DIFFUSION OF INNOVATION THEORY AND ADOPTION OF LIQUEFIED PETROLEUM GAS FOR COOKING

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Abstract
This paper applied Rogers' Diffusion of Innovation (DOI) Theory to adoption of liquefied petroleum gas (LPG). The target population includes the residents of four estates in Agege, Lagos State. A survey of households (N = 384) in the four estates in the Agege area of Lagos State, Nigeria was undertaken with a structured questionnaire. A multiple regression analysis was conducted to test the research hypotheses. The findings revealed that relative advantage (β = .288, T = 5.856, p<0.05); compatibility (β = .306, T = 7.763, p<0.05); complexity (β = . 268, T = 5.736, p<0.05)); trialability (β = . 384, T = 8.798, p<0.05); and observability (β = . 454, T = 8.429, p<0.05) significantly and positively affected LPG adoption by households in the surveyed estates. It was concluded that the DOI theory is appropriate to explain the phenomenon of a clean cooking fuel adoption in the context of a developing country like Nigeria. The paper made a number of recommendations for marketers, government agencies, and potential household adopters, highlighted the limitations of the research, and provided future research directions.

Key words: *Diffusion of Innovation Theory, Relative advantage, Compatibility, Complexity, Trialability, Observability, and Liquefied Petroleum Gas*

Introduction

New product adoption and diffusion is a crucial subject in marketing because it assists marketers to understand how consumers get to know about a new product, try it on a limited basis before they subsequently adopt it over time (Aminu, 2022). Adoption is defined as buying and using a product for the first time and regularly thereafter if it satisfies the need of the consumer (Aminu, 2018). Diffusion is defined as the "process by which an innovation is communicated through certain channels, over time among the members of a social system" (Rogers, 1983). Marketers' interests in research on adoption of a range of new products and services have grown exponentially over the years. This is because, among other things, marketers need to understand determinants of new product adoption and the implications for strategy implementation and success in the market. Consequently, marketers have used a number of theories, especially from psychology, economics, anthropology, and sociology, to understand the factors that

influence consumer adoption of new products and services. One of these theories is the Diffusion of Innovation (DOI) Theory (Rogers, 1983).

According to Karakaya et al. (2014), marketing, sociology, economics, and anthropology have contributed largely to the development of the DOI theory. The theory is perceived as belonging to the earliest theories in social science used in explaining the spread of innovation in a society (Inwood et al., 2009). The theory has been used to explain the adoption of "eco-innovation," "green technology," or "sustainable innovations" (Halila, 2007; Karakaya et al., 2014). Awareness of eco-friendly innovations that supports economic boom is growing (Halila, 2007). The diffusion of innovation theory is most suitable to describe the phenomenon of "green technology" or "sustainable innovations." While DOI theory has been applied to explain the phenomenon of adoption of different products, its application to Liquefied Petroleum Gas (LPG), a green technology, adoption in Nigeria's domestic context, to the knowledge of the researchers, is not existing. Therefore, this present paper attempts to fill the gap in the literature and provides fresh insights into the predictors of LPG adoption anchored on the DOI theory.

The DOI theory explains how new ideas, products, or technologies are gradually accepted by members of a community through predetermined channels and over the years (Hirzallaha & Alshurideha, 2023; Rogers, 1983, 1995, 2003). Diffusion makes it possible for adopters to enjoy the benefits of a new technology (Allan et al., 2014). In consumer behaviour, new product adoption and diffusion is important to marketing performance (Rogers, 1976). The rate of new product adoption is determined by product attributes, such as relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003), and each of these attributes influences an innovation adoption differently (Chen et al., 2000). Beside product characteristics, Davis (1989) identified individual factors, including perceived usefulness and ease of use of a new technology, as drivers of a new technology acceptance. Literature has equated Rogers' relative advantage of an innovation to Davis' perceived usefulness of a new technology. Similarly, Rogers' complexity of an innovation is used synonymously in the adoption literature with Davis' perceived ease of use of a new technology (Karahanna et al., 2006; Kuperstein-Blasco & Makinen, 2023; Moore & Benbasat, 1991).

Roger (2003) defined all the five attributes of a new innovation. *Relative advantage* is the degree to which a new product is considered to be more superior in performance to current products and this may be reflected in terms of lower price, physical improvements, or ease of use. The greater the relative benefits of an innovation, the higher the propensity to adopt it. *Compatibility* is the connection between a new product and consumer's subsisting needs, experience, value, and knowledge. A new product that is consistent with the values and experiences of potential adopters may rapidly

attract new buyers and vice-versa. *Complexity* is the degree to which a new product is relatively difficult to understand and use. A complex product may attract a fewer potential adopters and vice-versa. *Trialbility* is the degree to which potential adopters can try a new product on a limited initial basis with a small financial commitment. A product that can be easily tried may have rapid adoption and vice-versa. Finally, *observability* is the degree to which other potential adopters can observe the benefits that initial adopters of a new product are deriving from using the product. The higher the rate of observability, the quicker will be the adoption rate and vice-versa. In summary, a new product, with greater relative advantage, compatibility, trialability, and observability, but with less difficulty, will be more rapidly adopted than its peers (Rogers, 1995).

