



Impact of Fuel Price Hikes on the Economic Sustainability of Msmes in Benue State: The Moderating Role of Energy-Efficient Technology

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Abstract: This study examines the impact of fuel price hikes on the economic sustainability of Micro, Small, and Medium Enterprises (MSMEs) in Benue State, Nigeria, and assesses the moderating role of energy-efficient technologies. Conducted across the three senatorial districts of Benue State, the study employed a survey research design with a sample of 400 MSME owners and operators, and collected data through structured questionnaires. For data analysis, the study employed descriptive statistics and Structural Equation Modelling (SEM) to explore relationships among variables and test the proposed hypotheses. The findings reveal that fuel price hikes have a significant adverse effect on the economic sustainability of MSMEs. Furthermore, energy-efficient technologies were found to influence MSME sustainability positively. However, these technologies did not significantly moderate the negative impact of fuel price hikes. Based on these findings, several policy recommendations were proposed: the establishment of a Fuel Cost Stabilization Fund for MSMEs by the Federal Government; the launch of a State-Level Energy Efficiency Initiative in Benue State; the development of green finance products for MSMEs by financial institutions; the enhancement of technical and managerial capacity among MSMEs for effective technology adoption; and the promotion of context-specific energy innovation through university-industry partnerships.

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INTRODUCTION

Micro, Small, and Medium Enterprises (MSMEs) are globally acknowledged as crucial engines of economic growth, industrialization, and employment generation, accounting for approximately 90% of businesses and over 50% of global employment (PwC Nigeria, 2020; World Bank, 2019). In Nigeria, MSMEs contribute significantly to the national economy, operating across a broad spectrum of sectors and playing a central role in poverty reduction and inclusive growth. However, their operational viability remains highly sensitive to

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macroeconomic shocks, particularly fluctuations in energy prices, which have become increasingly volatile in recent years.

Despite Nigeria's status as Africa's leading oil producer, domestic fuel prices remain disproportionately high due to limited refining capacity, inconsistent subsidy policies, and exchange rate instability. The removal of fuel subsidies in June 2023 led to a steep increase in petrol prices from ₦185 to over ₦600 per litre (Orluchukwu & Lilly-Inia, 2024), placing significant cost pressures on MSMEs that rely heavily on petroleum-based energy for power generation and transportation. These fuel price hikes have far-reaching implications for business continuity, raising production costs, compressing profit margins, and threatening the sustainability of MSMEs, especially in subnational economies like Benue State, where grid electricity remains unreliable.

In Benue State, as in much of Nigeria, the fuel-dependent nature of business infrastructure exacerbates MSMEs' economic vulnerability. The sharp rise in fuel prices has led to increased logistics and raw material costs, declining consumer purchasing power, and, ultimately, a weakening of business resilience. Prior studies (Enejo & Ojabo, 2024; Kadiri, 2024) have documented the cascading effects of fuel price hikes, including supply chain disruptions and workforce downsizing, that compromise the long-term viability of small enterprises. Notably, Taiwo et al. (2024) reported that sectors such as block manufacturing experienced declining productivity and employment following the removal of fuel subsidies. Against this backdrop, energy-efficient technologies such as solar photovoltaics, inverter systems, and biomass solutions have emerged as potential buffers against energy-related shocks. Several empirical studies (Oboreh, 2024) suggest that adopting energy-efficient systems can reduce operating costs and enhance the financial resilience of MSMEs. However, the actual moderating role of these technologies in the context of acute fuel price hikes remains underexplored, particularly in rural and semi-urban settings where capital constraints, technical skills shortages, and policy inertia limit widespread adoption.

While MSMEs in Benue State have begun exploring alternative energy solutions, the depth of integration and the actual economic benefits derived from these technologies are not well-documented. The high upfront cost of clean energy solutions and limited institutional support have made adoption uneven and, in many cases, insufficient to counterbalance the adverse effects of fuel price increases. Although energy-efficient technologies hold promise for enhancing MSME sustainability, their current deployment levels raise questions about their effectiveness as moderating factors in fuel-related economic shocks.

This is where the present study addresses a critical research gap. While the literature recognizes MSMEs' vulnerability to fuel price shocks and the potential of energy-efficient technologies to mitigate costs, there is limited empirical evidence on whether and how these technologies moderate the relationship between fuel price hikes and enterprise sustainability in Nigeria. Most existing studies either examine the direct consequences of fuel price changes (cost escalation, productivity decline, and supply chain disruptions) or focus on the general benefits of renewable and energy-efficient technologies. There are limited studies that have

analyzed these two strands together, particularly in Benue State, where energy poverty and infrastructural deficits create a unique operating environment for small enterprises.

Accordingly, this study empirically investigates the impact of fuel price hikes on the economic sustainability of MSMEs in Benue State, with specific attention to the moderating role of energy-efficient technologies. This research is timely and significant for three key reasons. First, it advances the scholarly discourse by filling a clear empirical and theoretical gap in the nexus between fuel price volatility, energy technology adoption, and MSME resilience. Second, it generates policy-relevant information for subnational governments and development agencies seeking to cushion small businesses from energy price shocks. Third, it offers practical guidance for entrepreneurs and investors exploring technology-driven energy diversification as a pathway to sustainability. By situating the analysis in post-subsidy Nigeria and focusing on Benue State as a case study, this research not only enriches the literature on MSME resilience but also provides actionable strategies for fostering inclusive and sustainable economic growth in fuel-dependent emerging markets.

The following specific objectives guide this study:

- To examine the impact of fuel price hikes on the economic sustainability of MSMEs in Benue State.
- To assess the role of energy-efficient technologies in enhancing the economic sustainability of MSMEs.
- To investigate whether the adoption of energy-efficient technologies moderates the relationship between fuel price hikes and MSME sustainability.

Accordingly, the study proposes the following hypotheses:

Ho₁: Fuel price hikes have no significant impact on the economic sustainability of MSMEs in Benue State.

Ho₂: The adoption of energy-efficient technologies has no significant effect on the economic sustainability of MSMEs in Benue State.

Ho₃: Energy-efficient technology does not significantly moderate the relationship between fuel price hikes and the economic sustainability of MSMEs in Benue State.

