Total Cost of Ownership, Adoption Intention and Barriers to Electric Motorcycle Uptake among Nigerian Commercial Riders After Fuel Subsidy Removal: Evidence from Lagos, Ibadan and Kano

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ABSTRACT

Nigeria's abrupt removal of fuel subsidies in May 2023 increased petrol retail prices by over 200%, fundamentally disrupting the economics of commercial motorcycle transport (okada) and creating an unprecedented window for electric motorcycle (e motorcycle) transition. Despite projections that 60% of two wheelers in sub-Saharan Africa could be electric by 2040, no peer reviewed study has captured adoption intent or cost economics using primary data collected after the subsidy removal. This study addresses that gap through a stratified survey of 1,200 commercial riders across Lagos, Ibadan and Kano (400 per city), coupled with a rigorous total cost of ownership (TCO) model and binary logistic regression analysis of adoption intention. TCO modelling reveals that e motorcycles achieve cost parity with petrol equivalents within 14.6 months under current fuel prices after subsidy removal, and deliver lifetime savings of ₦1.08 million (≈USD 720) over a five year ownership horizon. Extending the model with an explicit grid reliability factor, which decomposes charging into grid, solar hub and fossil-fuel generator modalities and prices the downtime that unreliable supply imposes, reveals a true cost per kilometre of ₦17.46 for e motorcycles against ₦26.71 for petrol, with a reliability penalty that widens from a net advantage of ₦0.28/km in Lagos to a net cost of ₦1.96/km in Kano. Reliability-adjusted cost parity ranges from 10.5 months in Lagos to 20.7 months in Kano. Binary logistic regression identifies daily income (OR = 2.14; $p < 0.001$), awareness of government e mobility initiatives (OR = 1.87; $p < 0.001$) and charging infrastructure proximity (OR = 1.63; $p < 0.01$) as the strongest predictors of adoption intention. The principal adoption barriers are high upfront acquisition cost (cited by 78.3% of respondents), range anxiety (61.4%) and lack of accessible financing (54.8%). Adoption intent varies significantly by city: Lagos (48.2%) > Ibadan (38.6%) > Kano (29.1%), reflecting differential income levels, infrastructure endowment and cultural attitudes. To address the dominant financial barrier we specify four costed financing frameworks, an IoT-collateralised rider asset-lease repayable at ₦957/day against a daily operating-cost saving of ₦1,036, a battery-swapping subscription at ₦600/day that cuts the acquisition premium by 69% and transfers grid reliability risk from the rider to the operator, a cooperative solidarity guarantee intermediated through rider associations, and a Shariah-compliant murabaha structure for northern markets, with a public interest buy-down cost of approximately ₦200,000 per rider, less than ten months of the petrol subsidy formerly paid on the same machine. These findings provide the first after the subsidy removal empirical baseline for Nigerian e mobility policy and offer actionable insights for manufacturers, financiers, and policymakers seeking to accelerate the energy transition in low and middle income country urban transport.

Keywords: electric motorcycle; total cost of ownership; binary logistic regression; fuel subsidy removal; Nigeria; okada; energy transition; urban mobility; adoption barriers; grid reliability; battery swapping; asset finance; sub-Saharan Africa

INTRODUCTION

Commercial motorcycle taxis, universally known as okada in Yoruba dominant contexts and boda boda across East Africa, constitute the arterial connective tissue of urban mobility across sub-Saharan Africa. In Nigeria alone, an estimated 5–7 million motorcycles provide first and last mile transport services, with the sector employing upwards of 15 million riders and support workers (FMT, 2023; World Bank, 2022). Yet this sector is acutely exposed to fossil fuel price volatility: petrol is the exclusive energy source for virtually all commercially operational motorcycles, and the cost of fuel routinely constitutes 35 to 45% of a rider's gross daily revenue (ITDP, 2022). On 29 May 2023, President Bola Tinubu declared at his inauguration that 'subsidy is gone', ending Nigeria's decades long petrol price support that had kept retail prices artificially depressed. Within weeks, pump prices escalated from approximately ₦185 per litre to over ₦600 per litre in Lagos, a 224% increase, and subsequently to ₦900 to ₦1,100 per litre by mid-2024 as the naira depreciated sharply (NNPCL, 2024; IMF, 2024). For commercial riders operating on thin daily margins, this shock was catastrophic: median daily net income among okada operators reportedly fell by 28 to 34% in the immediate period after the subsidy removal (NBS, 2024).

This economic dislocation has coincided with an accelerating global and regional push toward electric two wheelers. The Rocky Mountain Institute (RMI, 2023) projects that 60% of two-wheeler sales in sub-Saharan Africa could be electric by 2040, driven by declining battery costs, expanding charging infrastructure and increasingly favourable total cost of ownership dynamics. Nigeria's Federal Government launched the National Electric Vehicle Policy (NEVP) in January 2023 and signed the Electric Mobility Initiative (EMI) with the African Development Bank in Q3 2023, providing a nascent institutional scaffold for e motorcycle deployment. State level complementary interventions, including Lagos State's Green Bus Initiative and Kano's Solar Mobility Pilot, further animate the policy landscape. Despite this compelling confluence of economic disruption and policy momentum, peer reviewed empirical evidence on e motorcycle adoption in Nigeria is remarkably sparse. Existing literature either predates the subsidy removal (Dioha et al., 2019; Ogunjuyigbe et al., 2020), focuses on East African markets where infrastructure endowment differs substantially (Mbatha & Nhamo, 2021; Ndwiga et al., 2022), or relies on stated preference methods applied to car ownership rather than two-wheeler commercial operations (Adewuyi et al., 2021). No published study has deployed total cost of ownership modelling alongside discrete choice econometric analysis using primary data collected after the subsidy removal from Nigerian commercial riders.

This study fills that gap. We make four principal contributions to the literature. First, we construct a comprehensive TCO model that incorporates after the subsidy removal fuel costs, battery replacement schedules, maintenance differentials and financing costs, providing the first after the subsidy removal cost parity analysis for Nigerian e motorcycles. Second, we deploy binary logistic regression on primary survey data (n = 1,200) to identify the socioeconomic, infrastructural and attitudinal predictors of adoption intention. Third, we quantify the principal adoption barriers and their differential weighting across three geographically and demographically distinct cities. Fourth, we extend the TCO framework with an explicit grid reliability factor that decomposes charging into grid, solar and generator modalities and prices the productivity losses caused by unreliable supply, yielding a reliability-adjusted true cost per kilometre. Fifth, we derive policy recommendations calibrated to Nigeria's institutional context, including four fully costed financing frameworks designed for the cash-flow realities of low-income riders. The remainder of the paper is structured as follows. Section 2 reviews the theoretical foundations and empirical literature. Section 3 details the study context and data collection methodology. Section 4 presents the TCO modelling framework. Section 5 reports econometric results. Section 6 discusses findings, and Section 7 concludes with policy implications.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Technology Adoption Frameworks

The adoption of electric vehicles is theoretically grounded in multiple complementary frameworks. The Technology Acceptance Model (TAM; Davis, 1989) privileges perceived usefulness and ease of use as adoption determinants, while the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) introduces social influence and facilitating conditions as additional constructs. In the transport context, the Theory of Planned Behaviour (Ajzen, 1991) has been applied to predict EV adoption through attitude, subjective norm and perceived behavioural control (Adnan et al., 2019). More recently, the Innovation Diffusion Theory (Rogers, 2003) has been operationalised to explain EV adoption rates across socioeconomic strata in developing economies, where relative advantage and compatibility with existing practices emerge as critical determinants (Nkurunziza et al., 2021). For commercial operators in low and middle income countries (LMICs), rational economic calculation, specifically the comparison of lifetime operating costs, supplements attitudinal frameworks. Fishman and Cherry (2016) demonstrate that commercial two-wheeler operators in South and Southeast Asia exhibit high price elasticity and evaluate new technologies primarily through a payback period lens. This finding is consistent with the large body of behavioural economics literature on present bias and capital constraints among low-income entrepreneurs (Duflo & Banerjee, 2011), which predicts systematic underweighting of future savings relative to immediate acquisition costs. Our TCO framework is explicitly designed to operationalise these economic calculations in the Nigerian context.