The adoption of LPG as a new clean cooking fuel can be influenced by a combination of the constructs of DOI theory. The relative advantages of LPG in terms of cleanliness, ease of use, cooking efficiency, safety, cleanliness, and health benefits often motivate households in developing countries to switch to LPG (Suarez-Burguet et al., 2018). This is because most households globally use biomass for cooking (Norad, 2020) and are vulnerable to harmful household air pollution (HAP), which results in more diseases and a high rate of premature deaths (World Health Organization, WHO, 2020, 2024). In Nigeria, HAP from cooking with solid fuels caused the premature death of over 128,000 people in 2019 (Murray et al., 2020; Nwangwu, 2023; Nwangwu, Ozigbo, Ngige & Ugwu, 2020). In terms of compatibility, LPG can be easily integrated into existing appliances and infrastructure, making it a convenient and accessible alternative to traditional fuels such as wood, charcoal, or kerosene (Madina et al., 2017). LPG is also compatible with environmental and health concerns of households (Smith & Haigler, 2008). The rate of LPG adoption is greatly affected when LPG is compatible with the current ways households are cooking and their capacity to afford LPG (Doku-Marfo, 2022).

The high upfront investment of purchasing a cylinder is one of a major barriers to LPG adoption in developing countries (Jain et al., 2015; Norad, 2020; Ozoh et al., 2018). Therefore, providing households opportunities to try LPG on a limited basis without initial high financial investment and commitment can motivate more households to adopt LPG. For example, Perros et al. (2021) carried out an experiment in Rwanda involving LPG users in the low income communities, who were able to get fuel in small containers and pay little amounts. This experiment helped the users appreciate the economic and health benefits of LPG, resulting in LPG uptake over the years.

The Observability of a new product is well-defined as the extent to which the outcomes of innovations can be visible (seen) to others (Hirzallaha & Alshurideha, 2023). Observability is key in the adoption of LPG. The visible benefits of cooking with LPG, such as cleaner kitchens and reduced smoke-related health issues, motivates non-

adopters to adopt LPG (Williams, 2019).

Objectives

The current paper aims to examine:

i. The effect of relative advantage on the adoption of liquefied petroleum gas by households within the Agege community;

ii. the effect of compatibility on the adoption of liquefied petroleum gas by households within the Agege community;

iii. the effect of complexity on the adoption of liquefied petroleum gas by households within the Agege community;

iv. the effect of trialbility on the adoption of liquefied petroleum gas by households within the Agege community;

v. the effect observability on the adoption of liquefied petroleum gas by households within the Agege community.

The rest of the paper is structured as follows: section two presents a review of extant literature; section three describes the methods for collecting and analyzing data; section four analyzes data, presents and discusses findings; and the final sections concludes the paper.

Literature Review

LPG Adoption in Nigeria

LPG is a combination of propane, butane, and other substances of a small amount (Transportation Research Board, 2024). It is a combination of gases, such as hydrogen and carbon utilized as fuel for the purpose of home warming appliances or gas used for cooking, including industries (WLPGA, 2023). It is a product of crude oil and natural gas production and petroleum refining (Putri et al., 2021; Transportation Research Board, 2024; WLPGA, 2019). It is non-toxic, colorless, and odorless (Bruce et al., 2017). Globally, LPG is applied in the domestic, industrial, agricultural, transport, and other sectors (AssociationEuropéenne des Gaz dePétrole Liquéfés, AEGPL, 2019). In Nigeria, 85% to 95% of LPG applications are in the domestic sector (Badmus & Bakri, 2021). It is more popular as a clean fuel alternative (Gould & Urpelainen, 2018; Norad, 2020), especially in terms of its affordability and reliability (WGLA, 2024). However, clean cooking fuels access in the world, including Nigeria, is limited. International Energy Agency (IEA et al., 2023) estimated that around 2.3 billion people globally would lack access to clean cooking fuels. Most of these people would be in sub-Saharan

Africa and Asia in 2021.

The lack of access to clean cooking fuels has led several households, especially in developing countries to continue to depend on traditional solid biomass fuels for cooking (Norad, 2020; Chukwujama, Nwangwu & Ihim, 2023; Ifechukwu-Jacobs, Arinze, Nwangwu & Atueyi, 2025). Sadly, traditional fuels emit dangerous pollution, HAP (Desai et al., 2004; Smith, 2006), which increases morbidity rate and causes a high premature mortality rate (WHO, 2020, 2024). Women and children are the worst hit by the adverse effects of cooking with traditional fuels (WHO, 2016; World Liquid Gas Association, WLGA, 2024). The analysis of IEA data on access to clean cooking fuels in Nigeria by Dataphyte (2024) showed that only 35.5 million people of the estimated 211 million population in Nigeria in 2021 had access to clean cooking fuels and technologies. This represents 16.8% of the population and suggests that about 175.9 people used dirty cooking fuels. Oyeniran and Isola (2023) lamented that clean cooking fuels adoption in Nigeria is taking eternity. Unfortunately, HAP from cooking with solid fuels caused the premature death of over 128,000 people in Nigeria in 2019 (Murray et al., 2020). Due to government interventions (KPMG, 2020), LPG consumption in Nigeria has grown phenomenally from a paltry 20,000 tons in 2004 (Kelly, 2015; Nwangwu, 2024; Nwangwu, 2022) to 1.4 million tons in 2023 (Hyde, 2023). However, Nigeria's LPG per capita consumption remains very low at 5kg in 2021 (Omuojine, 2021). For example, Morocco had the highest LPG per capita consumption of 72kg/year in Africa in 2018; Egypt trailed Morocco behind with 43kg; this is followed by Ivory Coast and Ghana with 13kg each; Senegal and Angola had 9kg apiece; and South Africa, Cameron, Kenya, and Nigeria had 7kg, 4.5kg, 4.4kg, and 4kg respectively (Clean Cooking Alliance, 2022).