Theoretical Framework

This study integrates three complementary theoretical lenses —the Resource-Based View (RBV), Institutional Theory, and Innovation Diffusion Theory (IDT) — to examine how MSMEs in Benue State respond to rising fuel prices and the potential moderating role of energy-efficient technologies in sustaining their operations.

Resource-Based View (RBV): The Resource-Based View (RBV), pioneered by Penrose (1959) and formalized by Barney (1991), posits that firms achieve sustained competitive advantage through internal resources that are valuable, rare, inimitable, and non-substitutable (VRIN).

The RBV shifts the strategic focus inward toward firm-specific assets and capabilities rather than external market conditions, as emphasized in models like Porter's Five Forces. RBV rests on two core assumptions: resource heterogeneity and immobility. The former implies that firms differ in their resource endowments, leading to variations in performance. At the same time, the latter suggests these resources are not easily transferable across firms due to embedded tacit knowledge or firm-specific routines (Helfat & Peteraf, 2003). In this study, MSMEs with superior financial, technological, or managerial resources are better positioned to withstand the shocks of fuel price hikes. Access to capital to acquire energy-efficient technologies or maintain diversified supply chains may enable some firms to maintain operational efficiency despite rising costs. However, RBV has limitations in explaining firm behavior under dynamic, high-uncertainty environments like Nigeria's post-subsidy fuel market. It tends to overlook external pressures such as regulatory changes or macroeconomic shocks, and has been critiqued for tautologically defining successful firms as resource-rich without predictive specificity (Priem & Butler, 2001). Therefore, while RBV offers a compelling foundation for examining firm-level resilience, this study complements it with Institutional Theory, which accounts for broader environmental influences.

Institutional Theory: Institutional Theory, as developed by DiMaggio and Powell (1983), emphasizes the influence of formal and informal regulatory, normative, and cognitive institutional pressures on organizational behavior. It posits that firms operate not solely on the basis of efficiency but also in pursuit of legitimacy within structured environments governed by laws, norms, and societal expectations. Three mechanisms of institutional isomorphism are particularly relevant. Coercive isomorphism arises from legal mandates (e.g., fuel subsidy removal or energy policy shifts); mimetic isomorphism from imitation of peer firms under uncertainty; and normative isomorphism from industry-wide professional norms and standards. In this context, MSMEs in Benue State may adopt energy-efficient technologies not only for cost savings but also to comply with policy incentives or emulate competitors perceived as successful innovators. Institutional pressures may further encourage alliances or collective actions among MSMEs, such as shared transport systems or advocacy for government subsidies. However, a critique of Institutional Theory is its emphasis on conformity, which often underplays firms' agency and strategic discretion (Oliver, 1991). Some MSMEs may innovate, resist norms, or even influence institutional rules through lobbying and market leadership. Thus, this framework helps situate MSMEs' responses to fuel price volatility within the broader socio-political and regulatory context of Nigeria.

Innovation Diffusion Theory (IDT): The Diffusion of Innovations Theory (IDT), developed by Rogers (2003), explains how new ideas and technologies spread within social systems. It identifies five perceived attributes —relative advantage, compatibility, complexity, trialability, and observability— as key factors influencing innovation adoption. Energy-efficient technologies, such as solar panels or inverter systems, represent innovations that can help MSMEs adapt to fuel price shocks by offering clear relative advantages (e.g., reduced fuel costs) and compatibility with operational needs. Their trialability —the ability to test

solutions like solar lighting before full adoption — can reduce uncertainty and enhance uptake. Moreover, observability of outcomes such as cost savings or improved productivity in peer firms may spur broader diffusion across the MSME community in Benue State. However, the explanatory power of IDT is constrained in environments like Nigeria, where economic and infrastructural barriers heavily influence adoption. High upfront costs, limited access to credit, and inadequate technical support often inhibit the uptake of innovation, regardless of perceived benefits.

Furthermore, IDT assumes relatively rational decision-making, yet MSMEs in fuel-stressed environments may adopt innovations based on survival instincts or peer imitation rather than structured evaluations. The theory also underrepresents structural factors such as policy incentives, cultural dynamics, and systemic power imbalances. Despite these limitations, IDT remains valuable in understanding the behavioral and perceptual dimensions of how MSMEs consider and integrate energy-efficient technologies. When viewed alongside RBV and Institutional Theory, it provides a sound understanding of the internal and external dynamics that influence energy-related decisions.

Empirical Review

This section synthesizes empirical studies thematically around two interrelated domains: (1) the impact of fuel price hikes on the economic sustainability of MSMEs, and (2) the moderating role of energy-efficient technologies in enhancing MSME resilience.

Fuel Price Hikes and MSME Sustainability. Several previous empirical studies confirm that significant increases in fuel prices significantly raise MSME operational costs, thereby reducing profitability and threatening long-term sustainability. For instance, Enejo and Ojabo (2024) found that in Lokoja, Nigeria, fuel price volatility leads to elevated production costs, disrupted supply chains, and constrained investment. Similarly, Kadiri (2024) observed that subsidy removal in Kogi State directly increased operational expenses and prices of goods, leading to higher inflation and reduced business competitiveness. In Katsina State, Dodo et al. (2024) corroborated these findings, revealing that subsidy reforms elevate raw material and transportation costs while weakening consumer demand. This double squeeze on input and output markets undermines SME profitability and growth prospects. Studies such as Oboreh (2024) further demonstrate that fuel price hikes lead to average cost increases and declining profit margins in the retail and manufacturing sectors across Delta State.

Fuel price volatility not only affects finances but also induces structural retrenchment within firms. Abejirinde and Odoh (2024) demonstrated that unreliable electricity supply and surging fuel costs led to reduced hours and widespread closures in Yenagoa. In Ghana, Ayakwah and Mohammed (2014) echoed these patterns, documenting reduced turnover, capital strain, and output losses due to rising energy costs. These findings underline the transnational relevance of fuel pricing as a systemic risk to MSME viability. In terms of sector-specific vulnerabilities, transport-dependent and energy-intensive sectors like logistics, manufacturing, and retail are disproportionately affected. For instance, Plaza (2023) in the

Philippines found that microenterprises, especially food vendors and retailers, are severely affected by transport-related inflation, with cost increases cascading through the supply chain.