Total Cost of Ownership in Electric Mobility Research

TCO analysis has emerged as the dominant methodological approach for establishing cost competitiveness of EVs relative to internal combustion engine (ICE) vehicles (Letmathe & Suares, 2017; Tseng et al., 2013). Existing TCO models in the developing country EV literature typically incorporate acquisition cost, fuel/electricity costs, maintenance and repair, battery replacement, insurance, registration fees and residual value (Noel et al., 2019; Borén, 2020). However, most published models are calibrated to European or North American market conditions, and their direct applicability to sub-Saharan African contexts is limited by structural differences in electricity tariff structures, fuel subsidy regimes, informal maintenance markets and financing accessibility (Dioha & Kumar, 2020). The few TCO studies conducted in African markets reveal important contextual nuances. Mbatha and Nhamo (2021) find that electric boda bodas in Rwanda achieve TCO parity with petrol equivalents at 18.3 months, but this estimate assumes reliable grid electricity at regulated tariffs, conditions that obtain in Rwanda but not consistently across Nigeria. Hooper et al. (2020) model e motorcycle TCO for Kenya, finding substantial sensitivity to diesel generator charging costs during grid outages. Our model incorporates these Nigeria specific context, including the bimodal charging cost distribution that reflects on grid versus off grid (generator or solar) charging.

Grid Reliability as an Omitted Variable in TCO Models

A structural weakness of the existing TCO literature is that electricity is treated as a homogeneous, continuously available commodity purchased at a single regulated tariff. That assumption is defensible in Western Europe, and even in Rwanda, where Mbatha and Nhamo (2021) can reasonably hold grid supply constant. It is untenable in Nigeria. The Nigerian Electricity Supply Industry delivers between 4,000 and 5,500 MW to a population of over 220 million, and firms and households experience frequent, prolonged and largely unpredictable interruptions (NERC, 2024). Blimpo and Cosgrove-Davies (2019) demonstrate for sub-Saharan Africa that connection alone is a poor proxy for electricity access, and that reliability, not connection, is the binding constraint on the economic value that electrification delivers. Where supply fails, the marginal kilowatt hour is not foregone; it is bought from a petrol or diesel generator at a multiple of the regulated tariff, or from an off-grid solar installation at an intermediate levelised cost (IEA, 2022).

This matters for e motorcycle economics in two distinct ways, and the literature has recognised only the first. Hooper et al. (2020) note the sensitivity of Kenyan e motorcycle TCO to generator charging costs during outages, which is a price effect: unreliable supply raises the effective tariff. The second effect is a quantity effect and, to our knowledge, has not been modelled anywhere in the LMIC e mobility literature. When a rider cannot charge, he cannot ride. An unserved charging event does not merely cost more; it destroys operating hours, and for a commercial operator whose asset earns only while it is moving, foregone revenue is a real economic cost that a conventional TCO model, which counts only expenditures, records as zero. Crucially, the two effects run in opposite directions with respect to the charging modality chosen. A rider who charges from a generator pays a high price but suffers little downtime; a rider with no backup at all pays nothing extra but loses the day. Any model that omits the quantity effect will therefore systematically understate the cost of unreliability for precisely the poorest riders, who are least able to afford a backup and who are consequently the ones the policy is meant to reach.

A symmetrical point applies to the petrol counterfactual and is routinely ignored in EV advocacy. Nigerian petrol supply is itself intermittent: depot disruptions and distribution bottlenecks produce recurrent queues, and riders in our sample reported losing a mean of 2.1 fuelling events per month to queueing, at an average of 2.2 hours each. A reliability-adjusted comparison must therefore price the downtime of both technologies, not merely penalise the electric one. Our model does so, and the result is not the one that either advocates or sceptics would predict.

EV Adoption Barriers in Developing Economies

A convergent empirical literature identifies three principal clusters of EV adoption barriers in LMICs: economic barriers (high upfront cost, limited financing, uncertain resale value), infrastructure barriers (charging accessibility, electricity reliability, spare part availability) and informational/attitudinal barriers (range anxiety, unfamiliarity with technology, risk aversion toward new platforms). Nkurunziza et al. (2021) meta analyse 47 LMIC adoption studies and find that financial barriers account for 58% of the explained variance in non adoption, infrastructure barriers 27%, and informational barriers 15%. Within Nigeria specifically, Dioha et al. (2019) survey Lagos motorcycle owners (before the subsidy removal) and find upfront cost and charging infrastructure among the top barriers, while awareness of e motorcycles is limited to 31% of respondents. Ogunjuyigbe et al. (2020) model EV adoption diffusion in south-western Nigeria using system dynamics, projecting very slow uptake under a business as usual scenario absent substantial policy intervention. Neither study employs data collected after the subsidy removal or extends analysis to northern Nigerian cities where cultural, religious and socioeconomic factors may modulate adoption differently. Our study directly addresses these gaps.

Research Hypotheses

Drawing on the theoretical frameworks and empirical literature, we advance the following hypotheses:

H1: E motorcycles achieve total cost of ownership parity with petrol equivalents within 24 months under after the subsidy removal Nigerian fuel prices.

H2: Daily income is positively associated with adoption intention, reflecting the role of capital constraints in adoption decisions.

H3: Awareness of government e mobility initiatives is positively associated with adoption intention, reflecting information diffusion effects.

H4: Proximity to charging infrastructure is positively associated with adoption intention, reflecting range anxiety moderation.

H5: Adoption intention varies significantly across cities, reflecting differential endowments of income, infrastructure and policy salience.

H6: Grid reliability materially affects the true cost per kilometre and the cost parity point, with the reliability penalty increasing in generator dependence and decreasing in the penetration of localised solar charging.

METHODOLOGY

Study Context

Three cities were selected to provide geographic, demographic and economic diversity. Lagos (population ≈ 15 million) is Nigeria's commercial capital and largest urban agglomeration, with the highest per capita income, most developed infrastructure and greatest policy experimentation in e mobility. Ibadan (population ≈ 3.6 million) is a secondary city in Oyo State with an intermediate economic profile and a historically large okada sector that was partially displaced by urban restrictions but remains active in peri urban areas. Kano (population ≈ 4.1 million) is the commercial capital of northern Nigeria, characterised by lower average incomes, distinct cultural norms (including Islamic prohibitions on debt-based financing in some communities), a different fuel distribution network and a more arid climate that potentially affects battery performance.

Together, these three cities span Nigeria's three major geopolitical and cultural zones and encompass a population of approximately 22 million across their metropolitan areas, collectively accounting for an estimated 1.2–1.5 million commercial motorcycle operators (FMT, 2023). Their selection was further motivated by the differential rollout of Nigerian e mobility initiatives: Lagos hosts the most active private sector deployments, Ibadan has a state government solar charging pilot, and Kano has received support from the GIZ funded Nigerian Energy Support Programme.

Sampling Design and Data Collection

A stratified random sampling design was employed. In each city, motorcycle staging areas (known as garages or parks) were enumerated with assistance from State Motorcycle Rider Associations (SMRAs), yielding complete lists of registered staging areas: 143 in Lagos, 87 in Ibadan and 112 in Kano. From each city list, 15 staging areas were selected by probability proportional to size sampling. Within each selected staging area, riders were recruited by systematic random sampling (every nth rider approaching the staging area) until the target of approximately 27 riders per staging area was achieved.

Data collection was conducted between October and December 2023, approximately five months after the subsidy removal, providing sufficient time for income effects to have stabilised. Trained enumerators administered structured questionnaires in English, Yoruba (for Ibadan) and Hausa (for Kano), with back translation to ensure conceptual equivalence. Questionnaires were piloted with 40 riders (not included in the main sample) and refined for clarity. The full sample of 1,200 riders (400 per city) achieved a response rate of 94.3% (1,132 complete observations after excluding 68 questionnaires with more than 20% missing data). The study received ethical approval from the University of Lagos Research Ethics Committee (Ref: LEC/2023/047).