Diffusion of Innovation and LPG Adoption

Relative Advantage of LPG

Relative advantage of an innovation is the degree to which a an innovation is considered to be more superior in performance to current products and this may be reflected in terms of lower price, physical improvements, or ease of use (Rogers, 1983, 1995). It is an innovation perceived to be better than the idea it supersedes (El Malouf & Bahemia, 2023). It is the perceived benefits of adopting green innovation compared to traditional practices. This includes improvements in efficiency, cost savings, enhanced reputation, and reduced environmental impact (Chen & Panichakarn, 2024). The existence of improved features, including reduced operational costs of EVs significantly impact buying behavior and can trigger consumer intention to purchase EVs. Therefore, the greater the relative advantage of an innovation, the greater will be its adoption (Kim et al., 2018). There is a number of relative advantages of LPG over traditional fuels that encourage households to adopt LPG. They include cleaner burning, cooking efficiency,

convenience, and time saving (Adamu et al., 2022; Akter & Pratap, 2022; Raktim, 2023), environmental friendliness or sustainability (Gebreslassie et al., 2023), and health benefits (Gould, 2020; Suarez-Burguet et al., 2018; Rehfuess et al., 2014; Sulley et al., 2023). Rehfuess et al. explained that the HAP reduction benefit of LPG, which reduces the risk of contracting diseases motivates urban and rural households to switch to LPG.

Allan et al. (2014) undertook a survey on diffusion of green technology and found that the speed of technology spreading was influenced by how large the new technology's benefits and costs are when compared to competing technologies. They concluded that a new technology with relative benefits was rapidly adopted and diffused. Arora et al. (2022) used the diffusion of innovation theory and attitudinal factors to predict intention to purchase electric vehicles (Evs) in India. They found that relative advantage and attitude positively impacted the purchase intention toward EVs. Ahmad et al. (2022) investigated the households' perception-based factors influencing biogas adoption in Pakistan using an innovation diffusion framework. The findings revealed that relative advantage significantly drove LPG adoption. The study suggested that biogas quality enhancement and efficiency, local market development, the incentivization of households, and so forth reduced the risk exposure of investors. Based on the foregoing, we hypothesize that:

H_1: Relative advantage significantly affects LPG adoption.

Compatibility of LPG

Compatibility is described as how well an innovation is consistent with the potential adopters' current way of doing things (Call & Herbert, 2022). It is the connection between a new product and consumer's subsisting needs, experience, value, and knowledge (Aminu, 2022). It is degree to which an innovation can be easily understood and used (Deng et al., 2023). It is the degree to which an innovation aligns with the values, prior experiences, and requirements of potential adopters (Martin et al., 2024). Innovations that are connected to existing customs of the people are quickly accepted (Martinez-Roman et al., 2020). LPG adoption can be enhanced if its attributes as cleaner burning and safe fuel are consistent with households' expectations (Sharma, 2020); if it conforms to the current ways households do cooking and is considered affordable (Doku-Marfo, 2022; Williams et al., 2020); if households are aware of the health dangers of using traditional dirty fuels and the sustainability advantages of cooking with cleaner fuel (Badmus & Bakri, 2021); and if it aligns with the convenience expectations of women who have a primary task of cooking in households (Gould, 2020).

Putzer and Park (2010) investigated the intention of physicians to adopt mobile technologies based on attitudes and innovation factors affecting Smartphone use in the

Southeastern United States. The findings suggested that compatibility has the strongest relationship to attitude toward using a Smartphone. The results further showed that physicians' attitude toward the use of Smartphones improved because they were compatible with other devices and technologies in the hospital. The empirical study of Nagele (2015) on the diffusion and adoption of technological innovation in energy sector in the South of Germany found that "compatibility with everyday practices is the most influential driver of experiential technology adoption" (p. 25). The findings indicated that the adoption of experiential consumer technologies is greatly influenced by how freely they can match adopters' lifestyles. The study concluded that early adopters of experiential technologies are more interested in the compatibility of the technologies with their current situation, daily routines, etc than the usefulness of such technologies. Deng et al. (2023) examined the influence of compatibility and other diffusion of innovations characteristics on the adoption of in-vehicle games. They found that compatibility and play value significantly influenced continuous intention to adopt in-vehicle games. In light of the aforementioned, we state that:

H_2: Compatibility significantly affects LPG adoption.

Complexity of LPG

Complexity is the degree to which an innovation is hard to comprehend or use. An innovation that is simple to use will be seen as having an advantage (Almaiah et al., 2022). It is the degree to which an innovation can be easily understood and used (Deng et al., 2023). Complexity is equivalent to the constructs of perceived ease of use and effort expectancy in terms of complexity of an innovation (Kuperstein-Blasco & Makinen, 2023). Adoption of an innovation that is considered to be more complex will be more likely slow. High complexity can considerably slow down diffusion of innovations that are rated higher in relative advantage and compatibility (Call & Herbert, 2022).

Gould and Urpelainen (2020) emphasized that the complexity of LPG can be reduced through effective communication and education. They suggested that households are more likely to adopt LPG if they understand its benefits and usage. Ozoh et al. (2018) noted that the complexity of LPG adoption can be addressed through the development of user-friendly LPG appliances and cost-effective approach to improve LPG adoption. The authors suggested that misinformation and beliefs regarding benefits, safety, and cost of LPG are important barriers to LPG use.

