condition (F)						**4.14**
• The resources necessary to install/use technologically innovative roofs are readily available *(F1)*	73(23.9)	124(40.7)	0(0.0)	98(32.1)	10(3.3)	3.50
• Information on the installation and benefits of technologically innovative roofs are readily accessible *(F2)*	155(50.8)	119(39.0)	12(3.9)	17(5.6)	2(0.7)	4.34
• If I have any doubts concerning the installation/use of technologically innovative roofs, I do have a support line to help me *(H3)*	162(53.1)	95(31.1)	26(8.5)	14(4.6)	8(2.6)	4.28
• There is the possibility of future expansion in the installation/use of technologically innovative roofs *(H4)*	240(78.7)	4(1.3)	20(6.6)	33(10.8)	8(2.5)	4.43
Hedonic Motivation (H)						**4.05**
• Using technologically innovative roofs is interesting *(H1)*	240(78.7)	24()7.9	32(10.5)	0(0.0)	9(3.3)	4.49
• Using technologically innovative roofs is enjoyable *(H2)*	55(18.0)	122(40.0)	97(31.8)	0(0.0)	31(10.2)	3.24
• Using technologically innovative roofs is advantageous *(H3)*	240(78.7)	4(1.3)	20(6.6)	33(10.8)	8(2.6)	4.43
Habit (Ht)						**4.32**
• People readily install/use technologically innovative roofs *(Ht1)*	162(53.1)	95(31.1)	27(8.9)	14(4.6)	7(2.3)	4.28
• The installation/use of technologically innovative roofs has become a norm in the society *(Ht2)*	156(51.1)	117(38.4)	25(8.2)	0(0.0)	7(2.3)	4.36
Price Value (P)						**4.08**
• The cost of installing technologically innovative roofs is relatively affordable *(P1)*	73(23.9)	123(40.3)	99(32.5)	0(0.0)	10(3.3)	3.49
• The benefits tied to the use of technologically innovative roofs far outweigh the cost *(P2)*	154(50.5)	119(39.0)	13(4.3)	17(5.6)	2(0.7)	4.33
• The installation/use of a technologically innovative roof is cost-effective *(P3)*	161(51.8)	95(31.1)	26(8.5)	15(4.9)	8(2.6)	4.27
• There is little or no maintenance cost associated with the use of technologically innovative roofs *(P4)*	158(51.8)	96(31.5)	26(8.5)	16(5.2)	9(3.0)	4.24
• **Grand mean**						**4.10**

Key: 5 = Strongly agree; 4 = Agree; 3 = somewhat agree; 2 = disagree and 1 = strongly Disagree enjoyment gained from using the innovations, and the influence of others in their social network also play a significant role in determining whether homeowners will choose to adopt rooftop innovations. This finding is supported by Alchapar and Correa (2016), Kotsiris *et al.* (2012), and Adegoke *et al.* (2021). Alchapar and Correa (2016) observed that the material's initial cost, maintenance costs, potential longer-term cost reduction related to a specific white roof application, and the long-term reliability of the particular material chosen are the major factors influencing the adoption of rooftop innovations. Durability was highlighted by Kotsiris *et al.* (2012) as one of the major factors influencing the adoption of roofing innovations. Adegoke *et al.* (2021) also emphasized the importance of considering the environmental impact of rooftop innovations as well as the potential energy savings that could result from their adoption. These studies collectively suggest that factors such as cost, durability, energy efficiency, and environmental impact play significant roles in the decision-making process for adopting rooftop innovations. It is clear that a comprehensive understanding of these factors is essential for encouraging the widespread adoption of sustainable roofing practices in the future.

Measurement Model of Rooftop Innovation Adoption in Southwestern Nigeria

The measurement model was used in determining the structure of the dataset based on inter-variable grouping, and presented in Table 4.

Table 4: Factor Loading and Model Assessment Test of Rooftop Innovation Adoption

Observed Variables	Unobserved Variables						
	Adoption	Effort Expectancy	Habit	Hedonistic Motivation	Performance Expectancy	Price Value	Social Influence
AL1	0.981						
AL10	0.939						
AL12	0.952						
AL13	0.978						
AL2	0.894						
AL3	0.981						
AL4	0.729						
AL5	0.957						
AL6	0.938						
AL8	0.950						
AL9	0.970						
E1		0.838					
E2		0.710					
E3		0.882					
H1				0.980			
H3				0.984			
Ht1			0.957				
Ht2			0.999				
P1						0.986	
P2						0.844	
P3						0.849	
P4						0.828	
PE1					0.919		
PE2					0.986		
PE3					0.963		
PE4					0.989		
S1							0.907
S2							0.987
S3							0.926
S4							0.921
Cronbach's alpha	***0.985***	***0.755***	***0.970***	***0.964***	***0.982***	***0.957***	***0.966***
Composite reliability (rho_c)	***0.987***	***0.853***	***0.978***	***0.982***	***0.982***	***0.931***	***0.966***
Average variance extracted (AVE)	***0.876***	***0.661***	***0.957***	***0.965***	***0.931***	***0.773***	***0.876***

The results showed that seven (7) out of the eight (8) unobserved variables, with a total of thirty (30) observed variables with factor loadings of above 0.7, the minimum threshold, were extracted from the dataset. The extracted constructs include effort expectancy, habit, hedonistic motivation, performance expectancy, price value, social influence, and adoption, while items of facilitating condition were not extracted in the model. In addition to the high factor loadings, the construct reliability and validity tests were assessed using Cronbach's alpha, composite reliability, and average variance extracted. The result of Cronbach's alpha showed that all the unobserved variables have values above the minimum threshold (>0.7), which revealed internal consistency among each of the constructs and their observed variables. The table also presents the composite reliability (rho_c) result and gives a robust outcome of the internal consistency of latent variables. The results showed composite reliability has values well above the minimum threshold of 0.7 (Hair *et al.*, 2010).