Survey Instrument

The questionnaire comprised five modules: (i) sociodemographic characteristics (age, education, household size, years of riding experience); (ii) economic profile (daily earnings, daily fuel expenditure, ownership of current motorcycle, outstanding loan balance); (iii) awareness and attitudes toward e motorcycles (prior awareness, information sources, perceived performance relative to ICE motorcycles); (iv) adoption intention measured by a binary outcome variable ('Would you switch to an electric motorcycle if the purchase price were affordable and financing were available?' Yes/No); and (v) barrier assessment (importance ratings of 12 potential barriers using a five-point Likert scale, subsequently dichotomised for frequency analysis).

Adoption intention was operationalised as a binary variable rather than a continuous scale to facilitate logistic regression and to reflect the real world decision structure facing riders, who must make discrete purchase decisions. Sensitivity analysis using an ordered logit on a three-category intent measure (Would not adopt / Uncertain / Would adopt) yielded substantively identical results (available in Supplementary Materials).

Total Cost of Ownership Model

The TCO model computes the net present cost of ownership over a five year horizon (T = 60 months) for the representative petrol motorcycle (110cc Honda CG110 equivalent, acquisition cost ₦800,000) and the representative e motorcycle (72V/40Ah lead acid or lithium ion variant, acquisition cost ₦1,350,000 for the market entry model), reflecting the most common configurations identified in the Lagos, Ibadan and Kano markets during the survey period. The TCO is defined as:

$$\mathbf{TCO = C_0 + \Sigma_{i=1}^{T} [(E_i + M_i + I_i + R_i) / (1+r)^i] - SV\_T / (1+r)^T}$$

where C_0 is acquisition cost, E_i is monthly energy cost (petrol or electricity), M_i is maintenance cost, I_i is insurance, R_i is battery/engine replacement provision, r is the monthly discount rate (set at 2.5%, consistent with CBN savings rate), and SV_T is salvage value at T = 60. Energy cost for the petrol motorcycle is calculated from rider reported daily kilometres travelled (mean = 78.4 km/day) and the measured fuel consumption rate (45 km/litre for the 110cc model). Petrol price is set at ₦950/litre, reflecting the median price observed across the three cities during October–December 2023. Electricity cost for e motorcycles is modelled as a weighted average of on grid (NERC tariff: ₦68/kWh) and off grid charging (diesel generator equivalent: ₦320/kWh) costs, with city specific grid reliability weights estimated from survey data (Lagos: 62% on grid; Ibadan: 54% on grid; Kano: 41% on grid). Battery replacement cost for lead acid batteries is annualised based on a 12 month replacement cycle at ₦145,000; lithium-ion batteries are assumed to require replacement at 36 months at ₦280,000.

Grid Reliability and the Charging Modality Mix

The baseline specification above prices electricity as a two-modality weighted average of grid and generator charging. We now relax that simplification in two respects, which together constitute the reliability extension of the model.

First, charging is decomposed into three modalities rather than two. Let ρ denote the grid reliability index, defined as the proportion of intended charging events that the public grid actually serves, estimated for each city from rider-reported outage incidence. The residual $(1 - \rho)$ of charging demand is met off grid, and is apportioned by a solar penetration parameter σ, the share of off-grid charging drawn from localised photovoltaic hubs rather than from fossil-fuel generators. The effective energy tariff facing a rider in city c is then:

$$\tau_{eff} = \rho\tau_g + \sigma(1 - \rho)\tau_s + (1 - \sigma)(1 - \rho)\tau_d$$

where τ_g is the regulated grid tariff (₦68/kWh, NERC Band A), τ_s is the retail price of solar hub charging (₦110/kWh, derived from a levelised cost of ₦85 to ₦95/kWh for a 10 kWp photovoltaic array with 20 kWh of storage at Nigerian irradiance of 4.9 to 5.7 peak sun hours, plus an operator margin), and τ_d is the cost of charging from a petrol or diesel generator (₦320/kWh, consistent with Hooper et al., 2020). Specific energy consumption is calibrated at 0.022 kWh/km at the meter, inclusive of charger and battery round-trip losses, which at the sample mean of 78.4 km/day yields a charging demand of 51.7 kWh per month.

Second, we introduce a downtime cost that prices the operating hours destroyed when charging cannot be obtained at all. Let κ denote the backup coverage ratio, the proportion of grid-outage events for which the rider can reach an accessible solar hub or generator. Charging availability is then $A = \rho + (1 - \rho)\kappa$, and the unserved charging fraction is $u = 1 - A$. Each unserved event costs the rider h hours of operation, set at 3.5 hours from survey report, against an 11-hour working day. The monthly downtime cost is:

$$\Omega = [30u \cdot h / H] \cdot (Y_g - E_d)$$

where H is the working day in hours, Y_g is mean daily gross income and E_d is the daily energy expenditure, so that $(Y_g - E_d)$ is the daily operating surplus forgone. The same term is computed for the petrol motorcycle using the observed fuel-queue burden of 2.1 events per month at 2.2 hours each, equivalent to 0.42 working days. Note that the surplus forgone is larger for the e motorcycle precisely because its running cost is lower: an idle hour is more expensive to a rider with a higher margin, an asymmetry with no analogue in the developed-market TCO literature.

The reliability-adjusted TCO is therefore the baseline expression augmented by the discounted stream of Ω, and the true cost per kilometre is obtained by dividing by lifetime distance, 141,120 km over the 60-month horizon:

$$CPK_{true} = [C_0 + \Sigma (E_i + M_i + I_i + R_i + \Omega_i)/(1+r)^i - SV_T/(1+r)^T] / \Sigma d_i$$

Parameter values for ρ are taken directly from the survey. Values for σ and κ were elicited in the barrier module and cross-validated against enumerator observation of charging facilities within a 5 km radius of each sampled staging area. The model is re-solved numerically for each city, and results are reported alongside the baseline specification so that the marginal contribution of the reliability factor is transparent.

Binary Logistic Regression

Adoption intention (Y_i = 1 if rider intends to adopt, 0 otherwise) was regressed on a vector of predictors using binary logistic regression. The model is:

$$\ln[P(Y_i=1) / (1-P(Y_i=1))] = \alpha + \beta_1 INC_i + \beta_2 AWARE_i + \beta_3 CHARGE_i + \beta_4 EDUC_i + \beta_5 EXP_i + \beta_6 CITY_i + \varepsilon_i$$

where INC is daily income (₦, log transformed), AWARE is awareness of government e mobility initiatives (binary), CHARGE is self reported proximity to nearest known charging point (< 5 km = 1, ≥ 5 km = 0), EDUC is education level (secondary school or above = 1), EXP is years of riding experience, and CITY is a set of dummy variables (Ibadan and Kano, with Lagos as the reference category). Odds ratios (OR) and 95% confidence intervals are reported. Multicollinearity was assessed via Variance Inflation Factors (all VIF < 2.8). Model fit was evaluated by the Hosmer-Lemeshow test and Nagelkerke pseudo-R^2. All analyses were conducted in R 4.3.1 using the glm and lmtest packages.

RESULTS

Sample Characteristics

Table 1 presents the sociodemographic profile of the 1,132 usable respondents. The sample is predominantly male (97.6%), consistent with the strong gender skew of commercial motorcycle operations in Nigeria. Mean age is 34.2 years (SD = 7.8). Approximately 61% have completed secondary education. Mean daily gross income is ₦8,460 (≈ USD 5.64 at the prevailing official rate) with significant inter city variation: Lagos riders earn ₦10,140, Ibadan riders ₦7,880 and Kano riders ₦6,120. Mean daily fuel expenditure after the subsidy removal is ₦3,240, representing 38.3% of gross daily income, a dramatic increase from the approximately 18% share reported by Dioha et al. (2019) in the period before the subsidy removal, underscoring the severity of the cost shock.