Aminu (2018) employed the technology acceptance model (TAM) to predict motorists' intention to use PoS devices for petrol payment at the pumps in Lagos, Nigeria. The author found that perceived use of PoS devices indirectly predicted behavioral intention of motorists to pay petrol price with the devices. Choe and Noh (2018) examined the factors influencing the intention to use Smartwatches using the integrated model of

TAM and DOI in Korea. Their findings showed that perceive ease of use (complexity) has a significant effect on adoption of Smartwatch. The findings also revealed that perceived ease of use (complexity) affected the intention only through the mediated effect of perceived usefulness. In their research on the application of DOI model to EVs adoption in the India market, Arora et al. (2022) found that complexity of EVs has a negative effect on the intention to purchase EVs. Thus, we propose that:

H_3: Complexity significantly affects LPG adoption.

Trialbility of LPG

Trialbility is the degree to which potential adopters can try a new product on a limited initial basis without a high financial commitment. A product that can be easily tried may have rapid adoption and vice-versa (Aminu, 2022). It is the extent to which a new technology can be tested on a small scale (Liu et al., 2023). It is the degree to which a new product is available for free trial before use (Jilani et al., 2022). Trialability reduces potential adopters' risk (Ali & Puah, 2017) and assures them of new technology or innovation (Kogilavani & Jaya, 2021), thus significantly predicting a new product adoption (Ali & Puah, 2017).

Some experiments were undertaken in a few African countries to demonstrate the effects of trialability on the adoption of LPG (Carrion et al., 2021; Gill et al., 2022; Perros et al., 2021). An LPG trial program that gave households access to free or subsidized LPG in Tanzania enhanced the experience of many households and made them adopt LPG after the trial period (Gill et al., 2022). Another trial scheme in Rwanda provided LPG users, through a pay-as-you-go LPG system, to instalmentally pay for LPG. The users learned about the economic advantage and health sustainability of LPG, resulting in permanent use of the fuel (Perros et al., 2021). Another experiment by Williams (2019) indicated that many women, especially early LPG stove adopters, who participated in a cooking demonstration with LPG acknowledged that they got information about LPG benefits and found cooking with the fuel convenient. From the foregoing, we state that:

H_4: Trialbility significantly affects LPG adoption.

Observability of LPG

Observability is the likelihood that people who see the benefits of an innovation are more likely to use it (Rogers, 2003). It is the visibility of the benefits of innovations to those who are yet to adopt the innovations (Hirzallaha & Alshurideha, 2023). It is how the benefits of an innovation are seen by others. An innovation with more visible results will be more likely adopted (Kuperstein-Blasco & Makinen, 2023). Williams (2019) emphasized that observability plays a critical role in the adoption of LPG. He posited

that when community members can see the benefits of LPG, such as cleaner kitchens and reduced smoke-related health issues, it encourages others to adopt this innovation. The visibility of these positive outcomes creates a ripple effect, leading to a wider adoption within the community.

Al-Jabri and Sohail (2012) undertook a study on the application of the DOI theory to the adoption of mobile banking in Saudi Arabia. They found that observability have a significant effect on technology adoption in the country. Arora et al.'s (2022) findings on the DOI framework indicated that observability, via attitude, indirectly affected consumer intention to purchase EVs in India. Menzli et al. (2022) used Rogers' DOI theory to investigate open educational resources adoption in higher education institutions in Saudi Arabia. The findings indicated that observability has a positive and significant impact on adoption of educational resources in Saudi Arabia. Thus, we hypothesize that:

H_5: Observability significantly affects LPG adoption.

From the foregoing review of literature on application of Rogers' DOI theory, there is no single empirical study that has applied the innovation theory to LPG adoption in Nigeria's context. This is a gap filled by the present research.

Methodology

The study was carried out at Agege, one of the popular and populous metropolises in Lagos State. Lagos State is the financial, commercial, and economic center of Nigeria. (Resillient City Network, 2023). Agege is 6.12km away from Ikeja, the capital of Lagos State (Taxigator, 2025). Agege was selected because it is one of the urban areas in Lagos State. The residents of Agege have diverse demographic characteristics, comprising high-income, middle-income, and low-income classes. The urban nature of Agege is favorable for a widespread adoption of LPG among the residents, a condition that is apposite for our study.

The research is a cross-sectional study with data collected from the residents of four estates in Agege - New Dairy Farm Housing estate, Ibrahim estate, Greenhill estate, and Sunshine estate - between 1st of April, 2024 and 8th of June, 2024. A cross-sectional design helps researchers to collect data from a population at one point in time to measure respondents' attitude at that single time (Carlson & Morrison, 2009).

The population for this study is the households using LPG in Agege. They are males and females of different age categories and occupation. However, due to the large population of Agege, the study population is unknown and is an infinite population.

The sample size for the study is 384 determined by Cochran formula for a large or unknown population. According to Ahmed (2024), Cochran's formula is employed in a cross-sectional study when a population is substantial. Only 354 copies of the valid questionnaire were retrieved and processed, representing 92.2% of the total number of questionnaire distributed. The sample size is consistent with Hair et al.'s (2015) guidelines. The respondents were selected on the basis of their availability and readiness to participate in the survey. This is because of a lack of a sampling frame from which a sample can be drawn.

Questionnaire was the main instrument of data collection. Similar studies have been undertaken with a questionnaire (Ahmad et al., 2022; Al-Jabri & Sohail, 2012; Aminu, 2018; Moore & Benbasat, 1991). The questionnaire has two sections. Section A sought to obtain respondents' demographic information. Section B was designed to collect respondents' opinions about the five Rogers' constructs. They are relative advantage, compatibility, complexity, trialability, and observability. These are independent variables of the study while LPG adoption is the dependent variable. Moore and Benbasat's (1991) questionnaire was adapted to measure Rogers' DOI constructs. Dalaba et. al.'s (2018) was adapted to measure LPG adoption.

