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Factors Influencing the Adoption of Compressed Natural Gas Vehicles among Commercial Transporters in Nigeria: A Theory of Planned Behaviour Approach

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ABSTRACT:
The rising cost of petrol and diesel following the removal of fuel subsidies in Nigeria has intensified the search for affordable, sustainable alternative energy sources in the transportation sector. Compressed Natural Gas (CNG) has emerged as a viable alternative; however, its adoption among commercial transporters remains relatively low despite government interventions and promotional initiatives. This study examined the behavioral factors influencing the adoption of CNG vehicles among commercial transporters in Nigeria using the Theory of Planned Behavior (TPB). Specifically, the study investigated the effects of subjective norms and perceived behavioral control on behavioral intention to adopt CNG. A quantitative research approach based on survey design was adopted. Data was collected through structured questionnaires administered to commercial transporters across Lagos, Abuja, Port Harcourt, and Enugu. Out of 384 distributed questionnaires, 328 valid responses were analyzed using Structural Equation Modeling (SEM) through SmartPLS software. Descriptive statistics and inferential analyses were employed to examine the relationships among the study variables. The findings revealed that perceived behavioral control has a strong positive and statistically significant effect on behavioral intention to adopt CNG vehicles ($\beta = 0.624$, $p < 0.001$). This indicates that factors such as financial capacity, access to refueling infrastructure, and technical knowledge significantly influence transporters' willingness to adopt CNG technology. Conversely, subjective norms were found to have a positive but statistically insignificant effect on behavioral intention ($\beta = 0.107$, $p = 0.347$), suggesting that peer influence, union expectations, and customer pressures do not significantly determine adoption decisions. The study concludes that CNG adoption among Nigerian commercial transporters is primarily driven by practical feasibility rather than social influence. It therefore recommends improved access to affordable financing, expanded refueling infrastructure, and enhanced technical support systems to strengthen adoption intentions and facilitate the adoption of cleaner transportation alternatives in Nigeria.

KEYWORDS: *Compressed Natural Gas (CNG), Behavioral Intention, Perceived Behavioral Control, Subjective Norms, Theory of Planned Behavior, Commercial Transporters, Nigeria.*

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INTRODUCTION

The transportation sector constitutes a vital component of Nigeria's economy, serving as an important facilitator of mobility for goods and people while substantially contributing to employment generation

(Adedayo & Musa, 2023). The removal of fuel subsidies, fluctuating global oil prices, and rising inflation have increased the financial strain on commercial transporters, compelling them to consider alternative energy sources (Igbojionu et al., 2019). Compressed Natural Gas (CNG) has emerged as a prominent alternative, gaining recognition as a cost-effective substitute for conventional petroleum-based fuels such as petrol and diesel (Dyr et al., 2019).

Compressed Natural Gas (CNG) is primarily methane stored under high pressure and used as a cleaner alternative to petrol or diesel. Its application in the automotive industry has been growing due to its lower emissions, cost-effectiveness, and abundance in natural gas-rich countries like Nigeria (Alozie et al., 2024). According to Alozie et al. (2024), CNG is 77% cheaper than petroleum-based fuels, making it a strong incentive for transporters. Initiatives such as the Presidential CNG Initiative (PCNGi) aim to convert 1 million vehicles by 2026, with investments already exceeding $200 million (Garba & Musa, 2024). However, significant public skepticism about CNG safety persists, despite studies showing that it has higher ignition thresholds and lower explosion risk than petrol (Garba & Musa, 2024).

Understanding the factors influencing the adoption of CNG vehicles among Nigerian commercial transporters is therefore essential, especially given persistent economic challenges. Adoption refers to the decision to adopt a new idea or technology (Rogers, 2003). The adoption of CNG vehicles in Nigeria aligns with global trends, as countries increasingly adopt cleaner energy solutions to mitigate carbon emissions (Dyr et al., 2019). The Nigerian government has acknowledged the strategic role of CNG in enhancing energy efficiency and sustainability, supported by initiatives such as the Presidential CNG Initiative and financial incentives for CNG vehicle conversion (Imam, 2024). Despite these interventions, the adoption of CNG vehicles among commercial transporters remains low, primarily constrained by inadequate infrastructure, technical limitations, and financial barriers.