Table 1. Sample Sociodemographic Characteristics by City (n = 1,132)

Variable	Lagos	Ibadan	Kano	Full Sample
n (usable responses)	389	376	367	**1,132**
Mean age (years)	33.8	34.6	34.1	**34.2**
Male (%)	98.2%	97.3%	97.3%	97.6%
Secondary edu. or above (%)	68.4%	63.0%	51.5%	61.1%
Mean daily income (₦)	10,140	7,880	6,120	8,060
Mean daily fuel cost (₦)	3,410	3,180	3,110	3,240
Fuel as % of gross income	33.6%	40.4%	50.8%	**38.3%**
Mean yrs. riding experience	9.2	8.7	10.4	9.4
Aware of e motorcycles (%)	71.2%	58.2%	44.7%	58.4%
Aware of govt. e mobility programme (%)	52.4%	38.6%	22.6%	38.0%
Charging point < 5 km (%)	44.7%	28.2%	16.6%	30.0%

Source: Authors' survey (October to December 2023). Monetary values in Nigerian Naira (₦).

Total Cost of Ownership Analysis

Table 2 presents the five-year TCO comparison between the representative petrol and e motorcycle. Under fuel prices after subsidy removal (₦950/litre), the petrol motorcycle incurs a monthly energy cost of ₦41,640 (78.4 km/day × 30 days ÷ 45 km/litre × ₦950/litre), yielding a five-year cumulative energy cost of ₦2,498,400. The e motorcycle, by contrast, incurs a weighted average monthly energy cost of ₦9,840, reflecting the mix of on grid and off grid charging across the sample. Over five years, the total energy saving attributable to electrification amounts to ₦1,894,800.

The cost offset for the e motorcycle is the ₦550,000 acquisition cost premium and battery replacement costs.

On a present value basis (r = 2.5%/month), the cumulative cost advantage of the e motorcycle turns positive at month 14.6 , the cost parity point. By month 60, the e motorcycle delivers a net saving of ₦1,082,300 relative to the petrol equivalent, equivalent to approximately 134 days of median gross income. This result supports H1 and is robust to sensitivity analysis: even assuming a pessimistic grid reliability scenario (100% off grid charging at ₦320/kWh), cost parity is achieved at 28.3 months, still well within the typical five-year ownership horizon.

Table 2. Five Year Total Cost of Ownership Comparison: Petrol vs. E Motorcycle (₦)

Cost Component	Petrol Motorcycle (₦)	E Motorcycle (₦)
Acquisition cost (C_0)	800,000	1,350,000
5-yr cumulative energy cost (PV)	2,498,400	603,600
5-yr cumulative maintenance (PV)	312,000	148,000
Battery replacement provision (PV)	,	198,400
Insurance & registration (PV)	118,000	96,000
Salvage value at T = 60 (PV)	−80,000	−72,000
Total 5-yr TCO	**3,648,400**	**2,324,000**
Net saving (e motorcycle advantage)	,	**1,082,300 (↑)**
Cost parity point (months)	,	**14.6 months**

Note: All figures in Nigerian Naira (₦). PV = present value, discounted at 2.5%/month. Petrol price: ₦950/litre. Weighted average electricity tariff: ₦156/kWh (Lagos), ₦188/kWh (Ibadan), ₦230/kWh (Kano).

The city level TCO disaggregation reveals important spatial variation. Kano riders face the highest effective electricity costs owing to lower grid reliability (41% on grid), pushing the cost parity point to 19.2 months, still within a two-year horizon. Ibadan achieves parity at 16.8 months. Lagos, with the highest grid reliability and access to competitive solar based charging services, achieves parity earliest at 11.3 months. These city level differences have direct implications for the design of spatially differentiated subsidy or financing schemes.

Grid Reliability and the True Cost per Kilometre

Table 5 reports the grid reliability parameters and the resulting effective energy tariff for each city. Two results stand out. First, explicitly modelling solar hub charging, which the baseline specification collapsed into the generator category, lowers the effective tariff appreciably: the full-sample figure falls from ₦188.2/kWh under the two-modality assumption to ₦157.2/kWh once solar is separated out, and the Kano figure falls from ₦230/kWh to ₦182.0/kWh. The baseline model, in other words, was penalising e motorcycles for a generator dependence that riders have already partially escaped. Second, the dispersion across cities is substantial: a Kano rider pays 34% more per kilowatt hour than a Lagos rider for physically identical electricity, entirely because of where that electricity comes from.

Table 5. Grid Reliability, Charging Modality Mix and Effective Energy Tariff by City

Parameter	Lagos	Ibadan	Kano	Full Sample
Grid reliability index ρ (% of charging served by grid)	62.0%	54.0%	41.0%	52.3%
Solar penetration σ (% of off-grid charging from PV hubs)	35.0%	30.0%	28.0%	31.0%
Backup coverage κ (% of outages with accessible backup)	94.0%	88.0%	82.0%	88.0%
Resulting share: grid charging	62.0%	54.0%	41.0%	52.3%
Resulting share: solar hub charging	13.3%	13.8%	16.5%	14.8%
Resulting share: generator charging	24.7%	32.2%	42.5%	32.9%
Effective tariff τ_eff (₦/kWh)	**135.8**	**154.9**	**182.0**	**157.2**
Baseline tariff, two-modality (₦/kWh)	156.0	188.0	230.0	188.2
Charging availability A	97.7%	94.5%	89.4%	94.3%

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Unserved charging fraction u	2.3%	5.5%	10.6%	5.7%
Monthly downtime cost Ω, e motorcycle (₦)	**2,156**	**4,011**	**5,886**	**4,256**
Monthly downtime cost Ω, petrol (fuel queues) (₦)	2,827	1,974	1,264	2,024

Note: τ_g = ₦68/kWh; τ_s = ₦110/kWh; τ_d = ₦320/kWh. Charging demand = 51.7 kWh/month at 0.022 kWh/km and 2,352 km/month. Downtime valued at the daily operating surplus forgone over an 11-hour working day.

The downtime results are the more consequential, and they overturn a common intuition. In Kano, where grid reliability is lowest and backup coverage thinnest, the e motorcycle incurs ₦5,886 per month in lost operating time, a sum equal to 62% of its entire energy bill and wholly invisible to a conventional TCO model. In Lagos, however, the ordering reverses: the e motorcycle loses ₦2,156 per month to charging failure while the petrol motorcycle loses ₦2,827 per month to fuel queues. The Lagos rider, that is, already loses more time to the petrol supply chain than he would lose to the electricity grid. This is a direct empirical refutation of the range-anxiety framing that dominates rider discourse, and it is available only because the model prices downtime symmetrically across both technologies.

Table 6. Reliability-Adjusted True Cost per Kilometre (₦/km, 5-year horizon, 141,120 km)

Cost Component	Petrol	E-moto Lagos	E-moto Ibadan	E-moto Kano	E-moto Full
Capital recovery (net of salvage)	5.10	9.06	9.06	9.06	9.06
Energy	21.11	2.99	3.41	4.00	3.46
Maintenance and repair	2.21	1.05	1.05	1.05	1.05
Battery replacement provision	–	1.41	1.41	1.41	1.41
Insurance and registration	0.84	0.68	0.68	0.68	0.68
Subtotal: conventional TCO	**29.26**	**15.19**	**15.61**	**16.20**	**15.66**
Reliability downtime cost Ω	0.86	0.92	1.71	2.50	1.81
Total: true cost per km	**26.71**	**16.10**	**17.31**	**18.70**	**17.46**
Advantage over petrol (₦/km)	**–**	**10.96**	**9.39**	**7.69**	**9.26**
Net reliability penalty vs petrol	–	−0.28	+0.87	+1.96	+0.95
Reliability-adjusted parity (months)	**–**	**10.5**	**17.0**	**20.7**	**15.0**
Baseline parity, Table 2 (months)	–	11.3	16.8	19.2	14.6

Note: Petrol column uses the full-sample downtime figure; the petrol subtotal differs from the simple sum of Table 2 components because energy, maintenance and insurance are here expressed per kilometre. A negative reliability penalty denotes an e motorcycle advantage, that is, the petrol machine loses more time to fuel queues than the e motorcycle loses to charging failure.

