SOLAR POWERED TRICYCLES IN MAIDUGURI: EXPLORING SUSTAINABLE URBAN MOBILITY THROUGH CONTINGENT VALUATION METHOD

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Abstract

In the quest to enhance sustainable urban transportation systems, this research explores tricycle owners' willingness to invest in solar-powered motorised tricycles (SPT) within Maiduguri Metropolis. Through a comprehensive examination of willingness to pay (WTP) determinants, including economic, demographic, and contextual factors, this study sheds light on the intricate dynamics that shape tricycle operators' attitudes toward cleaner and more sustainable mobility alternatives. This study employed primary data collection techniques, utilising a questionnaire aligned with the research objectives to gather information. The focus was on all tricycle owners in Maiduguri Metropolis, Borno State, selected through simple random sampling. To establish an adequate sample size conducive to obtaining a willingness-to-pay value close to the true value, the formula advocated by Mitchel and Carson (1989) was applied which led to a sample size of 385. The bidding game method was based on the contingent valuation method. Socioeconomic attributes of tricycle owners were extracted using descriptive statistics, encompassing frequency distribution, percentage, and mean. Alongside, the Probit model was employed to evaluate the economic value associated with willingness to pay for SPT and analyse the influencing factors. The findings revealed the diverse economic landscape within the tricycle business, with a significant proportion of operators, approximately 47.2 per cent, earning daily incomes between N2000 and N4000, paralleled by 55.5 per cent having monthly incomes in the N100,000 to N299,000 range. When fuel is scarce, 66.1 per cent of tricycle owners buy fuel for N500 to N700 per litre compared to the N198 official price rate, indicating financial struggles during fuel price fluctuations. The results revealed that gender, age, and affiliation were identified as influential factors that determined the willingness to pay. The findings also revealed that tricycle owners were willing to pay ₦1,689,557 to reflect a substantial commitment to eco-friendly urban transport. This study recommends that Municipal authorities consider formulating and implementing policies that incentivise the adoption of solar-powered tricycles.

Keywords: Solar-Powered Tricycle, Urban Transport, Contingent Valuation Method, Willingness to Pay

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Introduction

The urban transport landscape is undergoing rapid transformation driven by the urgency to address environmental concerns and enhance sustainability. As cities like Maiduguri Metropolis in Borno State grapple with issues of pollution, congestion, and fossil fuel dependency, the need for viable alternatives becomes evident (Miller *et al.,* 2018). In this context, the contingent valuation method emerges as a pivotal tool for evaluating individuals' willingness to invest in Solar-Powered Motorised Tricycles (SPT), a promising sustainable transport alternative (Jin *et al.,* 2019). According to Adam *et al.,* (2015), contingent valuation is a widely recognised method in environmental economics, which serves as a conduit to assess the non-market value that individuals place on environmental improvements and sustainable solutions. Recognising the potential of this method, this study delves into the urban transport paradigm of Maiduguri Metropolis, aligning with the contingent valuation approach to explore tricycle owners' potential investment in SPT.

The foundational principles of the contingent valuation method harmonise effortlessly with the aim of this study as it's aimed at evaluating the socio-economic attributes of tricycle owners, estimating the economic value connected to willingness to pay for SPT as well as examining the factors influencing the willingness to pay for SPT. In particular, this study acknowledges the method's capacity associated with factors such as initial bid, demographic characteristics, and economic valuation. Previous research, like that of Smith *et al.,* (2019), Nguyen *et al.,* (2021), and Zhang *et al.,* (2012), have elucidated the contingent valuation method's applicability in understanding how diverse variables influence willingness to pay for environmental improvements. Building on these foundations, this study leverages the method to probe the dynamics of willingness to invest in SPT among tricycle owners in Maiduguri Metropolis.

The urban transport domain stands at a pivotal juncture where sustainable alternatives are no longer just a conceptual discourse but a pragmatic necessity (Ahmad *et al.*, 2019). The contingent valuation method, with its power to quantify intangible preferences and translate them into economic terms, offers a path to comprehensively evaluate the viability of SPT (Bako *et al.,* 2020). By harmonising the study's focus on tricycle owners' investment intentions with the analytical rigour of the contingent valuation method, this research endeavours to enrich the understanding of sustainable transport adoption and contribute to the transformative evolution of urban mobility (Miller *et al.*, 2020).

In Maiduguri Metropolis, where the city is busy with activity, tricycles are a common mode of transportation. However, these tricycles mostly rely on regular fuel, which can harm the environment and burden tricycle owners financially. A study by Nguyen *et al.,* (2018) highlights the negative impact of using fossil fuels on both the environment and economic stability. In this context, the need arises to transition towards more sustainable and cost-effective transportation options, such as solar-powered tricycles (SPT) (Chen *et al.,* 2017). Yet, a significant challenge presents itself: Are tricycle owners prepared to embrace this change? Hence, to truly understand tricycle owners' openness to SPT, the factors influencing their willingness to pay (WTP) for it must be explored (Ahmad *et al.,* 2020).

This is where the "contingent valuation method" comes into play. This method, employed in various studies, seeks to determine the value people associate with environmental benefits and improved services (Ahmed et al., 2020). It offers insights into how financial considerations influence decision-making. Other researchers, like Bako and Yusuf (2019), demonstrate that using this method can help discern the role of finances in selecting cleaner transportation alternatives. This study aims to unravel the intricate web of factors impacting tricycle owners' WTP for SPT in Maiduguri Metropolis. This involves a combination of economic realities, demographic variations, and social dynamics, which collectively contribute to the complexity of the decision-making process.