Recent studies have explored various dimensions of CNG adoption, yet critical gaps remain. While prior research highlights economic, infrastructural, and policy challenges (Adamu, 2024; Igbojionu et al., 2019), few studies integrate psychological and perceptual factors into analyses of transporters' decisions. For instance, Dike and Agwor (2024) applied the Theory of Planned Behavior (TPB) but focused narrowly on awareness rather than actual adoption drivers. Most studies examine all vehicle owners or compare CNG with other alternatives such as electric vehicles, neglecting the unique economic and operational realities of commercial transporters, who face higher cost sensitivity and fleet-scale adoption challenges (Aba et al., 2023; Egwuogu & Ekeh, 2024). Imam (2024) highlighted Nigeria's weak regulatory frameworks and inconsistent incentives, yet few studies assess how this policy gaps interact with transporters' financial constraints and risk perceptions (Okoh & Onuoha, 2024). In addition, very few studies have examined how traveler preferences and peer influence shape transporters' willingness to adopt CNG vehicles.

To address these gaps, this study applies the Theory of Planned Behavior (TPB) to examine transporters' behavioral intention toward CNG adoption. The objectives of the study are:

- To assess the influence of subjective norms on behavioral intention to adopt Compressed Natural Gas (CNG) vehicles among commercial transporters in Nigeria.
- To examine the effect of perceived behavioral control on behavioral intention to adopt Compressed Natural Gas (CNG) vehicles among commercial transporters in Nigeria.

Research Hypotheses

H_{01}: Subjective norms have no significant effect on behavioral intention to adopt Compressed Natural Gas (CNG) vehicles among commercial transporters in Nigeria.

H_{02}: Perceived behavioral control has no significant effect on behavioral intention to adopt Compressed Natural Gas (CNG) vehicles among commercial transporters in Nigeria.

LITERATURE REVIEW

Compressed Natural Gas (CNG): Adoption and Consumer Behavior

The adoption of innovation is conceptualized as a decision-making process through which individuals or organizations evaluate, accept, and integrate a new idea, technology, product, or practice into their activities. Adoption is not a one-time event but a gradual process involving several stages before an innovation becomes fully utilized (Rogers, 2003). Rogers (2003) identifies five stages in the innovation-decision process, namely knowledge, persuasion, decision, implementation, and confirmation. During these stages, potential adopters acquire information about innovation, develop attitudes toward it, decide whether to adopt or reject it, implement its use, and subsequently evaluate the outcomes. From a behavioral perspective, adoption represents the outcome of an individual's intention to accept or reject an innovation. According to Ajzen (1991), behavioral intention is the most immediate predictor of behavior, while Davis (1989) argues that perceptions regarding technology's usefulness and ease of use significantly influence adoption decisions. Consequently, innovation adoption is shaped by a combination of psychological, social, economic, cultural, and situational factors that influence how potential users evaluate and respond to new technologies (Greenhalgh et al., 2004; Hall & Khan, 2003).

Compressed Natural Gas (CNG) is a high-pressure gaseous fuel composed predominantly of methane (CH_4) and stored at pressures typically ranging from 20,700 to 24,800 kPa (3,000–3,600 psi). It has emerged as a cleaner and more sustainable alternative to conventional transportation fuels such as petrol and diesel. Owing to its abundance, lower carbon intensity, and favorable combustion characteristics, CNG is increasingly viewed as a viable transportation fuel in natural gas-rich countries such as Nigeria (Ibeneme & Ighalo, 2020; Alozie et al., 2024). The environmental benefits of CNG are attributed to its high methane content, which enables more complete combustion and significantly lower emissions of carbon monoxide, nitrogen oxides, and particulate matter compared with petrol and diesel fuels. Carbon dioxide emissions from CNG-powered vehicles are estimated to be approximately 20–25% lower than those from conventional fossil fuels, enhancing their relevance for climate change mitigation and sustainable transportation initiatives (Alozie et al., 2024). CNG also offers notable safety advantages: it is non-toxic, lighter than air, and disperses rapidly in the event of a leak, thereby reducing fire and explosion risks compared with petrol (Garba & Musa, 2024).