A five-point Likert scale, including Strongly Agree, Agree, Undecided, Disagree, and Strongly Disagree, was used in the questionnaire. Likert scale allows researchers to "capture feelings, actions and pragmatic opinions of the participants about mutually exclusive issues around phenomena under study" (Joshi et al., 2015, P. 398).

We used a 24-item questionnaire to measure the study constructs - the DOI theory and LPG adoption. The items are:

Relative advantage

RA1 - Using LPG enables me to accomplish cooking tasks more quickly.

RA2 - Using LPG improves the quality of the food I cook.

RA3 - Using LPG increases my cooking productivity.

RA4 - Using LPG gives me greater control over my cooking activities.

Compatibility

CPT1 - Using LPG is compatible with all aspects of my cooking.

CPT2 - Using LPG is completely compatible with my current situation.

CPT3 - I think that using LPG fits well with the way I like to cook.

CPT4 - Using LPG fits into my cooking style.

Complexity

CPX1 - I believe that LPG is easy to use.

CPX2 - Learning to operate LPG is easy for me.

CPX3 – It is easy for me to use LPG to do what I want it to do.

CPX4 - Using LPG can be frustrating at times.

Trialability

TR1 - I was able to properly test the use of LPG before deciding whether to use it.

TR2 - I was permitted to use LPG on a trial basis long enough to see what it could do.

TR3 - I've had the opportunity to try out various sizes of LPG.

TR4 - I did not have to expend very much effort to try out the use of LPG.

Observability

OBS1 - I have seen LPG in various households.

OBS2 - I have seen how various households make use of LPG in their homes.

OBS3 - It is easy for me to observe households using LPG in my estate.

OBS4 - I have seen other households and businesses use LPG in my community.

Adoption of LPG

ADP1 - We use LPG to cook in my household.

ADP2 – My household prefers to use LPG rather than biomass fuel.

ADP3 – I recommend the use of LPG to other households.

ADP4 – I like LPG because it is eco-friendly.

The questionnaire was personally administered to the respondents of New Dairy Farm Housing Estate, Ibrahim Estate, Greenhill Estate, and Sunshine Estate in Agege, Lagos State from the 1st of April, 2024 to the 8th of June, 2024.

Colleagues validated our instrument, enabling us to make necessary modifications to it before administring it to the respondents. This helped us make the wordings of the questionnaire simpler and the number of items in the questionnaire shorter to secure respondents' cooperation and enhance the response rate. Kost et al. (2018) found that a shorter questionnaire was reliable, resulting in high response and completion rates.

The reliability of the research instrument was using pilot data. Forty copies of questionnaire were administered to 40 households of LPG users in Maple Wood Estate in Agege, two months before the main data was collected. O'Sullivan et al. (2017) explained that the pretesting of a survey instrument allows researchers to determine the adequacy and feasibility of data collection plans, train fieldworkers, and adjust the instrument, if necessary. The data was analyzed to determine the internal consistency of the instrument using the Cronbach's Alpha reliability coefficient. According to Cronbach's Alpha, a reliability coefficient of .70 or higher is considered acceptable (Cronbach, 1951). The results of the analysis are shown in section four.

Data was coded and analyzed using Statistical Package for Social Sciences (SPSS) version 23. The data was screened and cleaned to identify any significant outliers or missing values. Regression analysis statistics were used to test the study hypotheses.

Results

Reliability of the Questionnaire

Table 1 Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.704	30

Note: Data collected by authors (2024).

Table 1 shows the alpha coefficient of .704, suggesting that the items have relatively high internal consistency. According to Cronbach's Alpha, a reliability coefficient of .70 or higher is considered acceptable. Therefore, the questionnaire is reliable and reproducible.

Hypothesis Testing

Hypothesis testing will be guided by a coefficient decision rule, which states that if $P \leq 0.05$, the test is significant; and if $P > 0.05$, the test is not significant.

H_1: Relative advantage significantly affects households' adoption of LPG.

Regression Analysis for Relative Advantage and Adoption of LPG

Table 2
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.312[a]	.097	.095	.38113

Note: Data collected by authors (2024).

In the model, the coefficient of determination ® is .312, which means the strength of the relationship between the dependent and independent variables is weak. The coefficient of determination (R^2) is .097%. This implies that only 9.7% of the variations in the adoption of LPG is explained by the relative advantage while the remaining 90.3% is accounted for by factors not included in the model.

Table 3
ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.982	1	4.982	34.297	.000[b]
	Residual	46.193	318	.145		
	Total	51.175	319			

Note: Data collected by authors (2024).

The ANOVA shows that F = 34.297 and is statistically significant. This indicates that the predictor to predict LPG adoption is significant. Also the model is considered to be good fit if significance value falls between 0% and 5%. The table shows the sig. value of .000 which means that relationship between independent and dependent variable is highly significant hence the model is a good fit. The residual sum of squares of 46.193 and the total sum of squares of 51.175 are used to calculate the R Squared value.

Table 4
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.020	.068		14.918	.000
	Relative Advantage	.288	.049	.312	5.856	.000

Note: Data collected by authors (2024).