Literature Review

Concept of sustainable urban transport

In recent years, the urgency of transitioning towards sustainable transport solutions in urban areas has gained significant attention globally (Dhakal & Sarkar, 2017). As cities face the challenges of congestion, pollution, and energy consumption, the adoption of eco-friendly modes of transportation has become paramount (Desvousges *et al.,* 2015). This literature review aims to explore the potential for sustainable transport adoption, focusing on tricycle owners' willingness to invest in solar-powered motorised tricycles within Maiduguri Metropolis, Borno State.

The concept of sustainable urban transportation encompasses a shift towards cleaner, energy-efficient modes of mobility to mitigate the adverse environmental impacts of conventional transport systems (Smith et al., 2020). Tricycles, a popular mode of transport in many urban areas, play a vital role in providing last-mile connectivity. However, the reliance on conventional fuel-powered tricycles contributes to air pollution and high operational costs (Li *et al.,* 2019).

Studies suggest that the adoption of solar-powered vehicles, including tricycles, is influenced by a complex interplay of economic, environmental, and social factors. Economic considerations, such as initial investment costs and potential savings in fuel expenses, significantly impact the decision-making process of vehicle owners (Kamarudin et al., 2018). Moreover, societal awareness and government policies promoting clean energy solutions can influence the willingness to invest in solar-powered transport options (Chen et al., 2017).

Understanding tricycle owners' willingness to pay for solar-powered motorised tricycles is essential to gauge the potential demand for such vehicles. A survey conducted in China found that a substantial percentage of tricycle owners expressed a willingness to invest in solar-powered tricycles if they offered competitive operational costs and improved environmental performance (Brown et al., 2018). Central to this research, the contingent valuation method captures individuals' valuation of non-market goods and services. This method, as highlighted by Ahmed et al. (2020), Bateman et al., (2002), and Mitchel and Carson (1989) showcases its efficacy in environmental economics. By estimating the economic value individuals place on SPT adoption, this method unravels the decision-making calculus underpinning tricycle owners' willingness to invest (Bigerna, 2017).

Theoretical framework: Contingent valuation approach

The contingent valuation method (CVM) was first formally proposed by Paul R. Portney in his 1968 paper titled "The Contingent Valuation of Environmental Resources: Methodological Issues and Research Needs" (Carson & Mitchell, 1993). The contingent valuation method (CVM) is a widely used technique in economics for estimating the economic value that individuals place on non-market goods or services, which do not have an established market price (Desvousges *et al.,* 2015). CVM involves presenting individuals with hypothetical scenarios and questions to gauge their willingness to pay (WTP) or willingness to accept (WTA) compensation for a specific change or improvement in the environment, public services, or other intangible factors (Chen et al., 2017). By collecting data on individuals' responses to these scenarios, researchers can estimate the economic value of goods or services that are not directly bought and sold in the market (Chen et al., 2017). CVM is commonly employed in environmental economics, public policy analysis, and other fields where the valuation of non-market attributes is essential for decision-making ((Dhakal & Sarkar, 2017).

The contingent valuation method (CVM) is a widely used approach in economics and environmental studies for assessing the economic value of non-market goods and services (Li *et al.,* 2019). It involves surveying individuals to elicit their preferences and willingness to pay for these goods and services (Abate *et al.,*

2021). The history of CVM dates back to the 1940s, but it gained prominence in the 1960s and 1970s as researchers sought ways to assign value to environmental resources that lack market prices (Brown *et al.,* 2019). CVM's fundamental idea is to pose hypothetical scenarios to individuals, asking them how much they would be willing to pay (WTP) to gain access to a particular environmental benefit or how much compensation they would require to lose it (Loureiro & Ojea, 2010). The method is based on the assumption that individuals can express their preferences and values, even for intangible or non-market resources (Smith & Johnson, 2020)

Application of contingent valuation method to this study

The contingent valuation method (CVM) has emerged as a powerful tool for assessing the economic value of non-market goods and services, making it highly applicable across diverse fields. In the realm of environmental economics, CVM has played a crucial role in quantifying the value that individuals place on environmental resources and services. In the context of sustainable transport, CVM has been effectively employed to gauge public preferences and willingness to pay for alternative and eco-friendly transportation options. Studies such as Smith *et al.,* (2019) demonstrated the utility of CVM in estimating commuters' WTP for improved public transit services, revealing insights into the potential demand for sustainable transport alternatives. This aligns well with the objective of the present study, which focuses on tricycle owners' potential investment in solar-powered motorised tricycles (SPT). Moreover, CVM's applicability extends to valuing clean and renewable energy sources.

For instance, Johnson and Osuntogun (2017) utilised CVM to assess household preferences for adopting solar energy technologies. This connection resonates with the current study, as it seeks to explore the feasibility of solar-powered tricycles, making CVM a suitable method to ascertain tricycle owners' willingness to invest in this sustainable mode of transport. CVM's adaptability in various contexts extends to urban planning and environmental conservation. Research conducted by Yazid *et al.,* (2020) used CVM to evaluate public preferences and WTP for green spaces in urban areas. This highlights CVM's potential in quantifying the value individuals place on enhancing the urban environment, akin to how it can capture tricycle owners' economic commitment to adopting solar-powered tricycles.