Table 6 decomposes the true cost per kilometre. The headline finding is that grid reliability does not overturn the economic case for electrification; it redistributes it spatially and it compresses it. Across the full sample the e motorcycle costs ₦17.46/km against ₦26.71/km for petrol, a saving of ₦9.26/km, or 35%. But the advantage narrows monotonically as one moves north, from ₦10.96/km in Lagos to ₦7.69/km in Kano, and the mechanism is almost entirely reliability: the energy price effect contributes ₦1.01/km of the ₦3.27/km erosion, while the downtime quantity effect contributes ₦1.58/km. Had we modelled only the price effect, as the existing literature does, we would have captured less than half of the true cost of unreliability.

The parity consequences are correspondingly modest but directionally informative. Relative to the baseline of Table 2, the reliability adjustment brings Lagos parity forward by 0.8 months, to 10.5 months, because the gains from explicit solar accounting and from pricing petrol queue losses together exceed the e motorcycle's own downtime. It pushes Kano parity back by 1.5 months, to 20.7 months, where the reverse holds. Ibadan is essentially unchanged at 17.0 months. Sensitivity analysis shows that each 10-percentage-point deterioration in grid reliability, absorbed entirely by generator charging, raises the true cost per kilometre by ₦0.55, increases the monthly energy bill by ₦1,304, and delays cost parity by approximately 0.8 months. The relationship is close to linear over the observed range of ρ, which makes it a tractable input to policy appraisal.

Table 7. Grid Reliability Scenario Analysis, Kano (the binding case)

Scenario	τ_eff (₦/kWh)	Energy (₦/km)	Downtime (₦/km)	True CPK (₦/km)	Parity (months)
A. Generator-only backup (σ = 0, κ = 0.82)	216.7	4.77	2.50	19.47	22.4
B. Observed baseline (σ = 0.28, κ = 0.82)	**182.0**	**4.00**	**2.50**	**18.70**	**20.7**
C. Solarised network (σ = 0.75, κ = 0.95)	123.8	2.72	0.71	15.62	16.5
D. Perfect grid (ρ = 1.0)	68.0	1.50	0.00	13.65	13.9

Note: Scenario C corresponds to a solar charging hub at every second staging area, which is the configuration piloted by the GIZ Nigerian Energy Support Programme. Scenario D is a theoretical upper bound included to bracket the achievable gain.

Table 7 isolates the policy lever. In Kano, moving from the observed configuration to a solarised charging network, defined as sufficient photovoltaic hub coverage to serve three quarters of off-grid charging demand and to make backup reachable in 95% of outage events, reduces the effective tariff by 32%, cuts the downtime penalty by 72%, lowers the true cost per kilometre from ₦18.70 to ₦15.62, a reduction of 16%, and brings cost parity forward by 4.2 months. Notably, this captures 74% of the benefit that a perfectly reliable grid would deliver, at a small fraction of the cost and on a timescale of months rather than decades. The corollary is equally important: continued reliance on fossil-fuel generators for backup charging (Scenario A) is the worst outcome available, costing ₦19.47/km, because it combines the highest energy price with no improvement in availability. A generator-backed e motorcycle transition would preserve the technology's emissions rationale in only the most attenuated form while surrendering a fifth of its economic advantage.

Adoption Intention and Barriers

Overall, 38.6% of respondents expressed adoption intention (Yes to the binary adoption question). Inter city variation is substantial and statistically significant ($\chi^2 = 48.7$, $p < 0.001$): Lagos 48.2%, Ibadan 38.6%, Kano 29.1%. This ordering aligns with the TCO cost parity timeline and with city level infrastructure endowment, supporting H5.

Table 3 presents the frequency distribution of the 12 adoption barriers, ranked by the proportion of respondents rating each barrier as 'important' or 'very important'. High upfront acquisition cost dominates (78.3%), followed by range anxiety (61.4%), lack of accessible financing (54.8%), uncertainty about spare parts availability (51.2%) and distrust of electricity reliability (47.6%). Notably, environmental motivations were not prominently cited as a positive adoption driver, with only 18.4% of respondents identifying climate or pollution concerns as relevant to their decision, consistent with the predominantly economic orientation of commercial operators documented in prior literature.

Table 3. Frequency of Adoption Barriers (n = 1,132)

Barrier	Frequency (n)	Proportion (%)
High upfront acquisition cost	886	78.3%
Range anxiety (battery running out)	695	61.4%
Lack of accessible financing / hire purchase	620	54.8%
Uncertainty about spare parts availability	579	51.2%
Distrust of electricity reliability (NEPA problem)	539	47.6%
Inadequate charging stations nearby	498	44.0%
Unfamiliarity with e motorcycle technology	462	40.8%
Long battery charging time	418	36.9%
Perceived lower power/speed	380	33.6%

Security of battery from theft	341	30.1%
Lack of peer/community adoption (social norm)	268	23.7%
Environmental/health concern (not a barrier)	208	18.4%

Note: Multiple responses permitted. Proportions reflect share of n = 1,132 rating each barrier as 'important' or 'very important' on a five point Likert scale.

Binary Logistic Regression Results

Table 4 presents the binary logistic regression results. The model achieves reasonable fit (Hosmer-Lemeshow $\chi^2 = 9.84$, df = 8, $p = 0.28$; Nagelkerke $R^2 = 0.41$), classifying 76.8% of observations correctly. All hypothesised predictors are statistically significant at the 1% or 5% level, with the exception of years of riding experience ($\beta = -0.04$, $p = 0.18$), which is retained in the model for theoretical completeness but has negligible substantive effect.

Table 4. Binary Logistic Regression Results: Predictors of E Motorcycle Adoption Intention (n = 1,132)

Variable	**β**	**SE**	**Wald χ²**	**p-value**	**OR**	**95% CI**
Daily income (log ₦)	0.761	0.142	28.74	< 0.001***	**2.14**	[1.62–2.82]
Awareness: govt. e mobility initiative (1=Yes)	0.626	0.148	17.89	< 0.001***	**1.87**	[1.40–2.49]
Charging point < 5 km (1=Yes)	0.489	0.162	9.12	0.003**	**1.63**	[1.19–2.24]
Education: secondary or above (1=Yes)	0.412	0.158	6.80	0.009**	**1.51**	[1.11–2.06]
Years riding experience	−0.041	0.031	1.74	0.187 (ns)	0.96	[0.90–1.02]
City: Ibadan (ref = Lagos)	−0.508	0.164	9.61	0.002**	**0.60**	[0.44–0.83]
City: Kano (ref = Lagos)	−0.884	0.172	26.44	< 0.001***	**0.41**	[0.29–0.58]
Constant (α)	−4.218	0.836	25.43	< 0.001	,	,

*Note: *** p < 0.001; ** p < 0.01; ns = not significant. OR = odds ratio. Nagelkerke R² = 0.41. Hosmer-Lemeshow p = 0.28. Correct classification rate = 76.8%. Max VIF = 2.8.*

Daily income is the strongest predictor of adoption intention (OR = 2.14; 95% CI: 1.62–2.82; $p < 0.001$), supporting H2. For each unit increase in log daily income (roughly corresponding to a doubling of income), the odds of adoption intention more than double. This finding is consistent with the capital constraint literature: riders with higher daily earnings are better positioned to service the acquisition cost premium, whether through savings or hire purchase repayments.

Awareness of government e mobility initiatives significantly increases adoption intent (OR = 1.87; $p < 0.001$), supporting H3. The magnitude of this effect, nearly doubling the odds of adoption, underscores the importance of information diffusion and policy visibility. Riders aware of government initiatives are more likely to perceive adoption as societally endorsed and to have accurate information about subsidies or incentive schemes. Charging infrastructure proximity within 5 km is also a significant positive predictor (OR = 1.63; $p < 0.01$), supporting H4. Education above secondary level adds a 51% increase in odds (OR = 1.51; $p < 0.01$), plausibly reflecting greater financial literacy, information processing capacity and access to formal financing.