Energy-Efficient Technologies and MSME Sustainability. A growing body of literature investigates the role of energy-efficient technologies in mitigating the effects of fuel price shocks. Owusu-Sekyere et al. (2024) provide compelling evidence across Lagos, Kano, and Ondo states, showing that MSMEs adopting solar energy experienced an average 24–27% increase in monthly income and a 36.6% reduction in energy expenditures. In Pakistan, Qamar et al. (2022) identified enterprise size, perceived reliability, and ease of use as primary drivers of solar energy adoption among MSMEs, while upfront costs and limited technical knowledge remained key barriers.

From a strategic perspective, energy-efficient technologies are seen not only as coping mechanisms but also as drivers of competitiveness. Toromade and Chiekezie (2024) argue that integrating innovations like renewable energy and circular economy practices helps SMEs reduce operating costs and strengthen market positioning. Though qualitative, their policy-oriented analysis highlights the importance of regulatory reform, access to green financing, and institutional support. Similarly, Privat and Guerrieri (2024) found, through a global systematic literature review, that SMEs can become agents of sustainability transitions when equipped with financial and technical resources. However, resistance to change, limited investment capital, and regulatory burdens remain persistent constraints. Despite the promise of energy-efficient technologies, empirical evidence points to multiple adoption constraints. As Oboreh (2024) observed, only 15% of surveyed SMEs in Delta State had considered energy alternatives due to high initial investment costs. Qamar et al. (2022) emphasized that perceived complexity and lack of reliability can slow the diffusion curve despite policy support.

The reviewed studies highlight the detrimental impact of fuel price hikes on MSME sustainability, leading to higher operational costs and reduced profitability. While energy-efficient technologies offer a viable pathway for mitigation, empirical gaps remain regarding their moderating role in Benue State. This study addresses these gaps by empirically evaluating how fuel price fluctuations affect MSME sustainability in Benue State and to what extent the adoption of energy-efficient technologies moderates this relationship.

RESEARCH METHOD

Research Design

This study employs a survey research design, which is well-suited to obtaining firsthand information from respondents on the topic. The study collects data through structured questionnaires distributed to selected MSME owners and operators across the three senatorial districts in the State.

Study Population

The study population comprises MSMEs owners and operators in Benue State, representing 2.1% of the total 39.64 MSMEs in Nigeria. This national figure includes 38.4 million informal MSMEs and 1.24 million formal MSMEs as of 2024 (PricewaterhouseCoopers [PwC], 2024; International Finance Corporation, 2022). Based on this percentage, the estimated number of MSMEs in Benue State is approximately 832,440 enterprises.

Sample Size Determination

The sample size for this study was determined using Yamane's (1967) formula at a 95% confidence level with a 5% margin of error:

$$n = \frac{N}{1 + N(E)^2}$$

Where: n= the sample size, N= the estimated population of MSMEs in Benue State (832,440), E level of significance or limit of tolerable margin of error (0.05), and 1= unit (a constant value). Applying the formula:

$$n = \frac{832,440}{1 + 832,440(0.05)^2}$$

$$n = 400$$

Therefore, 400 fully completed questionnaires were collected and submitted for data analysis.

Sampling Technique: The study employs a purposive, stratified random sampling approach to ensure a representative selection of MSMEs in Benue State. For purposive sampling, the three local government areas of Makurdi, Otukpo, and Katsina-Ala were deliberately chosen for their economic significance as major commercial hubs within the State. These areas host a high concentration of MSMEs, making them ideal for the analysis. In stratified random sampling, within each selected LGA, MSMEs were further categorized into strata based on location and business type to ensure adequate representation. The strata were determined by key business districts within each area. These businesses were further classified into major SME categories: retail, manufacturing, and services. Respondents were randomly selected from each stratum to maintain diversity and balance in the sample distribution. To facilitate the data collection, a Google Form link was shared with MSME operators through their respective market associations in the identified strata. The respondents were invited to complete the form online between March 27th and April 6th. This method ensured efficient data collection while enabling broad participation across different MSME sectors. In total, each local government area had approximately 133 respondents, resulting in a final sample of 400 SME operators selected for analysis.

Data Sources

This study relies on primary data collected through structured questionnaires. To facilitate broad participation and ensure efficient data collection, the questionnaire was administered online via Google Forms. This online approach enabled business owners to access the survey easily, minimized logistical challenges, and improved response accuracy by allowing participants to complete the survey at their convenience. The questionnaire was designed to cover key areas relevant to the study.

Research Instrument

The primary data collection instrument for this study was a structured questionnaire, designed to obtain quantitative information. The questionnaire comprised a mix of closed-ended and Likert-scale questions, allowing respondents to provide precise, measurable responses on fuel price hikes, business sustainability, and the adoption of energy-efficient technologies. To enhance the validity and reliability of the research instrument, a panel of economic experts reviewed the questionnaire to ensure that it effectively captured the essential variables relevant to the study. The experts assessed the content for clarity, relevance, and alignment with the study objectives, leading to necessary refinements before distribution. Additionally, to establish the internal consistency and reliability of the questionnaire, Cronbach's alpha coefficient was calculated, indicating a high level of reliability and consistency in the responses.

Model Specification

This study employs Structural Equation Modelling (SEM) to examine the influence of fuel price hikes (FPHN) on the economic sustainability of MSMEs in Benue State, Nigeria. The Covariance-Based Structural Equation Modeling (CB-SEM) was considered over Partial Least Squares SEM (PLS-SEM) because the primary objective was theory testing and confirmation of a theoretically grounded, multidimensional model that examines both direct and moderating effects among latent constructs (fuel price hikes, energy-efficient technology adoption, and economic sustainability of MSMEs), requiring rigorous evaluation of model fit indices, which CB-SEM is more suited to handle than the prediction-oriented PLS-SEM.