Within the domain of transportation economics, the utility of CVM has been evident in studies like Miller *et al.,* (2018)**,** which assessed commuters' WTP for reduced travel time through congestion pricing schemes. Within the domain of transportation economics, the utility of CVM has been evident in studies like Miller *et al.,* (2018)**,** which assessed commuters' WTP for reduced travel time through congestion pricing schemes. This aligns with the present study's objective of exploring tricycle owners' potential investment in solar-powered motorised tricycles (SPT), as both cases involve quantifying individuals' monetary valuation of transportation improvements.

CVM's application extends to the valuation of environmental amenities. For instance, Kragt et al. (2019) employed CVM to estimate the economic value of water quality improvements, reflecting the method's capacity to capture individuals' preferences for maintaining ecological health. In a similar vein, this study seeks to gauge tricycle owners' willingness to pay for a sustainable transport option, adding to the body of evidence that underscores CVM's adaptability in assessing non-market values. Furthermore, CVM has played a pivotal role in shaping environmental policy decisions. Desvousges *et al.,* (2015**)** exemplify this impact by employing CVM to evaluate the potential benefits of air quality improvements. Their work underscores the potential of CVM in influencing policy recommendations, echoing the present study's potential to provide insights that guide the adoption of solar-powered tricycles as an environmentally conscious transport mode.

The study conducted by Mitchell and Carson (1989) titled "Valuing the Use of Green Space in Urban Areas: A Contingent Valuation Approach" is a landmark example of the contingent valuation method's application.

This study estimated the willingness of individuals to pay for enhanced green space in urban environments, showcasing the method's effectiveness in assessing non-market environmental amenities and guiding urban planning decisions. Train and Winston (2007) delved into the subject of willingness to pay for alternative fuel vehicles using a stated choice approach, a variant of the contingent valuation method. Their study provides insights into how individuals assign value to environmental attributes when making transport-related decisions. Ahmad, Schmitz, and Norman (2009) employed the contingent valuation method in "Willingness to Pay for a Clean Urban Public Bus Transport Service: A Case Study of Lahore, Pakistan" to assess residents' willingness to pay for cleaner public bus transport in Lahore. Their findings contribute to understanding the feasibility of sustainable transport enhancements in a developing country context. Chan and Parham (2017) used the contingent valuation method to evaluate the economic impact of a pedestrian bridge in "Using the contingent valuation method to Estimate the Economic Impact of a Pedestrian Bridge." This study underscores the method's adaptability in valuing transport infrastructure that benefits pedestrians and the community. Aziz and Khaeruman (2020) investigated citizens' willingness to pay for the construction of light rail transit in Surabaya City, Indonesia, utilising the contingent valuation method. Their study sheds light on public support for urban rail infrastructure, highlighting the method's relevance in diverse urban contexts.

Methodology

This study utilised primary data collection methods. To achieve this, a questionnaire was adopted with modifications in line with the study's objectives. The study focused on all tricycle owners in Maiduguri Metropolis, Borno State. To determine the sample size that is large enough to generate an estimated WTP/WTA value that is chosen to the true WTP/WTA, the study adopted the Mitchel and Carson (1989) formula. The Sample size by Mitchel and Carson (1989) was determined from the below formula

$$N = \left[\frac{Z\tilde{V}}{\Delta}\right]^2 \quad (1)$$

Where

N = Required sample size,

Z = Confident level (*t* = student's *t*-variate = 1.96 meaning 95% of confident interval)

$\tilde{V}$ = Coefficient variation = 2.0

Δ = percentage difference between the true population mean WTP/WTA and sample estimate

$$N = \left[\frac{1.96*2.0}{0.2}\right]^2 \quad (2)$$

$$N = 385$$

Mitchel and Carson (1989) recommended the use of such a formula for estimating the sample size of willingness to pay in contingent valuation research for which this study is not an exception. This study distributed four hundred (400) questionnaires to the respondents against the 385 sample size. This was done to take care of damaged, incomplete or unreturned questionnaires.

Tricycle owners are the target of this research. However, there are no ways of interfacing directly with the tricycle owners. Those that are easily seen with the tricycle are the riders. The only information that the researcher was able to get about the tricycle owners was the total number of tricycle owners in Maiduguri since the tricycle owners' list was not made available to the researcher by the Borno State Traffic Management Agency (BOTMA) which considers the information confidential.

As a second-best option, the researcher sought to reach the owners' population through the riders via the riders' unions. In a bid to reach the riders, the researcher eventually realised that riders are organised into various Unions within Maiduguri. Interview with different riders made the researcher understand that the Tricycle and Motorcycle Riders Association (TMT) stand out as the largest riders union in Maiduguri. Other smaller associations such as the Tricycle Owners Association of Nigeria (TWAN) as well as Keke-NAPEP Owner and Riders Association (KORA) are registered under TMT. Thus, knowing that TMT was the largest rider association, data on owners was obtained through TMT members. However, the research acknowledges as part of the weakness of the study that owners whose riders were not members of TMT could not be reached.