The constant (intercept) term is 1.020 indicating that if relative advantage is held constant, adoption of LPG will rise by 0.288. The coefficient of determination for relative advantage is positive (0.288) and is highly significant (0.000) for adoption of LPG. Further, from the coefficient table above, the p-value for regression coefficient of relative advantage is given by 0.000, which is less than 0.05 (β = .288, T = 5.856, $p<0.05$), so we accept the hypothesis. Therefore, the result of hypothesis 1 indicates that relative advantage is statistically significant and has a significant and positive effect on LPG adoption for out sample. In addition, the t statistic is used to test for the significance of the coefficients. The t statistic of 5.856 is the slope on Relative Advantage and the p-value is .000, which is less than 0.05. Therefore, there is sufficient evidence to accept the hypothesis. Overall, the result suggests that as the relative advantage of LPG increases, more households in Agege adopt LPG for cooking.

H_2: Compatibility significantly affects households' adoption of LPG.

Regression Analysis for Compatibility and Adoption of LPG

Table 5
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.410[a]	.168	.165	.36512

Note: Data collected by authors (2024).

In the model, the coefficient of determination (R) is .410 which means the strength of the relationship between the dependent and independent variables is weak. The coefficient of determination (R^2) is 0.168%. This implies that only 16.8% of the variations of adoption of LPG is explained by the independent variable while the remaining 83.2% is accounted for by factors not included in the model.

Table 6
ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.035	1	8.035	60.271	.000[b]
	Residual	39.727	298	.133		
	Total	47.762	299			

Note: Data collected by authors (2024).

The ANOVA shows that F= 60.271 and is statistically significant. This indicates that the predictor to predict LPG adoption is significant. Also the model is considered to be a good fit if significance value falls between 0% and 5%. The table shows the sig. value of .000 which means that relationship between independent and dependent variable is highly significant hence the model is a good fit. The residual sum of squares of 39.727 and the total sum of squares of 47.762 are used to calculate the R Squared value.

Table 7
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.933	.065		14.460	.000
	Compatibility	.306	.039	.410	7.763	.000

Note: Data collected by authors (2024).

The constant (intercept) term is 0.933 indicating that if compatibility is held constant, adoption of LPG will rise by 0.306. The coefficient of determination for compatibility is positive (.306) and is highly significant (0.000) on adoption of LPG. The p-value for regression coefficient of compatibility is 0.000, which is less than 0.05 (β = .306, T =

7.763, p<0.05), so we accept the hypothesis. Therefore, the result of hypothesis 2 indicates that compatibility is statistically significant and has a significant and positive effect on LPG adoption for the dataset. Similarly, the t statistic of 7.763 is the slope on compatibility and the p-value is .000, which is less than 0.05. Therefore, there is significant evidence to accept the hypothesis. The result means that as the compatibility value of LPG increases, more households in Agege adopt LPG for cooking.

H_3: Complexity significantly affects households' adoption of LPG.

Regression Analysis for Complexity and Adoption of LPG

Table 8
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.292[a]	.085	.083	.38387

Note: Data collected by authors (2024).

In the model, the coefficient of determination ® is .292 which means the strength of the relationship between the dependent and independent variables is weak. The coefficient of determination (R^2) is 0.085%. This implies that only 8.5% of the variations of adoption of LPG is explained by the independent variable while the remaining 91.5% is accounted for by factors not included in the model.

Table 9
ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.849	1	4.849	32.907	.000[b]
	Residual	51.871	352	.147		
	Total	56.720	353			

Note: Data collected by authors (2024).

The ANOVA shows that F= 32.907 and is statistically significant. This indicates that the predictor to predict LPG adoption is significant. Also the model is considered to be a good fit if significance value falls between 0% and 5%. The table shows the sig. value of .000 which means that relationship between independent and dependent variables is highly significant hence the model is a good fit. The residual sum of squares of 51.871 and the total sum of squares of 56.720 are used to calculate the R Squared value.

Table 10

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.014	.071		14.273	.000
	Complexity	.268	.047	.292	5.736	.000

Note: Data collected by authors (2024).

The constant (intercept) term is 1.014 indicating that if complexity is held constant, adoption of LPG will rise by 0.268. The coefficient of determination for complexity is positive (0.268) and is highly significant (0.000) for adoption of LPG. Further, the p-value for regression coefficient of complexity is 0.000, which is less than 0.05 (β = .268, T = 5.736, $p<0.05$), so we accept the hypothesis. Therefore, the result of hypothesis 3 shows that complexity is statistically significant and has a significant and positive effect on LPG adoption for the sample. Similarly, the t statistic of 5.736 is the slope on complexity and the p-value is .000, which is less than 0.05. Therefore, there is considerable evidence to accept the hypothesis. The result shows that as the complexity value of LPG increases, more households in Agege adopt LPG for cooking.

H_4: Trialbility significantly affects households' adoption of LPG.

Regression analysis for trialbility and adoption of LPG

Table 4.11

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.455[a]	.207	.205	.36003

Note: Data collected by authors (2024).

In the model, the coefficient of determination ® is .455 which means the strength of the relationship between the dependent and independent variables is weak. The coefficient of determination (R^2) is 0.207%. This implies that only 20.7% of the variations in adoption of LPG is explained by the independent variable while the remaining 79.3% is accounted for by factors not included in the model.

Table 12

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.034	1	10.034	77.413	.000[b]
	Residual	38.368	296	.130		
	Total	48.403	297			

Note: Data collected by authors (2024).

The ANOVA shows that F= 77.413 and is statistically significant. This indicates that the predictor to predict LPG adoption is significant. Also the model is considered to be a good fit if significance value falls between 0% and 5%. The table shows the sig. value of .000 which means that relationship between independent and dependent variable is highly significant hence the model is a good fit. The residual sum of squares of 38.368 and the total sum of squares of 48.403 are used to calculate the R Squared value.

Table 13

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.854	.067		12.724	.000
	Trialbility	.384	.044	.455	8.798	.000

Note: Data collected by authors (2024).