Recognizing the critical role of affordable energy in business operations, the model also explores the moderating effect of energy-efficient technology adoption (EETN) on this relationship. This modeling approach is grounded in structural equation modeling. The core latent variable of interest, Economic Sustainability of MSMEs (ESM), is operationalized through four key constructs: profitability, operational cost, business continuity, and resilience to economic shocks. Each construct is further measured by multiple indicators that provide a comprehensive picture of MSMEs' economic health. For profitability, the indicators include whether recent fuel price hikes have reduced profit margins, whether businesses have struggled to maintain stable profits, the extent to which high fuel prices have increased the cost of goods and affected customer demand, and how fuel price fluctuations have disrupted business revenue planning. Operational costs are assessed through items measuring

increases in overall business operating costs, impacts on the ability to pay salaries and expenses, rising raw-material and production costs due to fuel costs, and effects on logistics and distribution expenses. Business continuity focuses on disruptions to operations caused by fuel hikes, reductions in business scale, difficulties adapting without significant changes, and the perceived threat to long-term sustainability. Lastly, resilience to economic shocks is captured through indicators assessing the presence of strategies like alternative energy sources, business income diversification, the effectiveness of government support policies, and the financial stability needed to withstand fuel-related economic shocks.

Fuel price hikes (FPHN) are measured using three leading indicators: the frequency with which businesses have been affected by FPHN over the past year, the perceived severity of FPHN within the MSME sector, and the percentage increase in fuel consumption costs incurred by MSMEs following the hikes. These variables collectively capture both the objective and perceived burden of energy inflation on enterprise operations. On the other hand, energy-efficient technology adoption (EETN) is evaluated through multiple indicators that assess the extent to which MSMEs have integrated energy-efficient solutions into their operations. These include solar energy, hydropower, energy-saving appliances, and biomass sources such as biofuels or biogas. The model also considers the financial investments MSMEs have made in these technologies, as well as the perceived effectiveness of such investments in maintaining business continuity and performance amidst rising fuel prices. To capture the interactive effect between fuel price hikes and energy-efficient technology, the model includes a moderating term (FPHN*EETN). This interaction term is essential for identifying whether the adoption of energy-efficient technologies amplifies or mitigates the effect of fuel price volatility on MSME sustainability. This allows the study to determine whether energy-efficient technology adoption serves as a strategic resilience tool or introduces additional complexities that alter the direct relationship between fuel prices and business outcomes. The model for the study is stated as:

$$ESM = f(FPHN) \quad (1)$$

In order to account for the moderating effect of energy-efficient technology on the relationship between fuel price hikes and economic sustainability of MSMEs, equation 1 is re-specified as:

$$ESM = f(FPHN, EETN, FPHN * EETN) \quad (2)$$

Where ESM=Economic sustainability of MSMEs

FPHN=Fuel Price Hikes

EETN=Energy-Efficient Technology Adoption

FPHN*EETN=Interaction term measuring the moderating effect of energy-efficient technology on the relationship between fuel price hikes and MSME economic sustainability. The confirmatory factor analysis is presented in Figure 1.

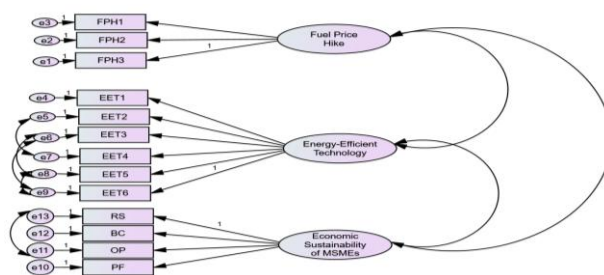


Figure 1: Measurement Model

The Confirmatory Factor Analysis (CFA) path diagram shows the measurement and structural relationships among the three key latent constructs: Fuel Price Hike (FPHN), Energy-Efficient Technology (EETN), and Economic Sustainability of MSMEs (ESM). Each construct is measured by multiple observed indicators with strong standardized loadings, most of which exceed the recommended threshold of 0.5, confirming convergent validity. For the Fuel Price Hike, indicators FPH1, FPH2, and FPH3 load strongly (0.51–0.76), while Energy-Efficient Technology is explained by six indicators (EET1–EET6) with loadings ranging from 0.65 to 1.00, indicating high construct reliability. Economic Sustainability of MSMEs is captured by four observed variables (RS, BC, OP, PF) with very high loadings (0.81–0.90), indicating robust measurement of the latent construct. The structural paths reveal a negative, significant relationship between Fuel Price Hike and Economic Sustainability (-0.66), highlighting MSMEs' vulnerability to rising fuel costs. Conversely, Energy-Efficient Technology positively affects MSME sustainability (0.64), affirming its role in enhancing resilience. The strong negative correlation (-1.01) between Fuel Price Hike and Energy-Efficient Technology suggests that higher reliance on fuel discourages investment in alternative technologies. The CFA results support good construct validity.

Turning the measurement model into the structural equation model (SEM), the SEM path is specified as:

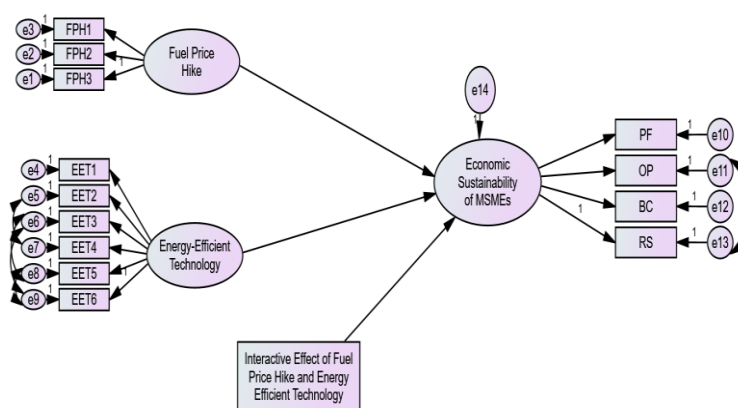


Figure 2: SEM Path

As shown in Figure 2, the model incorporates several covariance relationships among error terms to improve the robustness and explanatory power of the SEM framework. Specifically, covariance was allowed among the error terms of the indicators measuring the use of energy-

saving appliances and biomass energy sources, acknowledging potential shared latent factors, such as affordability, accessibility, or a general orientation toward sustainable energy alternatives. Another covariance relationship was established between the error terms of financial investment in energy-efficient technologies and their effectiveness, reflecting the intuitive connection between spending and outcomes. Similar covariances were included between hydropower solutions and both investment and effectiveness indicators to capture shared variance that may arise from technology-specific investment behaviors or infrastructural limitations. Furthermore, within the ESM latent construct, the error terms of operational cost and resilience to economic shocks were allowed to covary, as both constructs may share unobserved financial stressors or external economic conditions not explicitly accounted for in the model.