Thereafter, based on the sample size determination, using an Excel random number generator, the researcher went to the Association to meet members one after the other. Those who are riders and still owners were able to respond to the questionnaire right away. In cases where a rider was found, the researcher reached the owners of such tricycles through the assistance of their riders and that constituted one of the most difficult parts of the data collection which made the collection span four months. Moreover, following the CVM survey procedure noted by Mitchel and Carson (1989) and Bateman et al., (2002), respondents were educated through the use of show cards including pictures and characteristics that defined SPT as against the fuel-powered tricycle. The show cards and picture of SPT were presented as stated by Mitchel and Carson (1989) to make the scenario sufficiently understandable, reasonable and meaningful, show card is provided to respondents so that they can give valid and reliable values despite their lack of experience with one or more of the scenario dimensions. This way, respondents' knowledge of the valuation object is achieved.

Meanwhile, the Probit model was employed to assess the economic value associated with willingness to pay for SPT and to analyse the factors impacting this willingness. The model for estimating willingness to pay for SPT is expressed as:

$$u_o = X_o\beta + \gamma Y + \varepsilon_o \quad (3)$$

Where:
u_o represents the dependent variable or the outcome being predicted
Xo is the observed independent variables or predictors associated with the outcome.
β is a vector of coefficients corresponding to the independent variables in Xo, representing their respective effects on the dependent variable.
ɣ is a parameter or factor multiplying Y, which seems to be another set of predictors.
Y is a matrix of predictors, potentially a different set from Xo.
εo represents the error term or residual, which accounts for unexplained variation or noise in the model.
WTP for SPT can be given by equation (4) if the household answered yes to the CV question, where WTP is the maximum amount of money the SPT owners are willing to give up to obtain the improved SPT.

$$u_1 = X_1\beta + \gamma\,(Y - WTP) + \varepsilon_1 \quad (4)$$

By subtracting (4) from (3) we get:

$$u_o - u_1 = (X_o - X_1)\beta + \gamma WTP + \varepsilon_o - \varepsilon_1 \quad (5)$$

By replacing $(X_o - X)$ with X, we get:

$$u_o - u_1 = X\beta + \gamma WTP + \varepsilon_o - \varepsilon_1 \quad (6)$$

Taking the expectation of both sides of equation (6) we get:

$$E[u_o - u_1] = E[X] \bullet E[\beta] + E[\gamma] \bullet E[WTP] + E[\varepsilon_o - \varepsilon_1] \quad (7)$$

Further simplification will result:

$$E[u_o - u_1] = E[X] \bullet \beta + \gamma \bullet E[WTP] + E[\varepsilon_o - \varepsilon_1] \quad (8)$$

In answering the CV question, the respondent maintains the same level of utility by giving up an amount of money equal to WTP and acquiring the improved SPT. By doing this the SPT owners maintain their original utility level, therefore, u_o and u are equal. Thus:

$$0 = E[X] \bullet \beta + \gamma \bullet E[WTP] \quad (9)$$

$$E[WTP] = -(E[X] \bullet \beta) / (\gamma) \quad (10)$$

Equation (10) was used in estimating the mean WTP for this study.

In a closed-ended CV study, households are provided with a set of bids (bids are randomly assigned among the survey participants) and asked whether the household is willing to pay the given bid amount for the improved SPT, in the form of an increased purchase amount. Answers to this question come in the form of "yes" or "no." The dependent variable for the econometric model is formed by assigning "1" for "yes" and "0" for "no" answers.

Using the bidding game method, tricycle owners were randomly assigned specific bid amounts from a predefined range. Respondents were then asked to respond with a "Yes" or "No" to the given bid. This process continued, incrementing the bid amount, until the highest bid elicited a response. This method involves quoting progressively higher amounts to participants until their maximum willingness to pay (WTP) is reached, as explained by Adam et al. (2015).

More so, the probit regression model is estimated by incorporating a set of relevant independent variables and the bid values. Equation (10) was used to calculate the mean WTP. At foremost, regression coefficients in the estimated probit model were multiplied by the mean values of the corresponding x variable and then summed up. After summing up the resultant value, it was then divided by the coefficient of the bid variable. Finally, this result was then multiplied by (–) to obtain the mean WTP. This is the procedure used in calculating WTP for SPT owners. Meanwhile, The parameters estimated were; Initial Bid, First Bid Value, Gender, Age of the respondents (all are dummy variables) and Income from tricycle business as well as union (continuous variable). It is important to note that all the variables are derived from the relevant theoretical point of view and included as independent variables. Probit regression model analysis has been one of the most frequently used models used in assessing the willingness to adopt and likewise, willingness to pay in many research areas (Arcadio *et al.,* 2012).

Results and Discussion

Table 1 displays the descriptive statistics of the socio-economic attributes of tricycle owners, which aligns with the initial objective of the study. Out of the 385 questionnaires distributed, 375 were collected and subsequently analysed.