The constant (intercept) term is 0.854 indicating that if trailability is held constant, adoption of LPG will rise by 0.384. The coefficient of determination for trialbility is positive (.384) and is highly significant (0.000) on adoption of LPG. Further, from the coefficient table, the p-value for trialability is 0.000, which is less than 0.05 ($\beta = .384$, $T = 8.798$, $p<0.05$), so we accept the hypothesis. Therefore, the result of hypothesis 4 indicates that trialability is statistically significant and has a significant and positive effect on LPG adoption for the sample. Furthermore, the t statistic of 8.798 is the slope on trialability and the p-value is .000, which is less than 0.05. Therefore, there is significant evidence to accept the hypothesis. The result implies that as the trialability value of LPG increases, more households in Agege adopt LPG for cooking.

H_5: Observability significantly affects households' adoption of LPG.

Regression analysis for observability and adoption of LPG

Table 14
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.438[a]	.192	.189	.36918

Note: Data collected by authors (2024).

In the model, the coefficient of determination ® is .438 which means the strength of the relationship between the dependent and independent variables is weak. The coefficient of determination (R^2) is 0.192%. This implies that only 19.2% of the variations of adoption of LPG is explained by the independent variable while the remaining 80.8% is accounted for by factors not included in the model.

Table 15
ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.684	1	9.684	71.051	.000[b]
	Residual	40.752	299	.136		
	Total	50.435	300			

Note: Data collected by authors (2024).

The ANOVA shows that F = 71.051 and is statistically significant. This indicates that the predictor to predict LPG adoption is significant. Also the model is considered to be good a fit if significance value falls between 0% and 5%. The table shows the sig. value of .000 which means that relationship between independent and dependent variable is highly significant hence the model is a good fit. The residual sum of squares of 40.752 and the total sum of squares of 50.435 are used to calculate the R Squared value.

Table 16
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.792	.076		10.363	.000
	Observability	.454	.054	.438	8.429	.000

Note: Data collected by authors (2024).

The constant (intercept) term is 0.792 indicating that if observability is held constant, adoption of LPG will rise by 0.454. The coefficient of determination for observability is positive (.454) and is highly significant (0.000) for adoption of LPG. The p-value for regression coefficient of observability is 0.000, which is less than 0.05 (β = .454, T =

8.429, $p<0.05$), so we accept the hypothesis. Therefore, the result of hypothesis 2 indicates that observability is statistically significant and has a significant and positive effect on LPG adoption for the dataset. Similarly, the t statistic of 8.429 is the slope on observability and the p-value is .000, which is less than 0.05. Therefore, there is significant evidence to accept the hypothesis. The result indicates that as the observability value of LPG increases, more households in Agege adopt LPG for cooking.

Discussion

We ran a regression analysis to explain households' LPG adoption in the Agege area of Lagos State with the five constructs of Rogers' (2003) DOI theory. All the five hypotheses of the paper are supported. The relative advantage of LPG over SBFs and kerosene has the second lowest coefficient of .288. The relative advantage of LPG makes it attractive to households that have adopted it for cooking. This finding is consistent with the findings of previous studies (Ahmad et al., 2022; Allan et al., 2014; Arora et al., 2022; Chong, 2006; Jang, 2010). In line with the postulation of Rogers (2003), LPG is perceived to be better in many ways than the traditional and intermediate fuels that it supercedes. It is clean burning, convenient, time saving, environmental friendly, and it reduces HAP that causes heavy health burdens for people and kills several people, especially women and children.

Our Findings also suggest that compatibility is a crucial factor in the adoption of LPG. Compatibility has the third largest coefficient of .306. This result corroborates the findings of extant research (Badmus & Bakri, 2021; Deng et al., 2023; Doku-Marfo, 2022; Nagele, 2015; Putzer & Park, 2010). Like the preceding fuels - SBFs and kerosene - LPG is a cooking fuel and meets the cooking needs of the households who have adopted it for cooking of all kinds of food. Majority of respondents admitted that LPG is compatible with all aspects of their cooking. They said they used LPG for boiling, frying, grilling, and baking, making it a versatile fuel that fits with all their cooking needs. They also said that they used LPG with a variety of cooking appliances and equipment, such as, ovens and grills, which makes it easy to integrate the fuel into their existing cooking practices.

Further, the findings of the study show that the ease of use of LPG is significant in its adoption. The complexity construct has the lowest beta value of .268. Unlike some new innovations, LPG is not complex to understand and use. The result supports the findings of prior research (Ahmad et al., 2022; Aminu, 2018; Arora et al., 2022; Choe & Noh, 2018). There is no doubt that the LPG technology is easy to understand and use effortlessly, just as Davis (1989) advanced in his TAM. Daily usage of an LPG technology does not require elaborate training and close supervision. In fact, an overwhelming majority of respondents admitted that it was easy to learn how to use the

technology. A complex innovation will suffer slow adoption, especially in a clime like Nigeria where consumers hardly read product manuals and instructions before consuming a product. The only aspect of LPG that consumers find frustrating is the stress and cost that are associated with refilling the cylinders.

Moreover, the findings revealed that trialability, with the second largest beta value of .384, is another characteristic of LPG promoting its adoption. This finding is in tandem with the findings of previous studies (Carrion et al., 2021; Gill et al., 2022; Perros et al., 2021; Williams, 2019). LPG cylinders are available in various sizes ranging from 0.5kg to 38kg for domestic users. The 0.5 kg cylinder will allow poor housholds and consumers, who want an opportunity to try the fuel on a limited basis to do so, before full adoption of the fuel, whether on a small or large scale. Based on the respondents' socio-economic characteristics, more than 71% of respondents claimed that they were using 1-6kg cylinders for their cooking needs. This implies that households that tried out smaller cylinders were more likely to adopt LPG on a larger scale, while those that tried out larger cylinders were more likely to continue using LPG on a larger scale.