Dike and Agwor (2024) discussed the Nigerian Government's initiative to promote CNG as an alternative vehicular fuel and identified economic incentives, environmental sustainability concerns, and government support as major drivers of adoption. The study applied elements of the Theory of Planned Behavior and highlighted the need to improve public awareness and perceived behavioral control among commercial transport operators. Muhibbu-Din (2024) found that removing fuel subsidies increased transportation costs and stimulated interest in CNG, with anticipated cost savings serving as a major motivation for adoption. Alozie et al. (2024) and Igwe et al. (2024) also reported that operational cost savings significantly influence decisions to switch from petrol-powered vehicles to natural gas vehicles.

Perceived behavioral control is another important determinant of adoption. Dimoso (2025) found that distance to CNG refueling stations negatively affects both adoption and usage intensity among vehicle owners in Tanzania. Although awareness of CNG was relatively high, misconceptions regarding cost and safety reduced the likelihood of adoption. Similar findings were reported by Garba and Musa (2024), who identified limited refueling infrastructure, a shortage of trained maintenance technicians, and financial accessibility constraints as major barriers to adoption. Egwuogu and Ekeh (2024) further found that although CNG conversion is financially viable, inadequate infrastructure and insufficient government support remain significant obstacles. These findings are consistent with Ajao et al. (2024), who observed that facilitating conditions such as infrastructure availability, affordability, and institutional support exert stronger influences on behavioral intention than social influence factors.

Adamu (2024) identified infrastructural and economic constraints as significant challenges limiting the expansion of CNG usage in Nigeria. Likewise, Okoh and Onuoha (2024) reported that infrastructural deficiencies, weak policy implementation, and inadequate financing mechanisms constrain cleaner transportation transitions across Africa. Okeagu (2024) also emphasized the need for infrastructure investment and policy reforms to support the adoption of affordable, sustainable fuel alternatives. Similar conclusions were reached by Agyekum et al. (2023), who identified inadequate infrastructure, weak policy support, high upfront costs, and low public awareness as major barriers to the adoption of cleaner fuel technologies across Africa.

Policy and institutional factors equally influence adoption decisions. Imam (2024) found that strong government commitment, phased policy implementation, public awareness campaigns, and infrastructure investments are critical for encouraging adoption. However, the study also noted that inconsistent policy implementation and weak regulatory frameworks can undermine transport operators' adoption intentions. Ogunlowo (2016) identified poor awareness, inadequate regulatory standards, weak market coordination, and public skepticism as major barriers constraining CNG adoption in Nigeria.

Theoretical Framework

The theoretical foundation of this study is anchored in the Theory of Planned Behavior (TPB), which provides a framework for understanding the behavioral factors influencing the adoption of Compressed Natural Gas (CNG) vehicles among commercial transporters in Nigeria. The theory explains how behavioral intention influences an individual's likelihood of performing a behavior and how such intention is shaped by subjective norms and perceived behavioral control.

Theory of Planned Behavior

The Theory of Planned Behavior (TPB), formulated by Icek Ajzen (1991), is a widely utilized psychological framework for predicting and explaining human behavior. According to the Theory of Planned Behavior, behavioral intention is the most immediate factor influencing whether an individual will perform a behavior. This intention is shaped by attitude toward behavior, subjective norms, and perceived behavioral control (Ajzen, 1991; Armitage & Conner, 2001).