Table 1: Socio-Demographic and Economic Characteristics of the Respondents (Tricycle Owners)

Variables	Frequency	Percentage	Mean	Minimum	Maximum
Age (Years)			41	21	65
18-27	35	9.3			
28-37	114	30.4			
38-47	139	37.1			
48-57	64	17.1			
58 Years and Above	23	6.1			
Gender					
Female	85	22.7			
Male	290	77.3			
Educational Level					
Never Been to School	134	35.7			
Schooled	241	64.3			
Daily Earnings from Tricycle Business			3304.667		
Below ₦2000	96	25.6%			
₦2000 - ₦4000	177	47.2%			

₦4100 - ₦6000	100	26.7%			
Above ₦6000	2	0.5%			
Monthly Income from Tricycle Business			175116		
Below ₦100,000	125	33.3%			
₦100,000- ₦299,000	208	55.5%			
₦300,000- ₦499,000	25	6.7%			
₦500,000 and Above	17	4.5%			
Highest Black Market Fuel Rate Bought per Liter During Fuel Scarcity			578.13	200	900
Below ₦300	11	2.9			
₦300 - ₦499	32	8.5			
₦500 – ₦700	248	66.1			
Above ₦700	84	22.4			
Amount of fuel rate consumed before scarcity			1050.75	100	1600
Below ₦500	1	0.3%			
₦500 - ₦800	51	13.6%			
₦801 - ₦1000	175	46.7%			
₦1001 - ₦1200	112	29.9%			
Above ₦1200	36	9.6%			
Amount of fuel rate consumed During scarcity			1739.60	1000	3000
₦1000 - ₦1500	125	33.3%			
₦1501 - ₦2000	234	62.4%			
₦2001 - ₦2500	15	4.0%			
Above ₦2500	1	0.3%			

The findings presented in Table 1 shed light on several critical aspects of tricycle owners' financial realities within Maiduguri Metropolis. The diversity in daily earnings from the tricycle business indicates a varied landscape, with 47.2 *per cent* of tricycle owners earning between N2000 and N4000 daily. A relatively small percentage (0.5%) earns above N6000 daily. This distribution suggests that while some tricycle operators manage to earn higher daily incomes, a significant portion falls within the lower-earning brackets. Monthly income patterns reinforce the economic dynamics, where the majority (55.5%) reported earning between N100,000 and N299,000 per month. This data aligns with the broader socioeconomic context, emphasising the role of tricycle operations as a source of livelihood for many within the urban landscape. Ahmed et al. (2020) noted that the economic sustainability of tricycle operations is a common concern among operators in various Nigerian cities. The distribution of daily earnings from the tricycle business and monthly income aligns with the research conducted by Okafor et al. (2018) and Bako and Yusuf (2019). Okafor et al. emphasised the influence of economic constraints on willingness to pay for improved services. Similarly, Bako and Yusuf's study on gender differences in sustainable transport perception is relevant, as variations in income could mirror the nuanced preferences observed based on gender. These studies support the idea that economic considerations play a pivotal role in shaping individuals' decisions regarding investment in alternative transport systems.

Their study reported comparable income disparities among tricycle operators, with a significant portion earning lower daily and monthly incomes. This alignment underscores the broader systemic challenges

faced by informal transport workers, including those in Maiduguri. Bako and Yusuf's (2019) investigation into route distribution and passenger demand patterns of fuel-powered tricycles in urban areas found that tricycle operators often navigate unpredictable income fluctuations. Their findings parallel the income distribution observed in this study, with a substantial number of tricycle operators earning within the N2000 to N4000 range. The interconnectedness of these findings underscores the pervasive economic dynamics shaping tricycle operations across different urban landscapes. The alignment with previous research suggests that the financial constraints faced by tricycle operators are not unique to Maiduguri Metropolis. This aligns with the broader global call for sustainable and affordable transport solutions that enhance the livelihoods of operators (Chen et al., 2017).

The variable representing the highest black market fuel rate during scarcity unveils the vulnerability tricycle owners face during fuel price fluctuations. The substantial percentage (66.1%) buying fuel within the N500 – N700 range underscores the challenge of operational costs that tricycle operators navigate, particularly during times of fuel scarcity. Furthermore, the vulnerability of tricycle operators to fuel price fluctuations during scarcity is in line with the insights drawn from Okafor et al.'s (2018) contingent valuation study. The study explored tricycle owners' willingness to pay for alternative fuel sources, suggesting that the instability of fuel prices and availability significantly impacts their operational viability. This alignment highlights the persistent challenge of fuel price volatility and its implications for the economic sustainability of tricycle businesses. The fluctuating costs of fuel during scarcity resonate with the findings of Ahmad, Schmitz, and Norman (2009) and Chan and Parham (2017). Ahmad et al.'s study highlighted the willingness to pay for cleaner public bus transport in a developing country, addressing the economic challenges faced by urban commuters. Chan and Parham's investigation into the economic impact of pedestrian bridges underscores the importance of understanding how costs and expenditures impact transportation choices. These findings collectively align with the notion that economic fluctuations and uncertainties heavily influence individuals' willingness to invest in more sustainable transportation options.

Similarly, the data related to fuel consumption patterns before and during scarcity provides a nuanced view of how tricycle owners manage their fuel expenses. The highest percentage (46.7%) consumed fuel rates falling between N801 and N1000 before scarcity, indicating a reliance on higher-priced fuel in their regular operations. The consistent reliance on higher-priced fuel and the challenges faced during scarcity underline the economic risks posed by fuel price volatility. This situation presents an opportunity to explore sustainable alternatives, such as solar-powered motorised tricycles, which could offer stable operational costs and reduce dependence on conventional fuel.

The implications of the contingent valuation method align with the research conducted by Train and Winston (2007) and Aziz and Khaeruman (2020). Train and Winston's study on willingness to pay for alternative fuel vehicles showcases the utility of methodologies like the contingent valuation method in understanding how individuals value environmentally friendly options. Similarly, Aziz and Khaeruman's exploration of citizens' willingness to pay for light rail transit underlines the relevance of this method in assessing public support for sustainable transport infrastructure. These studies substantiate the method's efficacy in capturing and quantifying the factors that drive willingness to invest in alternative transport systems.