Table 1: Convergent and Discriminant Validity Results (Fornell–Larcker) for Constructs

Construct	AVE	CR	ESM	FPHN	EETN
ESM (Economic Sustainability of MSMEs)	0.710	0.907	0.843	−0.660	0.635
FPHN (Fuel Price Hikes)	0.642	0.842	−0.660	0.801	−0.800
EETN (Energy-Efficient Technology)	0.681	0.926	0.635	−0.800	0.825

Note: Diagonal (bold)=VAVE (Fornell–Larcker criterion). Off-diagonals=latent correlations.

Table 2: Convergent and Discriminant Validity Results (HTMT Ratios: threshold<0.85) for Constructs

Pairwise Constructs	HTMT
ESM ↔ FPHN	0.662
ESM ↔ EETN	0.637
FPHN ↔ EETN	0.804

The results of the measurement model, presented in Tables 1 and 2, provide strong evidence of both convergent and discriminant validity for the constructs examined in this study. These include: Fuel Price Hikes (FPHN), Economic Sustainability of MSMEs (ESM), and Energy-Efficient Technology (EETN). Convergent validity was assessed using the Average Variance Extracted (AVE) and Composite Reliability (CR). The AVE values for the constructs ranged from 0.642 for FPHN to 0.710 for ESM and 0.681 for EETN. Since all these values exceed the recommended minimum of 0.50, it is clear that each construct explains more than half of the variance in its observed indicators. Similarly, the CR values, which measure the internal consistency reliability of the constructs, ranged from 0.842 for FPHN to 0.907 for ESM and 0.926 for EETN. All these values exceed the 0.70 threshold, suggesting that the measures are reliable and that the items assigned to each latent construct consistently represent the same underlying concept.

To assess discriminant validity, the Fornell–Larcker criterion was applied, comparing the square root of each construct's AVE with its correlations with other constructs. The diagonal values in the correlation matrix —0.843 for ESM, 0.801 for FPHN, and 0.825 for EETN —are all higher than the respective inter-construct correlations. This confirms that each construct shares more variance with its own indicators than with those of other constructs, thereby

meeting the Fornell–Larcker criterion. This is an important result because it demonstrates that the three constructs are empirically distinguishable and not simply measuring overlapping phenomena.

Further support for discriminant validity is provided by the Heterotrait-Monotrait Ratio of Correlations (HTMT). The HTMT values obtained were 0.662 for the relationship between ESM and FPHN, 0.637 for the relationship between ESM and EETN, and 0.804 for the relationship between FPHN and EETN. All these values fall below the conservative cut-off of 0.85, confirming that the constructs are sufficiently distinct from one another. Although the HTMT between FPHN and EETN is relatively high (0.804), it remains within acceptable limits. This suggests that, while there is a conceptual link between fuel price hikes and energy-efficient technologies, consistent with the expectation that energy costs and efficiency technologies are closely related, the two constructs remain empirically distinct. These findings demonstrate that the measurement model is both reliable and valid. The constructs of fuel price hikes, economic sustainability, and energy-efficient technology are well represented by their indicators and can be used with confidence in subsequent structural analyses. The relatively close yet distinct relationship between FPHN and EETN also supports the theoretical framing of this study, which posits that energy-efficient technology moderates the impact of rising fuel prices on the sustainability of MSMEs in Benue State.

Table 3: Reliability Test Results

Construct	No. of Items	Cronbach's Alpha (Based on Standardized Items)	Decision on Reliability
Energy-Efficient Technology (EETN)	6	0.863	Acceptable
Fuel Price Hikes (FPHN)	3	0.831	Acceptable
Economic Sustainability of MSMEs (ESM)	4	0.897	Acceptable
Average	13	0.864	Acceptable

The results in Table 3 present the internal consistency reliability of the three key constructs in the study (Energy-Efficient Technology, Fuel Price Hikes, and Economic Sustainability of MSMEs). The results show that the standardized Cronbach's Alpha coefficient, which measures reliability, improves to 0.863, surpassing the 0.70 threshold. This indicates that the construct is internally consistent once measurement direction is corrected. For Fuel Price Hikes, the Cronbach's Alpha (standardized version) is 0.831, which is acceptable. This indicates the construct's internal consistency. Similarly, the Economic Sustainability of MSMEs recorded a Cronbach's Alpha of 0.888 and a standardized alpha of 0.897, both indicating high internal consistency. Thus, the constructs meet the minimum reliability requirement, with standardized alphas ranging from 0.831 to 0.897. This implies that the measurement scales used in this study are consistent and reliable in capturing the underlying dimensions. Given the expected negative relationship between the constructs (higher fuel price hikes reducing MSME sustainability while energy-efficient technologies improving it), the use of standardized alphas ensures that the directionality of items does not distort the internal consistency of the measures. Thus, the average reliability across

constructs falls within an acceptable range, reinforcing confidence in the survey instrument's robustness. The data were tested for normality, and the distribution was found to be normal.

The empirical model has been explicitly presented using a structural diagram. The diagram is now included to show the hypothesized relationships among fuel price hikes, economic sustainability of MSMEs, and the moderating role of energy-efficient technology. All constructs, observed variables, paths, and moderating effects have been clearly labeled in the diagram for clarity and replicability. Furthermore, the instrument used for data collection was a questionnaire via Google Forms. The questionnaire was developed. The items were contextualized and validated through expert review. In addition, the results presentation has been expanded to include key diagnostics for the measurement model—a correlation matrix of the latent variables, item-level factor loadings, and cross-loadings to demonstrate construct validity. The Confirmatory Factor Analysis (CFA) results, along with the Average Variance Extracted (AVE), Composite Reliability (CR), and Heterotrait–Monotrait Ratio (HTMT) values, were computed to assess the validity and reliability of the constructs.