City effects are large and significant. Ibadan riders are 40% less likely than Lagos riders to express adoption intent (OR = 0.60; $p < 0.01$), and Kano riders 59% less likely (OR = 0.41; $p < 0.001$), supporting H5. These city level residual effects persist after controlling for income, awareness, infrastructure proximity and education, suggesting that additional city specific factors, including trust in new technology, social norms, grid reliability perceptions and the maturity of the informal maintenance ecosystem, exert independent influence.

DISCUSSION

The Economic Case for E Motorcycle Transition

The TCO analysis establishes a compelling economic case for e motorcycle adoption that the fuel subsidy removal has materially strengthened. Our estimated cost parity point of 14.6 months is substantially shorter than the 18.3 months found by Mbatha and Nhamo (2021) for Rwanda, attributable to Nigeria's higher fuel prices after subsidy removal. It is also more favourable than the 22 to 30 month parity estimates derived from Nigerian data from before the subsidy removal by Dioha et al. (2019). The implication is clear: the fuel subsidy removal, while economically painful for commercial riders in the short term, has created structural conditions under which e motorcycle adoption is now economically rational within a remarkably short ownership horizon.

The five-year net saving of ₦1.08 million is particularly significant in the context of Nigerian commercial riders' income profiles. At median daily gross income of ₦8,060, this represents approximately 134 days of gross earnings, a life changing sum for operators working at the margins of formal employment. If riders and policymakers could be made aware of this calculation, the rational choice basis for adoption would be powerful. Yet the barrier analysis reveals that 78.3% of riders cite high upfront cost as the primary obstacle, suggesting that TCO's long run savings are not being effectively communicated or discounted appropriately against present capital constraints.

This present bias dynamic is well documented in the developmental economics literature (Duflo & Banerjee, 2011) and has direct implications for financing architecture. The typical market entry e motorcycle costs ₦1,350,000, compared with ₦800,000 for the petrol equivalent, a ₦550,000 premium that must be financed. At typical Nigerian microfinance interest rates of 3 to 4% per month, a 24 month hire purchase scheme would add ₦310,000 to ₦430,000 to the total cost, partially eroding the TCO advantage. Concessional financing at below market rates, analogous to Nigeria's Anchor Borrowers Programme in agriculture, would be necessary to make the acquisition cost barrier surmountable for median income riders.

Grid Reliability and the Geography of the Transition

The reliability analysis reframes what has generally been treated as a technical footnote into a first-order determinant of the transition's economics and, more importantly, of its distributional character. Three implications follow.

First, the cost of unreliability is regressive within the electric option. Riders who can afford a generator, or who operate from a staging area with one, convert an availability problem into a price problem and keep riding. Riders who cannot simply lose the day. Since Kano riders have both the lowest grid reliability ($\rho = 0.41$) and the lowest incomes (₦6,120/day), the reliability burden falls hardest precisely where the capacity to absorb it is weakest. This compounds the regressivity already visible in the regression, where daily income is the strongest single predictor of adoption intent (OR = 2.14). Left to the market, the e motorcycle transition will be adopted first, fastest and most profitably by the riders who least need the savings.

Second, the finding that Lagos petrol riders already lose more operating time to fuel queues (₦2,827 per month) than prospective e motorcycle riders would lose to charging failure (₦2,156 per month) is a communication asset of considerable value. Distrust of electricity reliability, the so-called NEPA problem, was cited as an important barrier by 47.6% of respondents, and range anxiety by 61.4%. Yet in the largest market, the incumbent technology is the less reliable one on the metric riders actually care about, which is hours earning. This point is concrete, verifiable from riders' own experience and entirely absent from current e mobility messaging, which continues to lead with environmental benefits that only 18.4% of the sample considers relevant.

Third, and most consequential for policy design, localised solar charging is not merely a cheaper source of electricity; it is a reliability instrument. Scenario C in Table 7 shows that solarising the Kano charging network delivers 74% of the benefit of a perfect grid. National grid rehabilitation is a decadal project whose completion no rider should be asked to wait for. A photovoltaic hub at a staging area is a capital project of a few million naira with a construction period measured in weeks, and it attacks the price effect and the quantity effect simultaneously. The policy sequence is therefore unambiguous: distributed solar charging at okada garages should precede, not follow, grid investment in the e mobility strategy, and the case for it does not depend on any environmental argument whatsoever.

Financing Frameworks for Low Income Riders

The barrier analysis is unequivocal: 78.3% of riders cite upfront acquisition cost and 54.8% cite lack of accessible financing, and the regression shows that adoption intent more than doubles with each doubling of daily income. The transition is not constrained by economics, which are favourable, nor by attitudes, which are pragmatic. It is constrained by liquidity. A rider earning ₦8,060 gross per day cannot assemble ₦1,350,000 in capital, and no amount of TCO evidence will alter that fact. What follows is therefore not a general appeal for concessional finance but four specific, costed instruments, each designed against the actual cash-flow constraint the survey reveals.

The design constraint can be stated precisely. On the reliability-adjusted model, a petrol rider's all-in daily operating cost is ₦1,694 (fuel, maintenance, insurance and queue downtime), while an e motorcycle's is ₦659 (charging, maintenance, insurance, battery provision and charging downtime). The difference, ₦1,036 per day, is the entire fiscal space available to service an acquisition loan. Any instrument whose daily repayment exceeds ₦1,036 makes the rider worse off from day one and will fail, irrespective of what the five-year net present value says. This single number is the binding constraint that existing Nigerian microfinance products violate: at a representative commercial rate of 3.5% per month over 24 months, financing the machine requires ₦2,034 per day, nearly double the available headroom. The market cannot deliver this transition, not because lenders are unwilling but because the arithmetic does not close.

Instrument 1: the Rider Asset-Lease (RAL). The core instrument is a lease-to-own facility structured on the pay-as-you-go model pioneered by M-KOPA in Kenyan solar and by Ampersand in Rwandan e mobility. The rider trades in his existing petrol machine, valued at approximately ₦320,000 in the Lagos and Ibadan used markets, and adds a cash deposit of ₦50,000, roughly six days' gross earnings. The residual ₦980,000 is financed over 42 months at 1% per month on a reducing balance, giving a monthly instalment of ₦28,690, or ₦957 per day. Repayment is collected daily by USSD or mobile money, matching the rider's daily revenue cycle rather than imposing an alien monthly one, and an IoT immobiliser embedded in the controller serves as collateral: non-payment disables the machine, remotely and reversibly, which substitutes for the physical collateral and credit history that informal-sector riders do not possess. The critical property is that ₦957 sits below the ₦1,036 daily headroom. The rider is cash-flow positive by ₦79 per day, roughly ₦2,370 per month, from the first day of ownership, and owns the asset outright after 42 months. This directly defeats the present bias documented by Duflo and Banerjee (2011): the instrument requires no act of deferred gratification because there is no period of sacrifice to endure.

Instrument 2: the Battery-Swapping Subscription (BaaS). The second instrument attacks the acquisition premium directly by unbundling the battery from the vehicle. The rider purchases only the glider, the machine less its battery pack, at approximately ₦970,000. Since the petrol equivalent costs ₦800,000, this collapses the acquisition premium from ₦550,000 to ₦170,000, a reduction of 69%, and brings the financing requirement within reach of a 30-month lease at ₦833 per day. Energy is then purchased as a service: an unlimited-swap subscription at ₦600 per day, a figure built up from ₦4,653 per month of electricity at a hub-scale procurement cost of ₦90/kWh, ₦9,880 per month of pack depreciation at a pool ratio of 1.3 packs per rider, and ₦3,500 of station opex and margin. The rider's total daily outlay, including lease, subscription, maintenance and insurance, is ₦1,568, against ₦1,694 for the petrol counterfactual, and it falls to ₦736 once the glider lease terminates.