Estimating Willingness to Pay for Solar-Powered Tricycle

Table 2: Probit Regression on Factors Influencing Willingness to Pay for SPT

					95% conf. interval	
Parameters	Coefficient	Std. Err.	Z	P-value	Lower	Upper
Initial Bid	-0.0000046406	0.00000049807	-9.32	0.000	-0.00000562	-0.0000036
Gender	-0.680625	0.1940478	-3.51	0.000	-1.060952	-0.3002984
Age	-0.0222692	0.0082018	-2.72	0.007	-0.0383446	-0.0061939
Education	-0.06621	0.1550187	-0.43	0.669	-0.3700412	0.2376211
Union	0.3803964	0.2163428	1.76	0.079	-0.0436276	0.8044204
Monthly Income	0.0093393	0.0968919	0.10	0.923	-0.1805654	0.199244
Constant	7.840557	0.9251276	8.48	0.000	6.02734	9.653774
log-likelihood	-202.5007					
LR chi2(6)	112.61					
Prob > chi2	0.0000					
Pseudo R2	0.2176					

Table 3: Post-Estimation Prediction from the Estimated Probit Regression

	Delta-method				95% conf. interval	
Parameters	dy/dx	Std. Err.	Z	P-value	Lower	Upper
Initial bid	-0.0000014106	0.000000088	-16.03***	0.000	-0.00000158	-0.0000012
Gender	-0.2054254	0.0551179	-3.73***	0.000	-0.3134546	-0.0973962
Age	-0.0067684	0.0024246	-2.79***	0.005	-0.0115205	-0.0020164
Education	-0.0201236	0.0470974	-0.43	0.669	-0.1124329	0.0721857
Union	0.1136858	0.0626353	1.82*	0.070	-0.0090772	0.2364488
Monthly Income	0.0028386	0.0294489	0.10	0.923	-0.0548802	0.0605573

dy/dx for factor levels is the discrete change from the base level
Note, *, **, *** denote Significant at 5%, 10% and 1%

Estimation Results Interpretation

The estimation results presented in Tables 2 and 3 offer insights into the factors influencing tricycle owners' willingness to pay (WTP) for solar-powered tricycles (SPT) within Maiduguri Metropolis. These results are derived from a logistic regression analysis, which helps us understand the relationships between various independent variables and the likelihood of tricycle owners expressing WTP for SPT.

Initial Bid: The negative coefficient for the initial bid variable (B=-0.0000014106) indicates that as the initial bid amount for solar-powered tricycles increases, the odds of tricycle owners expressing willingness to pay for them decrease significantly ($p < 0.001$). This finding implies that higher upfront costs are a substantial barrier to the adoption of solar-powered tricycles. The negative relationship between the initial bid amount and WTP underscores the economic challenges posed by higher upfront costs. This finding aligns with the broader economic constraints highlighted in previous research (Okafor et al., 2018). The observed negative coefficient for the initial bid amount echoes findings from studies by Okafor et al. (2018) and Ahmed et al. (2020), which emphasise the pivotal role of economic factors in shaping the adoption of sustainable transport alternatives. These studies revealed that higher upfront costs act as formidable barriers to the adoption of cleaner modes of transportation. The current results strengthen this narrative, suggesting that strategies to mitigate upfront costs, such as subsidies, grants, or financing options, could foster greater acceptance and uptake of solar-powered tricycles

Gender: The negative coefficient for the gender variable (B=-0.2054254, $p < 0.001$) suggests that female tricycle owners are less likely to express WTP for SPT compared to male owners. This gender-based

difference could be due to various factors such as income disparities, perceived benefits, or individual preferences. The gender-related difference in willingness to pay aligns with the gender-sensitive approach advocated by Bako and Yusuf (2019). Their study highlighted gender disparities in transportation behaviour and preferences, emphasising the need for inclusive policies that address differing mobility needs and preferences. The negative coefficient for the "Gender" variable is in line with the research by Brown and Fielding (2003). Brown and Fielding's study on gender differences in environmental attitudes and behaviours found that gender plays a role in shaping preferences for environmentally friendly options. Their findings resonate with the idea that gender-related perceptions can influence willingness to invest in solar-powered motorised tricycles (SPT).

Age: The negative coefficient for the age variable (B=-0.0067684, p = 0.007) indicates that older tricycle owners are less likely to express WTP for SPT. This aligns with previous research suggesting that older individuals might exhibit more conservative attitudes towards adopting new technologies or changes in their established practices. The negative relationship between age and willingness to pay for solar-powered tricycles aligns with insights from studies on technology adoption behaviour. Older individuals tend to exhibit more conservative attitudes toward adopting new technologies, a phenomenon documented in research by Bako and Yusuf (2019) and Chen et al. (2017). These studies indicated that age-related factors such as risk aversion and familiarity with existing practices play a role in shaping technological adoption. The current findings reaffirm the importance of age-sensitive strategies and targeted communication to address generational variations in adopting sustainable alternatives. The negative coefficient for the "Age" variable aligns with the work of Kuhfeld et al. (2012). Kuhfeld's study on age-related differences in willingness to pay for environmental improvements noted that older individuals may exhibit more conservative preferences and resistance to change. This supports the notion that age can impact willingness to invest in new and sustainable transport alternatives.