Data Analysis

To assess the impact of fuel price hikes on the economic sustainability of MSMEs in Benue State and to examine the moderating role of energy-efficient technology, this study adopted a robust, multi-tiered data analysis framework—the analytical strategy utilized both descriptive and inferential statistical techniques. Descriptive statistics were employed to examine the distribution and central tendencies of the key variables in the dataset. Frequencies and percentages were computed to describe the demographic characteristics of respondents and to profile the prevalence of experiences with fuel price hikes, levels of energy-efficient technology adoption, and overall economic responses within the MSME sector in Benue State. Alongside frequency distributions, means and standard deviations were calculated to understand the nature and spread of the indicators associated with each latent variable in the model.

To further evaluate the economic effects of fuel price hikes, a paired-samples t-test was conducted to assess differences in profit levels, operational costs, and average working hours before and after the most recent fuel price increases. This inferential procedure was used to test whether statistically significant differences existed between pre- and post-hike conditions. The null hypothesis assumed that there was no significant difference in the mean values before and after the hike. A p-value of less than 0.05 was interpreted as evidence of a significant change.

Building upon the preliminary analysis, the study employed Structural Equation Modeling (SEM) for the core analytical phase. SEM was chosen for its strength in modeling complex relationships between observed and latent variables and its capacity to estimate both direct and indirect effects simultaneously. The structural model specified in this study incorporated three key latent constructs —fuel price hikes (FPHN), economic sustainability (ESM), and energy-efficient technology adoption (EETN) —as well as the interaction term (FPHN × EETN),

which captures the moderating effect. The use of SEM enabled validation of the measurement model via Confirmatory Factor Analysis (CFA), followed by estimation of path coefficients representing causal relationships among the constructs. Specifically, fuel price hikes and energy-efficient technology adoption were modeled as exogenous variables, while economic sustainability was treated as the endogenous outcome variable. The interaction term between fuel price hikes and energy-efficient technology was created to test the hypothesis of moderation.

These hypotheses were tested by analyzing the magnitude and significance of standardized path coefficients, associated p-values, and the confidence intervals of the estimates. A significant negative path coefficient from fuel price hikes to economic sustainability would support the assertion that energy cost inflation adversely affects MSMEs. In contrast, a significant positive coefficient from EETN to ESM would indicate that energy-efficient technologies contribute positively to business sustainability. Likewise, a significant interaction effect would suggest that the influence of fuel price hikes on MSME sustainability is either amplified or mitigated depending on the level of technological adaptation.

Furthermore, the goodness-of-fit of the SEM was evaluated using multiple fit indices to ensure the model's appropriateness and statistical adequacy. These included the Chi-square to degrees of freedom ratio (χ^2/df), where values less than 3 indicate a good fit, and comparative indices such as the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI), both of which should ideally be above 0.90. The Root Mean Square Error of Approximation (RMSEA) was also computed, with values below 0.08 representing acceptable fit and those below 0.05 indicating a highly satisfactory model. In addition, the Standardized Root Mean Square Residual (SRMR) was examined; values below 0.08 are generally accepted as indicating good model fit. These indices collectively ensured that the structural model not only captured the empirical relationships accurately but also reflected a well-fitting theoretical structure. To further refine the model and enhance its explanatory power, several covariances between measurement errors were incorporated. These relationships were introduced to capture the shared variance that may not have been explained by the latent constructs but still influenced the measurement indicators. Their inclusion contributed to improved model fit.

FINDINGS AND DISCUSSION

Business Characteristics and Economic Structure of MSMEs in Benue State

The distribution of the sampled MSMEs in Benue State, based on their business characteristics and economic structure, is presented in Table 4. The results from Table 4 show that the services sector is the most prominent, accounting for 31% (124 MSMEs) of the total. Following services, the wholesale/retail sector accounts for 23% (92 MSMEs) of the sample. The Manufacturing sector accounts for 21% (84 MSMEs) of the total sample. Among the sampled MSMEs, the smaller segments are agriculture (12%, 48 MSMEs) and construction (9%, 36 MSMEs).

Table 4: *Distribution of MSMEs According to Business Characteristics and Economic Structure*

The nature of MSMEs	Frequency	Percent
Manufacturing	84	21.0
Wholesale/Retail	92	23.0
Services	124	31.0
Agriculture	48	12.0
Construction	36	9.0
Others(please specify)	16	4.0
Total	400	100.0
Years of operation		
Less than 1 year	60	15.0
1–5 years	176	44.0
6–10 years	80	20.0
Over 10 years	84	21.0
Total	400	100.0
Number of employees		
Less than 10	248	62.0
10–49	104	26.0
50–99	36	9.0
100 and above	12	3.0
Total	400	100.0
Average Annual Turnover of MSMEs		
Below ₦5 million	216	54.0
₦5 million – ₦50 million	88	22.0
₦50 million – ₦500 million	64	16.0
Above ₦500 million	32	8.0
Total	400	100.0

Source: Field Survey, 2025

The "Others" category, consisting of 16 (4%) MSMEs' captures businesses operating in niche or emerging areas that do not neatly align with the conventional classifications listed above. The dominance of the services sector suggests a shift toward urban-oriented, non-agricultural economic activities, given that the majority of the MSMEs were sampled from urban centers within the State. Results on the distribution of the sampled MSMEs in Benue State based on their years of operation are presented in Table 4.

The results from Table 4 indicate that the majority of businesses in the sample have been in operation for 1–5 years, representing 44% (176 MSMEs) of the total. This is followed by businesses operating for over 10 years at 21% (84 MSMEs), and those in operation for 6–10 years, which account for 20% (80 MSMEs). Newer businesses, those less than 1 year old, make up the smallest segment, comprising 15% (60 MSMEs) of the sample. These findings suggest that a substantial majority (85%) of the MSMEs have been in operation for over a year, with many (particularly those in the 6–10 and 10+ year categories) having navigated both pre- and post-subsidy environments.