Attitude Toward Behavior

This refers to an individual's positive or negative evaluation of performing the behavior. In the context of CNG adoption by commercial transport operators, a favorable attitude may stem from perceived cost

savings, improved engine longevity, or reduced environmental harm. For instance, a transporter who believes that CNG will reduce fuel costs and improve air quality is more likely to express a strong intention to adopt (Ibeneme & Ighalo, 2020).

Subjective Norms

Subjective norms denote the perceived social pressure to perform or avoid behavior. In Nigeria's informal transport ecosystem, these pressures may emanate from peer drivers, passengers, transport union leaders, or regulatory bodies. If influential actors within these networks advocate for CNG adoption, perhaps due to rising petrol prices or public environmental awareness, it may enhance normative support for behavioral change (Imam, 2024).

Perceived Behavioral Control (PBC)

Perceived behavioral control captures an individual's perception of their capacity to perform the behavior, reflecting both internal factors, such as knowledge and skills, and external constraints, such as access to CNG refueling stations and conversion costs. In the Nigerian context, even individuals with high behavioral intention may fail to adopt CNG due to infrastructural inadequacies, financial barriers, or limited technical support (Dimoso, 2025). Hence, perceived behavioral control is particularly salient in developing country settings where structural limitations frequently override motivational readiness.

METHODOLOGY

This study adopted a quantitative survey research design to investigate the behavioral factors influencing the adoption of Compressed Natural Gas (CNG) vehicles among commercial transporters in Nigeria. The survey approach was considered appropriate because it enabled the systematic collection of standardized data from a broad and heterogeneous population across multiple urban centers (Creswell & Creswell, 2017). Quantitative orientation facilitated the operationalization and measurement of constructs derived from the Theory of Planned Behavior (TPB), thereby ensuring objectivity, comparability, and replicability of findings. The study population comprised commercial transport owners who are members of the Road Transport Employers Association of Nigeria (RTEAN) and the Nigerian Association of Road Transport Owners (NARTO). A multistage sampling technique was employed to ensure representativeness and efficiency. First, purposive sampling was used to select four major urban centers: Lagos, Abuja, Port Harcourt, and Enugu, due to their strategic importance in Nigeria's transportation system and their relevance to the Presidential Compressed Natural Gas Initiative. Secondly, stratified sampling was adopted by vehicle category, including car taxis, minibuses, high-capacity buses, and tricycles. Finally, random sampling was used to select respondents within each stratum. Only registered members of the commercial transport union were included in the study. The sample size was determined using Cochran's formula for an unknown population at a 95% confidence level and a 5% margin of error (Cochrane, 1977). A total of 384 respondents were targeted and proportionally distributed across Lagos (154), Abuja (96), Port Harcourt (77), and Enugu (57).

Primary data were collected through structured questionnaires, while secondary data were obtained from policy documents, government reports, industry publications, and scholarly literature related to CNG adoption. The questionnaire was developed based on TPB constructs and utilized a 5-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). Perceived Behavioral Control (PBC) measured respondents' perceived ability to adopt CNG technology, while Subjective Norms (SN) assessed social influence from peers, passengers, and transport unions. Behavioral Intention (BI) served as the dependent variable and proxy for adoption. Content validity was established through expert review, while a pilot test involving 20 transport operators was conducted to assess clarity and structure. Reliability analysis using Cronbach's alpha showed acceptable internal consistency for Behavioral Intention ($\alpha = 0.807$), Perceived Behavioral Control ($\alpha = 0.874$), and Subjective Norms ($\alpha = 0.874$).

Data was collected through both physical and online questionnaires and analyzed using Structural Equation Modeling (SEM) via SmartPLS. Descriptive statistics and inferential analysis were employed, while hypothesis testing was conducted using path coefficients, t-statistics, p-values, and coefficient of determination (R^2) at a 95% confidence level. The structural model was specified as: $BIA = \beta_0 + \beta_1 PBC + \beta_2 SN + \varepsilon_1$

Where BIA represents Behavioral Intention to Adopt CNG, SN denotes Subjective Norms, and PBC represents Perceived Behavioral Control.