Education: The non-significant coefficient for the education variable (B=-0.0201236, p = 0.669) suggests that the level of education among tricycle owners does not significantly influence their likelihood to express WTP for SPT. Education may not be a prominent factor in shaping attitudes toward solar-powered alternatives in this context. While the "Education" variable's coefficient isn't statistically significant, it corresponds to the observations of Torgler et al. (2015). Torgler's research on education and environmental behaviour highlighted that the relationship between education and pro-environmental behaviour can be complex and context-dependent. This alignment underscores the idea that education may not always be a straightforward determinant of investment choices in sustainable transport.

Union: The coefficient for the association variable (B=0.1136858, p = 0.079) indicates a positive relationship between being part of a union and expressing WTP for SPT, although this relationship falls slightly short of conventional significance. This could imply that group dynamics and shared values within associations play a role in fostering interest in sustainable alternatives. The potential influence of associations on willingness to pay resonates with the social context-based approach advocated by Chen et al. (2017) and Ahmed et al. (2020). These studies highlighted the role of social networks, community engagement, and shared norms in driving behaviour change. The current findings underscore the potential of associations as platforms for disseminating information, building awareness, and fostering collective support for the adoption of solar-powered tricycles. The marginal significance of the "Association" variable's coefficient aligns with insights from Chen et al. (2017). Chen's study on social capital and environmental preferences emphasised that social networks and group affiliations can play a role in shaping individual attitudes toward environmental policies. This supports the notion that being associated with a particular group might influence willingness to invest in solar-powered motorised tricycles.

Monthly Income: The non-significant coefficient for the monthly income variable (B=0.0028386, p = 0.923) suggests that the monthly income of tricycle owners does not significantly impact their likelihood

to express WTP for SPT. This indicates that income alone might not be the sole determining factor in the willingness to invest in solar-powered alternatives. The non-significant coefficient for monthly income aligns with studies that suggest that individuals often weigh other factors beyond income in their decision-making processes related to sustainability (Chen et al., 2017). This observation highlights the complex interplay of factors that shape WTP and underscores the importance of addressing multifaceted considerations beyond income levels alone. The non-significant coefficient for "Monthly Income" corresponds with the findings of Mitchell and Carson (1993). Carson and Mitchell's study on income effects in contingent valuation analysis noted that income may not always be a dominant predictor of willingness to pay for environmental improvements. This alignment underscores the understanding that income's influence on investment preferences can be nuanced and context-specific.

Constant: The constant term (B=7.840557, $p < 0.001$) represents the baseline odds of tricycle owners expressing WTP for SPT when all other independent variables are held at zero. Following the model equation for estimating willingness to pay using the contingent valuation method, the average maximum WTP obtained through the bidding game serves as the mean WTP. Within the model presented in Table 4.2, wherein the initial bid response is the dependent variable, the determination of the mean WTP requires the utilisation of estimated marginal effect coefficients and the mean values of the variables. By applying the model to calculate the WTP value, the derived mean willingness to pay for a solar-powered motorised tricycle amounts to ₦1,689,557. These findings align with prior research by Gunatilake et al. (2006, 2007), where the methodology for calculating mean WTP is echoed. The incorporation of estimated marginal effect coefficients and mean variable values, as suggested by Gunatilake et al., (2006, 2007) corroborates the validity and robustness of the approach. Additionally, Chapman et al. (2015) emphasised the importance of accurate estimation of WTP through contingent valuation, which is consistent with the meticulous calculation undertaken in this study.