The results in Table 4 show that the majority of businesses surveyed are small enterprises with fewer than 10 employees, accounting for 62% (248 MSMEs) of the total sample. This is followed by businesses with 10–49 employees at 26% (104 MSMEs), while medium-sized businesses employing 50–99 people account for 9% (36 MSMEs). Only 3% (12 MSMEs) of businesses have a workforce of 100 or more, representing the smallest category. The

predominance of micro and small enterprises reflects the informal and small-scale nature of the business environment, with implications for job creation, scalability, and the need for targeted support in areas such as business development services, access to finance, and workforce training.

The results from Table 4 reveal that over half of the businesses surveyed (54% or 216 MSMEs) report an average annual turnover below ₦5 million, indicating a prevalence of low-revenue enterprises. Businesses earning between ₦5 million and ₦50 million make up 22% (88 MSMEs), while those with annual revenues ranging from ₦50 million to ₦500 million constitute 16% (64 MSMEs). Only 8% (32 MSMEs) of businesses report turnovers exceeding ₦500 million, which represents the highest income bracket. The dominance of businesses with lower annual turnover explains the limited financial capacity of most enterprises, which may affect their ability to expand, invest in innovation, or withstand economic shocks.

Impact of Fuel Price Hikes on Profitability, Operating Costs, and Hours of MSMEs in Benue State

This section assesses how recent fuel price hikes have affected the operational and financial dynamics of MSMEs. Drawing on primary data, the analysis assesses average monthly profit distribution (Table 5), operating costs (Table 6), and average hours of operation (Table 7) before and after the hike.

The distribution of MSMEs according to the average monthly profit before and after fuel price hikes is presented in Table 5

Table 5: Average Monthly Profit Distribution of MSMEs

Average Monthly Profit	Frequency	Percent	Frequency	Percent
	Before the Fuel Price Hikes		After the Fuel Price Hikes	
Below ₦10,000	148	37.0	164	41.0
₦10,000 – ₦100,000	140	35.0	136	34.0
₦100,000 – ₦1 Million	92	23.0	68	17.0
Above ₦1 Million	20	5.0	32	8.0
Total	400	100.0	400	100.0
Mean		291,517		394,789
Standard Deviation		1,032,299.52		1,303,516.74
T-test (Prob.)				-2.053 (0.041)

Source: Field Survey, 2025

The result in Table 5 reveals a noticeable shift in MSMEs' profit structures following the fuel price hikes. Before the increase, the majority of businesses earned modest to mid-level profits, with 37.0% of firms earning below ₦10,000 and 35.0% earning between ₦10,000 and ₦100,000. A relatively healthy 23.0% were in the higher profit bracket of ₦100,000 to ₦1 million, while only a small elite (5.0%) surpassed ₦1 million in monthly profits. However, after the removal of the fuel subsidy and subsequent price hike, profitability declined for most MSMEs, particularly in the mid-income bracket. The percentage of businesses earning less than ₦10,000 per month rose to 41.0%, reflecting increased operational pressures and decreased earnings. Similarly, the ₦10,000–₦100,000 segment declined slightly to 34.0%, and

notably, the ~~₦100,000–₦1 million~~ bracket dropped by six percentage points to 17.0%. This contraction suggests that many medium-profit businesses likely fell into lower categories due to higher fuel-related expenditures. Interestingly, the number of firms reporting profits above ₦1 million rose from 5.0% to 8.0%. This could indicate that a small proportion of well-capitalized or more adaptable MSMEs were able not only to withstand but also to capitalize on the changing economic environment, possibly by adjusting pricing strategies, leveraging supply chain efficiencies, or diversifying revenue streams. The post-hike environment has intensified financial strain for the majority of MSMEs, especially those operating on tight margins or within the middle tier. The data shows a growing divide in business resilience, with a minority thriving while the majority face diminished profitability.

In addition to the distributional analysis, the average monthly profit increased from ₦291,517 to ₦394,789, suggesting a higher central tendency in the post-hike period. However, this apparent increase in mean profit was accompanied by a higher standard deviation of ₦1.3 million after the hike, which is relatively higher than the ₦1.03 million before the hike. This indicates wide variability in profit levels after the hike, likely driven by a few high-performing outliers. To statistically evaluate the difference in means, a paired sample t-test was conducted, yielding a t-value of -2.053 and a p-value of 0.041. Since the p-value is less than the 0.05 critical value, the result is statistically significant at the 5% level. This implies a significant difference in average monthly profits before and after the fuel price hikes. The statistically significant decline indicates that fuel price hikes have had a measurable adverse impact on MSME profitability.

The distribution of MSMEs by their average monthly operational costs, specifically transportation and logistics, is presented in Table 6.

Table 6: Average Monthly Cost of Operations of MSMEs

Average Monthly Cost of Operations	Frequency	Percent	Frequency	Percent
	Before the Fuel Price Hikes		After the Fuel Price Hikes	
Below ₦10,000	52	13.0	20	5.0
₦10,000 – ₦100,000	228	57.0	192	48.0
Above ₦100,000	120	30.0	188	47.0
Total	400	100.0	400	100.0
Mean	1050045.00		1609500.00	
Standard Deviation	5564628.415		7243301.682	
T-test (Prob.)	-5.784 (0.041)			

Source: Field Survey, 2025

Before the fuel price hike, the majority of MSMEs (57.0%) reported spending between ₦10,000 and ₦100,000 monthly on transportation and logistics. A notable 30.0% of businesses had already spent above ₦100,000, while 13.0% had operated on less than ₦10,000. These figures suggest a relatively moderate cost environment, with only a third of businesses incurring relatively high logistics expenses prior to the subsidy removal.

Following the hike, a striking shift occurred in the cost structure. The proportion of businesses spending above ₦100,000 surged from 30.0% to 47.0%, an increase of 17

percentage points. This indicates that nearly half of the MSMEs experienced substantial increases in logistics-related expenditures. Simultaneously, those in the ₦10,000–₦100,000 category declined from 57.0% to 48.0%, and the number of MSMEs spending below ₦10,000 shrank to just 5.0%. This reallocation suggests that the fuel price hikes disproportionately impacted MSMEs at the lower end of the cost spectrum, effectively pushing many into higher expenditure brackets.