The deeper argument for battery swapping, however, is not cost; on cost it is roughly neutral to the asset lease during the lease term. It is risk transfer, and it is here that the two halves of this paper connect. Every reliability cost quantified in Section 5, the elevated tariff τ_eff, the downtime cost Ω, the ₦2.50/km penalty borne by the Kano rider, is a risk that a swapping operator can hedge and an individual rider cannot. The operator charges packs overnight when the grid is available, buys at scale, installs photovoltaic capacity with a bankable balance sheet, and holds inventory to absorb outages. Charging availability from the rider's perspective approaches unity because the pack is always ready when he arrives. Battery swapping therefore internalises the grid reliability problem into the entity best equipped to manage it and removes it from the rider's balance sheet entirely. It also dissolves three of the top ten barriers in Table 3 at a stroke: range anxiety (61.4%), since a swap takes three minutes rather than a charge taking four to six hours; long charging time (36.9%), for the same reason; and battery theft (30.1%), since the rider no longer owns the pack. It is, on our reading, the single most powerful instrument available for the Kano and Ibadan markets, precisely because those are the markets where the reliability penalty is largest.

Instrument 3: the Cooperative Solidarity Guarantee. Neither instrument above is bankable at 1% per month without an answer to credit risk, and informal-sector riders have no collateral and no credit files. The answer is already in the field. This study enumerated 342 registered staging areas across the three cities through the State Motorcycle Rider Associations, and those associations constitute exactly the dense, information-rich, socially enforced networks that the group-lending literature identifies as substitutes for collateral (Ghatak, 1999; Karlan & Zinman, 2010). We propose that financing be extended not to individuals but to solidarity groups of 10 to 15 riders drawn from a single staging area, who jointly guarantee one another's obligations, with the association's allocation of staging rights, a genuinely valuable and revocable privilege, serving as the enforcement mechanism. Peer selection addresses adverse selection at origination, since riders know who is reliable; peer monitoring addresses moral hazard thereafter. The expected effect is a reduction in the lender's risk premium sufficient to make the sub-market rate commercially sustainable rather than permanently subsidised, and this is what converts the scheme from a grant programme into a financial product.

Instrument 4: Shariah-Compliant Structures for Northern Markets. Kano exhibits both the lowest adoption intent (29.1%) and the largest reliability penalty, and it is also the market where conventional interest-bearing finance encounters religious objection. The exclusion is unnecessary and easily remedied, because the asset-lease is already structurally Islamic. Ijara wa iqtina, a lease terminating in ownership, is functionally identical to the RAL with the interest coupon replaced by a rental (ujrah). Alternatively, under a murabaha the financier purchases the machine at ₦1,350,000 and resells it to the rider at a disclosed cost-plus markup of 12%, giving a sale price of ₦1,512,000; net of the same trade-in and deposit, the 42-month instalment is ₦27,190, or ₦906 per day. That is ₦51 per day cheaper than the conventional RAL. The practical conclusion deserves emphasis because it runs against a widespread assumption: Shariah-compliant financing of e motorcycles in northern Nigeria is not a costly accommodation of religious sensibility but a competitively priced product, and its absence reflects a failure of product design rather than any structural obstacle.

Table 8. Proposed Financing Frameworks for Low-Income Commercial Riders

Feature	Rider Asset-Lease (RAL)	Battery-Swap Subscription (BaaS)	Murabaha (Kano)	Market Microfinance (comparator)
Asset financed	Complete e motorcycle	Glider only (battery leased)	Complete e motorcycle	Complete e motorcycle
Sticker price (₦)	1,350,000	970,000	1,350,000	1,350,000
Acquisition premium vs petrol (₦)	550,000	170,000	550,000	550,000
Trade-in + cash deposit (₦)	320,000 + 50,000	320,000 + 50,000	320,000 + 50,000	320,000 + 50,000
Amount financed (₦)	980,000	600,000	1,142,000 (cost-plus)	980,000
Rate and tenor	1.0%/month, 42 months	1.5%/month, 30 months	12% markup, 42 months	3.5%/month, 24 months
Daily repayment (₦)	**957**	**833**	**906**	**2,034**
Daily energy/subscription (₦)	271 (self-charged)	600 (unlimited swaps)	271 (self-charged)	271 (self-charged)

Total daily outlay (₦)	**1,363**	**1,568**	**1,312**	**2,440**
Petrol counterfactual (₦/day)	1,694	1,694	1,694	1,694
Rider net position from day one	**+₦331/day**	**+₦126/day**	**+₦382/day**	**−₦746/day**
Collateral substitute	IoT immobiliser + group guarantee	Operator retains pack; immobiliser	Asset title held by financier	Physical collateral (unavailable)
Grid reliability risk borne by	Rider	Operator	Rider	Rider
Barriers addressed (Table 3)	Upfront cost; financing access	Upfront cost; range anxiety; charge time; theft	Upfront cost; financing; religious exclusion	None effectively
Verdict	**Viable; core instrument**	**Viable; best for Kano/Ibadan**	**Viable; cheapest per day**	**Structurally unaffordable**

Note: Total daily outlay includes lease/instalment, energy or subscription, maintenance and insurance, and is computed on the reliability-adjusted model. The petrol counterfactual of ₦1,694/day comprises fuel, maintenance, insurance and fuel-queue downtime. Positive net position denotes the rider is cash-flow positive from the first day of ownership.

Funding the concession. The instruments above require a rate of roughly 1% per month, against perhaps 1.8% achievable with a partial credit guarantee and a wholesale concessional line. The residual buy-down therefore costs approximately ₦4,764 per rider per month, or ₦200,082 over the 42-month tenor. That figure should be set against the counterfactual. A petrol okada consumes some 636 litres per year; at the implicit pre-removal subsidy of roughly ₦415 per litre, the Nigerian state was paying about ₦263,900 per rider per year to keep that machine running. The entire interest buy-down for a permanent transition to an electric machine costs less than nine months of the subsidy formerly spent on the petrol one. This is not an appeal for new money; it is an argument for redeploying a fraction of a fiscal saving the state has already banked. A blended stack of first-loss capital from the African Development Bank's Electric Mobility Initiative, already signed, a 50% partial credit guarantee from the Bank of Industry or the Development Bank of Nigeria, and an interest buy-down financed from subsidy-removal savings would be sufficient. Carbon revenue offers a further contribution: each converted machine abates approximately 1.1 tCO_2e per year net of charging emissions, or 5.5 tCO_2e over the horizon, worth some ₦68,000 at a conservative ₦8 per tonne and capable of funding roughly a third of the buy-down.

Progressive targeting. One design point must not be overlooked. Because daily income is the strongest predictor of adoption intent (OR = 2.14), a financing scheme offered on uniform terms will be taken up disproportionately by the riders who need it least, and the public subsidy embedded in it will flow upward. We therefore recommend explicit progressivity: a waived cash deposit, an extended 48-month tenor and a deeper buy-down to 0.5% per month for riders in the bottom income tercile, financed by charging the top tercile a rate closer to the guaranteed 1.8%. The scheme remains fiscally neutral in aggregate while its incidence is inverted. Given that the reliability burden documented in Section 5 already falls hardest on the poorest riders in the least reliable cities, a financing architecture that is merely neutral would compound an existing inequity rather than correct it.

Policy Implications

Our findings converge on three clusters of policy intervention that could accelerate e motorcycle adoption among Nigerian commercial riders.

First, concessional acquisition financing is the single most impactful lever. Given that upfront cost and financing access account for the two highest ranked barriers (78.3% and 54.8% respectively), a government backed hire purchase or rent to own scheme, modelled on Kenya's M-KOPA model or Rwanda's Ampersand partnership, could transform the adoption calculus. Section 6.3 specifies four costed instruments. The binding design constraint is that daily repayment must not exceed the ₦1,036 daily operating-cost saving that electrification actually generates; the rider asset-lease (₦957/day), the battery-swap subscription (₦833/day plus ₦600/day for energy) and the murabaha (₦906/day) all satisfy it, while commercial microfinance at 3.5%/month (₦2,034/day) does not. The public cost of buying the rate down to 1% per month is approximately ₦200,000 per rider, less than nine months of the petrol subsidy the state formerly paid on the same machine, and it should be targeted progressively so that the poorest tercile receives the deepest concession.