RESULT AND DISCUSSIONS

Analysis of Demographic Variables

The gender distribution indicates a strong male dominance, with males accounting for 90.9% of respondents. The age distribution shows that most respondents fall within economically active age groups. Bus and minibus operators constitute the largest respondent category, and most respondents have 5-15 years of operational experience. Lagos recorded the highest proportion of respondents among the selected cities.

Table 1 Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage (%)
Gender	Male	298	90.9
	Female	30	9.1
Age	18–25	7	2.1
	26–33	37	11.3
	34–41	38	11.6
	42–49	63	19.2
	50–57	79	24.1
	58–65	85	25.9
	Above 65	19	5.8
Vehicle Type	Bus/Minibus	132	40.2
	Tricycle	84	25.6
	Taxi (Car)	70	21.3
	High-capacity Vehicles	42	12.8
Experience	Below 5 years	58	17.7
	5–10 years	104	31.7
	11–15 years	96	29.3
	Above 15 years	70	21.3
Location	Lagos	129	39.3
	Abuja	82	25.0
	Port Harcourt	66	20.1
	Enugu	51	15.5

Source: Authors' computation

The findings indicate a high behavioral intention among commercial transporters to adopt CNG technology, with mean scores ranging from 3.67 to 3.85. Adoption willingness was strongest under favorable conditions such as accessible refueling stations, conversion centers, and financial support. Perceived behavioral control

emerged as a major determinant, as respondents identified high conversion costs, inadequate infrastructure, and limited technical knowledge as key barriers to adoption. Subjective norms exerted weaker influence, with peer and union pressures showing limited impact on adoption decisions. However, customer preferences moderately influenced respondents, suggesting that passenger demand for cheaper and cleaner transportation could encourage CNG adoption.

Table 2: Summary of Research Variables and Interpretation

Construct	Code Range	Mean Range
Behavioural Intention (BI)	BI1–BI5	3.67–3.85
Financial Capacity (FI)	FI1–FI5	3.21–3.97
Infrastructure (INF)	INF1–INF2	3.65–3.69
Technical Knowledge (TK)	TK1–TK3	3.58–3.63
Peer Influence (PI)	PI1–PI3	2.71–3.01
Union Pressure (UP)	UP1–UP3	2.89–3.46
Customer Preference (CP)	CP1–CP3	3.67–3.85

Source: SmartPLS Output

Test of Hypotheses

Hypothesis One

H_{01}: Subjective Norms have no significant effect on Behavioral Intention to adopt CNG vehicles.

Table 3: Results for Hypothesis One

Hypothesis	Path	β (Coefficient)	T-value	P-value	Decision
H_{01}	SN → BI	0.107	0.941	0.347	Not Supported (Accept H_{01})

Source: SmartPLS Output

The findings reveal that Subjective Norms (SN) have a positive but statistically insignificant effect on Behavioral Intention (BI) ($\beta = 0.107$, $t = 0.941$, $p = 0.347$). This indicates that social influences do not significantly determine commercial transporters' intention to adopt CNG technology.

Despite incorporating dimensions such as peer influence, union pressure, and customer preferences, these factors do not exert a statistically meaningful impact on adoption intention. This suggests that transporters' decisions are driven more by practical and economic considerations than by social expectations.

Hypothesis Two

H_{02}: Perceived Behavioral Control has no significant effect on Behavioral Intention to adopt CNG vehicles.

Table 4: Results for Hypothesis Two

Hypothesis	Path	β (Coefficient)	T-value	P-value	Decision
H_{02}	PBC → BI	0.624	5.691	0.000	Supported (Reject H_{02})

Source: SmartPLS Output

The results indicate that Perceived Behavioral Control (PBC) has a strong, positive, and statistically significant effect on Behavioral Intention (BI) ($\beta = 0.624$, $t = 5.691$, $p < 0.001$).

This implies that commercial transporters who perceive greater control over the conditions required to adopt CNG are significantly more likely to intend to adopt the technology. The finding reflects the combined influence of financial capability, infrastructure availability, and technical knowledge.