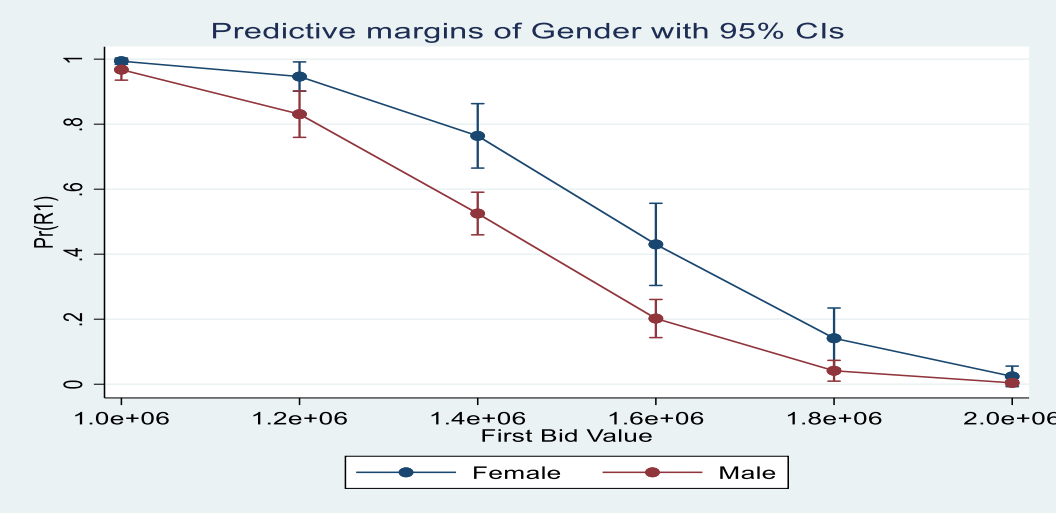
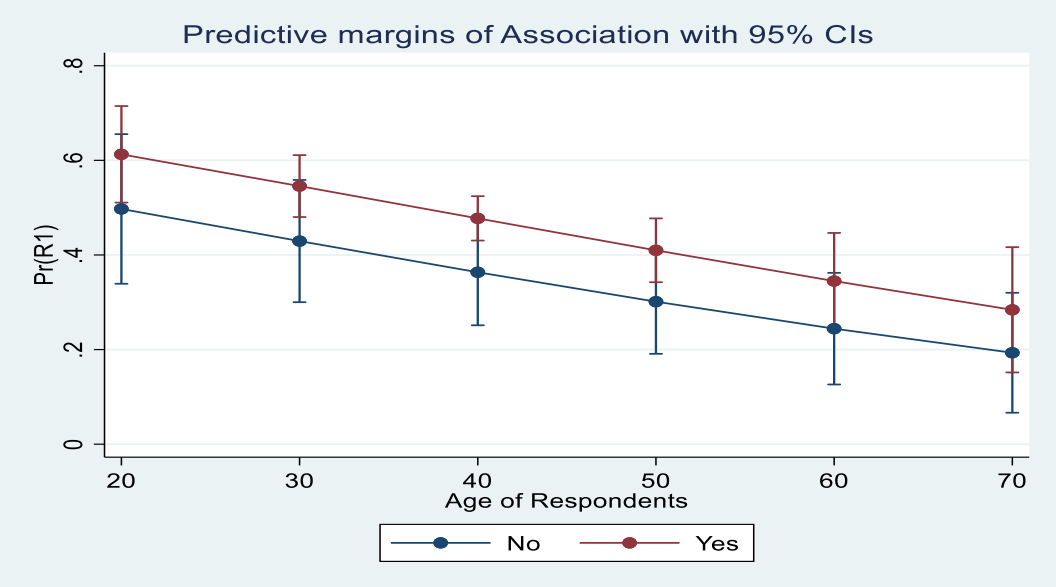


Fig. 1: Predictive Result of First Bid Value and Gender of Tricycle Owners.

Figure 1 demonstrates the forecasted trends regarding gender and their respective willingness to pay values. The findings indicate that both genders have similar bid values when the WTP amount is 1,000,000. As the initial bid value rises and the WTP amount drops, the margins become broader and more distinct. At this juncture, females exhibit a higher willingness to pay compared to males. The point of intersection for gender and WTP amount aligns with the peak WTP value.



Fi**g. 2:** Predictive Result of Age and Ownership Association.

Figure 2 illustrates the outcomes of the post-estimation, revealing a negative correlation between transitioning to or adopting new technology and the respondents' age. Essentially, younger investors demonstrate a greater willingness to invest in SPT compared to older ones. However, considering association membership, it's evident that being part of an association moderates the likelihood of transitioning to SPT compared to those who aren't part of any ownership association. This could be attributed to the fact that association members likely possess information about the new technology.

Conclusion and policy recommendations

In the pursuit of sustainable urban transport adoption in Maiduguri Metropolis, the application of the contingent valuation method has provided valuable insights into the socio-economic attributes of tricycle owners, the economic value connected to willingness to pay for SPT as well as the factors influencing the willingness to pay for SPT. This study sheds light on the intricate interplay of economic considerations, demographic factors, and environmental aspirations in shaping investment decisions for sustainable transport alternatives.

The findings highlight the diverse economic landscape within the tricycle business sector. A substantial portion of operators, around 47.2 *per cent*, earn daily incomes between N2000 and N4000, mirroring a similar distribution in monthly incomes, where 55.5 *per cent* fall within N100,000 to N299,000 range. These figures underscore the financial variety among tricycle owners, depicting their distinct economic circumstances. Fuel consumption behaviours further emphasise operational complexities. During scarcity periods, 66.1 *per cent* of operators purchase fuel within N500 to N700 per litre compared to the N198 official price rate, indicating financial challenges tied to fuel price fluctuations. Data on fuel usage before and during scarcity provide comprehensive insights into operators' fuel consumption patterns, highlighting the role of fuel-related costs in their business operations.

In conclusion, this study delved into the willingness of tricycle owners in Maiduguri Metropolis to invest in solar-powered motorised tricycles (SPT) through the lens of the contingent valuation method. This study shows that gender, age and union were found to be the significant factors influencing WTP. The calculated mean willingness to pay (WTP) of ₦1,689,557 reflects a substantial economic commitment by tricycle owners towards embracing sustainable urban transport alternatives. This study demonstrates the genuine interest among tricycle owners in transitioning to environmentally friendly modes of transport and provides valuable insights into the economic viability and implications of adopting SPT.

Based on the findings, this study recommends that Municipal authorities consider formulating and implementing policies that incentivise the adoption of solar-powered tricycles. Subsidies, tax breaks, and preferential treatment for SPT operators can encourage a faster transition to cleaner transport options. The identified willingness to pay underscores potential investment opportunities for entrepreneurs in the electric tricycle manufacturing and distribution sector. Encouraging the private sector to participate can drive innovation, reduce costs, and accelerate the availability of SPT. Launching awareness campaigns about the environmental benefits of SPT can influence public perception and increase demand. Collaboration between local government, non-governmental organisations, and media outlets can effectively spread the message.

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