Second, targeted charging infrastructure deployment is critical, particularly in Kano and Ibadan where proximity to charging points is lowest. Our regression results demonstrate that residing within 5 km of a charging point increases adoption odds by 63%. Strategic placement of solar powered charging hubs at motorcycle staging areas (garages), where riders already congregate and where the social infrastructure of okada commerce is located, would simultaneously address range anxiety, reduce effective charging costs and create employment for staging area managers. The GIZ Nigerian Energy Support Programme has already piloted this model in Kano; scaling it system wide represents a high return investment. Our reliability analysis sharpens the case considerably. Solar hubs are not merely a cheaper source of electrons; they raise charging availability and thereby attack the downtime cost, which is the larger and hitherto unmeasured component of the reliability penalty. Scenario C of Table 7 shows that solarising Kano's charging network cuts the true cost per kilometre by 16% and brings cost parity forward by 4.2 months, capturing 74% of the benefit of a perfectly reliable grid at a fraction of the cost and on a timescale of weeks rather than decades. Distributed solar charging should therefore precede grid investment in the sequencing of national e mobility strategy, and generator-backed charging, which combines the highest energy price with no gain in availability, should be explicitly designed out rather than tolerated as an interim expedient.

Third, information campaigns calibrated to commercial riders' economic worldview can substantially increase adoption intent. The 87 percentage point gap in awareness between Lagos (52.4%) and Kano (22.6%) of government e mobility programmes suggests that information diffusion is highly uneven. Our regression results indicate that policy awareness nearly doubles adoption odds (OR = 1.87). Dissemination through motorcycle staging associations, mosque and church networks (the primary social institutions in Kano and Lagos respectively) and through the SMRA structures already engaged in this research could efficiently reach the target population.

Contextual and Comparative Considerations

The north to south differential in adoption intent (Kano 29.1% vs. Lagos 48.2%) warrants contextual elaboration. Beyond income and infrastructure, Kano's lower adoption intent plausibly reflects three additional factors. First, the predominance of Islamic financing norms among some Kano riders may complicate access to conventional interest bearing hire purchase schemes; Shariah compliant murabaha financing structures would be necessary to reach this segment. Second, Kano's more arid climate creates distinct battery performance concerns: lithium-ion batteries lose capacity at high temperatures, and Kano's mean daily temperature of 36°C in the dry season could reduce effective range by 15 to 20% relative to manufacturer specifications derived from temperate conditions. Third, the social network effects of adoption are more constrained in Kano, where peer adoption rates are lower and technology demonstration effects are consequently weaker.

Our findings are broadly consistent with East African evidence (Ndwiga et al., 2022; Mbatha & Nhamo, 2021) in identifying financial barriers as dominant and infrastructure barriers as secondary. However, an important point of divergence is the much lower environmental motivation among Nigerian commercial riders (18.4%) relative to East African samples, where environmental concerns are cited by 35 to 45% of respondents. This difference likely reflects Nigeria's more acute economic hardship after the subsidy removal, which crowds out non economic considerations, and suggests that environmental messaging, a staple of many EV adoption campaigns, will be less effective in the Nigerian commercial rider context.

Limitations

Several limitations warrant acknowledgement. First, adoption intention is a stated preference measure that may overestimate actual behaviour: the intention behaviour gap is well documented in EV research (Adnan et al., 2019). Our binary logit results should therefore be interpreted as correlates of favourable disposition rather than predictors of actual purchase. Second, while our three city sample is the largest yet deployed in this context, it does not represent the full heterogeneity of Nigerian cities, and results may not generalise to smaller secondary cities or rural areas. Third, the TCO model employs a static fuel price assumption; given the ongoing naira depreciation and deregulation trajectory, actual lifetime fuel costs may differ significantly. Scenario analysis (presented in Supplementary Materials) explores price sensitivity. Fourth, the cross sectional design precludes causal inference; a longitudinal or experimental design, for instance, a randomised control trial of concessional financing, would provide stronger causal identification. Fifth, the grid reliability parameters, in particular the backup coverage ratio κ and the 3.5 hours lost per unserved charging event, are calibrated from rider self-report and enumerator observation rather than from metered data; a telematics study logging actual charging events and idle time would materially tighten these estimates, and we regard this as the single highest-value extension of the present model. Sixth, the financing frameworks are specified and costed but not tested; the used-motorcycle trade-in value of ₦320,000 on which they depend is drawn from market observation in Lagos and Ibadan and may not hold in a scenario of mass conversion, when a large simultaneous supply of used petrol machines would depress it. A wholesale trade-in guarantee, or a floor price underwritten within the blended-finance stack, would be a prudent design safeguard.

CONCLUSIONS

This study provides the first after the subsidy removal empirical baseline on e motorcycle total cost of ownership, adoption intention and adoption barriers among Nigerian commercial riders. Our findings establish that the 2023 fuel subsidy removal has transformed the economic calculus of commercial motorcycling in ways that are structurally favourable to electric transition: TCO parity is achieved within 14.6 months, and five-year ownership savings amount to ₦1.08 million, a sum equivalent to 134 days of median gross income. Binary logistic regression identifies daily income, government programme awareness and charging infrastructure proximity as the principal adoption facilitators, while high upfront cost, range anxiety and financing access remain the dominant barriers. Incorporating an explicit grid reliability factor, which prices both the elevated tariff paid for off-grid electricity and the operating hours destroyed when charging fails, establishes a true cost per kilometre of ₦17.46 against ₦26.71 for petrol. Reliability does not overturn the economic case, but it compresses and redistributes it: the advantage falls from ₦10.96/km in Lagos to ₦7.69/km in Kano, and the burden lands hardest on the poorest riders in the least reliable cities. Notably, Lagos petrol riders already lose more operating time to fuel queues than prospective e motorcycle riders would lose to charging failure.

The clear policy implication is that the e motorcycle transition in Nigeria will not self accelerate through market forces alone. The economics are compelling, but capital constraints and infrastructure gaps constitute genuine market failures that require corrective public intervention. The policy package that follows is coherent and, unusually, fully costed. Financing must be structured against the ₦1,036 daily operating-cost saving that electrification generates, which the rider asset-lease (₦957/day), the battery-swapping subscription and the murabaha all respect and which commercial microfinance (₦2,034/day) cannot; the public interest buy-down costs roughly ₦200,000 per rider, less than nine months of the petrol subsidy formerly paid on the same machine. Battery swapping deserves particular emphasis, because it is the only instrument that simultaneously cuts the acquisition premium by 69% and transfers grid reliability risk from the rider, who cannot hedge it, to an operator who can. Distributed solar charging at okada garages should precede grid rehabilitation in the sequencing of national strategy, since it captures 74% of the benefit of a perfect grid on a timescale of weeks. Shariah compliant structures for northern markets are not a costly concession but a competitively priced product. And because income is the strongest predictor of adoption intent, the concession must be targeted progressively, or the transition will be financed by the public and captured by the riders who least need it. If implemented at scale, these interventions could materially accelerate progress toward the RMI's 60%-by-2040 projection for electric two wheelers, with significant co benefits for urban air quality, oil import dependence and commercial rider livelihoods.

Future research should prioritise revealed preference studies tracking actual purchase behaviour following policy interventions, longitudinal panel studies of rider income trajectories after e motorcycle adoption, technical performance testing of leading e motorcycle models under Nigerian climatic and road conditions, and gendered analysis of the (currently marginal) female rider segment that may grow as the sector formalises. The 2023 subsidy removal has opened a data window that the research community should urgently exploit to inform what may be one of the most consequential energy transitions in Africa's largest economy.

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