The Table also displays the values for Cronbach's alpha, composite reliability (rho_c), average variance extracted (AVE), validity and reliability metrics for the different constructs. Effort Expectancy demonstrates satisfactory composite reliability (0.853), AVE (0.661), and Cronbach's alpha (0.755). Features demonstrate good validity measures (AVE of 0.801) and strong reliability (Cronbach's alpha of 0.949). Habit is a very valid and reliable habit with an AVE of 0.957, a composite reliability of 0.978, and a Cronbach's alpha of 0.970. With a composite reliability of 0.982, an AVE of 0.965, and a Cronbach's alpha of 0.964, 'Hedonistic Motivation' likewise receives remarkably excellent marks. Performance Expectancy exhibits high levels of validity and reliability, with an AVE of 0.931 and Cronbach's alpha and composite reliability at 0.982. With an AVE of 0.773, a composite dependability of 0.931, and a Cronbach's alpha of 0.957, the Price Value is also legitimate and dependable. These constructs are strong measures for use in research applications since they show a high degree of internal consistency and validity overall.

Multivariate Analysis of Rooftop Innovation Adoption in Southwestern Nigeria

Table 5 presents the results of multivariate analysis using partial least-structural equation model (PL-SEM) of the hypothesized model for the adoption of rooftop innovations in Southwestern Nigeria. This result presented describes the relationship between the independent variables and the dependent variables. The result showed that effort expectancy (t=2.879; $p < 0.05$), hedonic motivation (t=5.545; $p < 0.05$), and price value (t=3.141; $p < 0.05$) are the three factors significantly contributing to the adoption of rooftop innovations by users in Southwestern Nigeria.

Table 5: Regression Result of Dependent and Independent Variables

Variables	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)
Effort Expectancy -> Adoption	0.217	0.214	0.075	2.879***
Habit -> Adoption	-0.171	-0.236	0.319	0.537
Hedonic Motivation -> Adoption	0.696	0.664	0.125	5.545***
Performance Expectancy -> Adoption	-0.047	0.087	0.412	0.113
Price Value -> Adoption	-0.638	-0.624	0.203	3.141***
Social Influence -> Adoption	0.058	-0.014	0.196	0.297

This suggests that user's perception of the ease and cost of installation and maintenance of rooftop products, as well as their formability and advantage over other rooftops, influence their decision when adopting rooftop innovations. While habit (t=0.537; $p > 0.05$), performance expectancy (t=0.113; $p > 0.05$), social influence (t=0.297; $p > 0.05$) of users did not show any statistical evidence of influence on the adoption of rooftop innovations in Southwestern Nigeria. The findings of the study underscore the importance of designing user-friendly, aesthetically appealing, and cost-effective rooftop products to drive adoption. Efforts to improve awareness around product performance and long-term benefits, as well as leveraging emotional appeal, could further strengthen market uptake in Southwestern Nigeria.

CONCLUSION

In conclusion, the findings of this study provide valuable insights into the adoption of rooftop innovations and their performance in Southwestern Nigeria. The results indicate a high level of adoption of rooftop innovation by homeowners in the region. The study also identifies several factors that influence the adoption of rooftop technologies, highlighting the importance of understanding these factors for promoting further adoption and enhancing performance.
The high level of adoption of rooftop innovations observed in Southwestern Nigeria indicates a positive reception of these technologies among homeowners. This suggests a growing recognition of the benefits and potential of rooftop innovations in the region, such as improved energy efficiency, reduced electricity costs, and environmental sustainability. The widespread adoption of these technologies further reflects a positive trend toward embracing renewable energy solutions and leveraging the potential of rooftops for energy generation.

This finding underscores the positive impact that rooftop technologies can have on the quality of life and the overall satisfaction of individuals. By providing reliable and sustainable energy solutions, rooftop innovations contribute to enhanced comfort, cost savings, and reduced environmental impact. The identification of factors influencing the adoption of rooftop technologies is a crucial contribution of this study. Understanding these factors allows policymakers, industry stakeholders, and researchers to develop targeted strategies to promote further adoption and optimise the performance of rooftop innovations. Factors such as economic incentives, awareness campaigns, policy support, and technological advancements emerge as significant influences on adoption. Addressing these factors through effective policies, education, and incentives can facilitate broader adoption and maximize the positive impact of rooftop innovations in Southwestern Nigeria. Also, by leveraging these findings and addressing the influencing factors, policymakers and industry stakeholders can foster an environment conducive to sustainable energy practices, promote wider adoption of rooftop technologies, and contribute to a greener and more energy-efficient future in the region.

RECOMMENDATIONS

Rooftop manufacturing firms need to develop training programs and workshops in the form of community outreach in areas of design, installation, and maintenance of rooftop technologies for homeowners who intend to adopt rooftop innovations as part of their marketing strategy. This will enhance the knowledge of prospective adopters of rooftop innovations, as the study suggests that effort expectancy influences the adoption of rooftop innovation. Rooftop manufacturing firms also need to launch targeted awareness campaigns to educate homeowners about the benefits such as energy savings, environmental sustainability, and long-term cost-effectiveness, as well as other potentials they can enjoy by using innovative rooftop products. The study showed the influence of price value on the adoption of rooftop innovation. Hence there is a need for government at all levels to develop and implement policies and incentives, such as tax credits, subsidies, and grants to rooftop manufacturing firms, in order to encourage and incentivize the production of innovative rooftop products. These policies should be designed to make rooftop innovations financially attractive and accessible to a wider range of users.

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