Finally, the study found that observability is also significant in and has a positive effect on the adoption of LPG among the households in Agege. The observability construct has the highest coefficient value of 0.454. This suggests that it is the most significant characteristic of LPG that influenced LPG adoption. This finding aligns with the findings of prior research (Al-Jabri & Sohail, 2012; Arora et al., 2022; Menzli et al., 2022). The finding suggests that potential adopters observing households cooking with LPG will be motivated by the benefits enjoyed by the adopters.

Some of these benefits include cleaner burning, cooking efficiency, convenience, and time saving (Adamu et al., 2022; Akter & Pratap, 2022; Raktim, 2023); environmental friendliness or sustainability (Gebreslassie et al., 2023); and health benefits (Gould, 2020; Suarez-Burguet et al., 2018; Rehfuess et al., 2014; Sulley et al., 2023). Most of the respondents agreed that observing households using LPG provides a tangible and relatable example of the benefits and advantages of LPG.

Conclusion

The DOI Theory, developed by Rogers (2003), provides a good framework for understanding how innovations, especially new products in marketing are adopted by individuals and organizations. In the context of the adoption of LPG by households in Agege, this theory offers valuable insights into the characteristics of LPG that influence the adoption process for LPG fuel. The study found that the five key characteristics of

an innovation espoused in the DOI Theory - relative advantage, compatibility, complexity, trialability, and observability - significantly impacted the adoption of LPG by households in Agege. However, it is important to add that while the constructs are significant, they explain only a small variance suggesting there are other factors that influence LPG adoption.

The study suggests that the households in the community perceived LPG: to have relative advantages of being clean, efficient, and sustainable than SBFs; meets their cooking needs more than the traditional fuel; is easy to use without much ado; can be tried on a limited basis before full adoption; and its benefits are visible to non-adopters. Therefore, we conclude that LPG characteristics validate the increasing adoption of the fuel in Lagos State.

Recommendations

The following recommendations are made be based on the conclusion:

i. Marketers should highlight the relative advantage of LPG in terms of energy efficiency, cost savings, and health benefits to demonstrate its superiority over traditional fuels and motivate non-adopting households in Nigeria to adopt the clean cooking solution. Marketers can leverage the diverse advertising and other communication media to reach out to potential LPG adopters.

ii. Manufacturers should design and promote LPG cooking equipment that is compatible with existing kitchen infrastructure, making adoption seamless and convenient for non-adopting households in Nigeria. The current designs of cylinders in different sizes satisfy the need of households. In particular, the 2.5kg cylinders are mostly compatible with the expectations and desires of the mass segment of the market. The manufacturer should consider designing a 1kg cylinder for the poor segment of the market.

iii. Marketers should intensely promote the ease of use attribute of LPG to sensitize and persuade a few non-adopters, who may perceive LPG as complex to understand and use. This can be achieved by promotion and product demonstrations. The promotional campaigns should be educative and demonstrate the ease of setting up LPG equipment and how the equipment can be used effortlessly.

iv. Government agencies, researchers, and marketers should organize LPG trial programs or experiments, especially in rural and suburban areas of Lagos State and other States in Nigeria. This initiative will provide households access to free or subsidized LPG to let them have personal experience with LPG and motivate them to adopt it after the trial experiments. Product trials and experiments can be

organized in big markets and town halls.

v. Government agencies and marketers should showcase LPG adoption success stories and testimonials by LPG adopters to inspire and motivate non-adopters to switch to the clean cooking fuel. Marketers can use influencers to share the success stories. This will make the fuel and equipment more visible and quickly adopted by non-adopters.

Limitations and Further Research Directions

Although the research shows that LPG adoption for cooking is supported by Rogers' Diffusion theory, the paper has some limitations. One, Arora et al. (2022) has suggested an integrative framework that combines Rogers' five innovation characteristics with attitude in diffusion research. However, this paper only focuses on the Rogers' theory, excluding attitude. Future research should take the integrative approach to LPG adoption in the the context of Nigeria. Two, the future integrated approach should combine DOI and TAM constructs to explain LPG adoption in the context of Nigeria. This is necessary to appreciate the combined effects of DOI's product characteristics (Rogers, 1983) and TAM's individual factors (Davis, 1989) on LPG adoption.

Three, although LPG adoption is a recent phenomenon in Nigeria, research in this area is gradually growing. However, this research is increasingly focusing on the urban areas of Nigeria, neglecting the rural areas. Therefore, it is important that future studies provide insights into the application of DOI theory to LPG adoption in rural settings. Four, the generalizability of this study to the entire nation is not possible because of the small sample size used and the few estates from where data was obtained. Future studies should use a large sample and collect data from different cities in Nigeria.

Five, the findings of the research is limited by sampling biases that are associated with a non-probability sampling technique. Future research should use any of the probability sampling techniques in collecting data. This will ensure that the data are representative of the target population and further enhance the generalizability of the findings. Finally, the low R^2 value suggests that the five constructs do not effectively explain the adoption of LPG for our dataset. Researchers should consider further research that focuses on the effects of socioeconomic conditions, government policies, prices of LPG and alternative fuels, and other factors on LPG adoption. These factors may significantly explain the variation in the LPG adoption.

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