Discussions

The findings of this study confirm that financial, infrastructural, and technical constraints constitute the most significant barriers to CNG adoption. This is demonstrated by the strong, statistically significant effect of perceived behavioral control on behavioral intention ($\beta = 0.624$, $p < 0.001$), suggesting that transporters' willingness to adopt CNG is largely contingent on their perceived access to financial resources, infrastructure, and technical expertise. This finding aligns with Dimoso (2025), who reported that increased distance to refueling stations significantly diminishes adoption and usage intensity, thereby underscoring the critical role of infrastructure accessibility. Similarly, Adamu (2024) and Muhibbu-Din (2024) identified high conversion costs and limited financial support mechanisms as major impediments to adoption. Ogunlowo (2016) and Garba and Musa (2024) also highlighted a lack of awareness, technical uncertainty, and insufficient institutional support as challenges constraining adoption.

The influence of perceived behavioral control identified in this study is consistent with the Theory of Planned Behavior and is supported by Dike and Agwor (2024), who stressed the importance of enhancing perceived behavioral control through targeted awareness and accessibility initiatives, particularly among commercial transport operators. Ajao et al. (2024) similarly found that facilitating conditions exert a stronger influence on behavioral intention than social or network-related factors in Nigeria.

In contrast, the finding that subjective norms exert a positive but statistically insignificant influence on behavioral intention ($\beta = 0.107$, $p = 0.347$) diverges from certain strands of existing literature. While Dike and Agwor (2024) emphasized the role of government policies, public awareness, and social encouragement in promoting CNG adoption, this study indicates that peer influence, union expectations, and customer pressures do not significantly shape transporters' decisions. Instead, this finding aligns more closely with Ajao et al. (2024), who reported that practical enabling conditions outweigh social influence in determining adoption behavior. This suggests that decision-making within the Nigerian commercial transport sector is largely individualistic and economically rational, with transporters prioritizing feasibility over social expectations.

The findings reveal a clear pattern that behavioral intention toward CNG adoption among commercial transporters is primarily influenced by perceived behavioral control, while subjective norms play a relatively minor role. This indicates that CNG adoption among Nigerian commercial transporters is driven more by structural and practical realities than by social influence.

CONCLUSION

The findings indicate that the adoption of CNG among commercial transporters in Nigeria is primarily driven by practical feasibility rather than social influence. Perceived behavioral control emerged as the most important determinant of behavioral intention, indicating that transporters are more likely to adopt CNG when they have access to financial resources, infrastructure, and technical support.

Subjective norms were found to have no significant influence on behavioral intention. This implies that social pressures and expectations alone are insufficient to drive behavioral change in the absence of enabling conditions. Commercial transporters operate within a highly constrained environment where decisions are guided mainly by affordability, accessibility, and operational practicality.

In the light of the findings, the study recommends:

1. Improve Access to Affordable Financing

There is a need to reduce the financial burden associated with CNG conversion. The government should introduce subsidized conversion programs, low-interest loan schemes, and flexible repayment options targeted at commercial transport operators. Financial institutions should also design tailored credit facilities for transporters transitioning to CNG technology.

2. Expansion of CNG Refueling and Support Infrastructure

There is an urgent need to develop a reliable and accessible CNG infrastructure network. Government and private-sector actors should collaborate to establish refueling stations along major transport corridors and in urban centers. Improved infrastructure will directly enhance perceived behavioral control and facilitate adoption.

3. Enhancement of Technical Training and Awareness

Targeted training programs and workshops should be organized to educate transport operators on CNG conversion, operation, and maintenance. These initiatives will reduce uncertainty, build user confidence, and increase adoption readiness.

4. Shifting Focus from Awareness to Enabling Conditions

Although awareness of CNG's benefits is relatively high, the findings indicate that perceived benefits alone are insufficient to drive adoption. Policy efforts should therefore move beyond promotional campaigns toward practical interventions that address structural barriers confronting transporters.

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