Beyond categorical shifts, the average (mean) monthly operational cost rose sharply from ₦1,050,045.00 before the hike to ₦1,609,500.00 afterward, an increase of over ₦559,000. This substantial jump reflects a more profound operational cost crisis facing MSMEs. It is accompanied by a high standard deviation (₦5.5 million before, ₦7.2 million after), indicating wide cost disparities, likely influenced by business size, industry, and geographical location. To assess whether this increase is significant, a paired-samples t-test was conducted. The test produced a t-value of -5.784 with a p-value of 0.041, indicating statistical significance at the 5% level. Despite the negative t-value (reflecting the direction of change in the statistical computation), the low p-value confirms that the increase in average operational costs is statistically significant and not due to random variation.

The distribution of MSMEs by average hours of operation before and after fuel price hikes is presented in Table 7.

Table 7: Distribution of Average Hours of Operations of MSMEs

Average Hours of Operations of MSMEs	Frequency	Percent	Frequency	Percent
	Before the Fuel Price Hikes		After the Fuel Price Hikes	
Less than 4 hours	4	1.0	8	2.0
4-8 hours	64	16.0	128	32.0
8-10 hours	128	32.0	104	26.0
More than 10 hours	204	51.0	160	40.0
Total	400	100.0	400	100.0
Mean	12.16 hours		10.40 hours	
Standard Deviation	4.892		4.464	
T-test (Prob.)	14.048 (0.000)			

Source: Field Survey, 2025

From the results in Table 7, a clear picture emerges of the impact of fuel price hikes on MSME operational routines. Prior to the fuel price increase, the majority of MSMEs (51.0%) operated for more than 10 hours daily. This reflects a strong inclination toward extended working hours, most likely driven by the need to maximize output, meet customer demand, and compensate for thin profit margins through longer service availability. Additionally, 32.0% of businesses reported operating for 8–10 hours, meaning that over four-fifths (83.0%) of MSMEs maintained at least a standard 8-hour workday before the price hike. This operational pattern illustrates a robust and engaged business environment, with only 1.0% of firms operating for fewer than 4 hours daily.

However, following the removal of the fuel subsidy and the resulting price hike, a significant contraction in business hours was observed. The percentage of MSMEs operating more than 10 hours dropped to 40.0%, while those operating 8–10 hours fell to 26.0%.

Meanwhile, businesses working 4–8 hours daily doubled from 16.0% to 32.0%, and the proportion operating less than 4 hours increased to 2.0%. These changes reflect a straightforward behavioral adaptation among MSMEs, likely as part of a cost-containment strategy in response to the increased burden of fuel and energy expenses. Reduced hours could stem from efforts to lower generator fuel consumption, reduce labor hours, or manage operating costs for logistics, lighting, cooling, or equipment use.

Beyond these distributional shifts, the mean number of operating hours before the hike was 12.16 hours, compared with 10.40 hours after the hike, a reduction of 1.76 hours on average. This change is both practically and statistically significant. The t-test result of 14.048 with a p-value of 0.000 confirms that the difference in average hours is statistically significant at the 1% level. This means the observed reduction in working hours is unlikely to be due to chance and can be confidently attributed to the fuel price hike. The statistically significant reduction in average business hours carries important operational and economic implications. Shorter hours may lead to reduced daily output, narrower customer engagement windows, and, consequently, lower revenues, especially for time-sensitive sectors like manufacturing, hospitality, retail, or service-based MSMEs. Over time, this operational contraction could negatively affect productivity, employee income, job stability, and customer satisfaction.

Effects of Fuel Price Hikes on Economic Sustainability of MSMEs in Benue State

The results on the effects of fuel price hikes on the economic sustainability of MSMEs in Benue State and the moderating role of energy-efficient technology are presented in Table 8 and Figure 3.

Table 8: SEM Results on the Effects of Fuel Price Hikes on the Economic Sustainability of MSMEs and the Moderating Role of Energy-Efficient Technology in Benue State

Parameter	Unstandardized Estimates	Standardized Estimates	S.E.	CR.	P	Lower	Upper	P
ESM <---FPHN	-0.214	-0.115	0.098	-2.197	0.028	-0.257	-0.013	0.056
ESM <---EETN	0.624	0.558	0.094	6.677	***	0.41	0.656	0.001
Interactive Effect								
Term (ESM<---								
FPHvEET)	0.139	0.049	0.17	0.82	0.412	-0.047	0.172	0.376
FPH3<---FPHN	1	0.443				0.374	0.515	0.001
FPH2<--- FPHN	3.021	1.134	0.499	6.051	***	1.022	1.261	0.001
FPH<--- FPHN	1.321	0.592	0.142	9.308	***	0.534	0.654	0.001
PF<---ESM	0.79	0.869	0.042	18.929	***	0.83	0.906	0.001
OP<--- ESM	0.93	0.886	0.053	17.496	***	0.852	0.916	0.001
BC<--- ESM	0.884	0.743	0.054	16.523	***	0.679	0.798	0.001
RS<--- ESM	1	0.804				0.744	0.862	0.001
EET3<--- EETN	1.019	0.776	0.063	16.143	***	0.726	0.824	0.001
EET2<--- EETN	0.704	0.65	0.052	13.668	***	0.584	0.718	0.001
EET1<--- EETN	1.412	0.992	0.062	22.832	***	0.98	1.002	0.001
EET4<--- EETN	1.424	0.97	0.064	22.187	***	0.953	0.984	0.001
EET5<--- EETN	0.937	0.757	0.027	34.657	***	0.716	0.788	0.001
EET6<--- EETN	1	0.76				0.729	0.784	0.001

Model Fit Indices: CMIN=1729.822 (P=0.000), NFI=0.913, RFI=0.827, IFI=0.921, TLI=0.836, CFI=0.920, RMSEA=0.063, Standardized RMR = 0.0331

Source: Extracts from SPSS Amos. Note: ESM=Economic Sustainability of MSMEs, FPHN=Fuel Price Hikes, EETN=Energy-Efficient Technology, FPHVEET=Moderating Effect of Energy-Efficient Technology (Interactive Effect of Energy-Efficient Technology and Fuel Price Hikes), PF=Profitability, OP=Operational Costs, BC=Business Continuity, RS=Resilience to Economic Shocks.

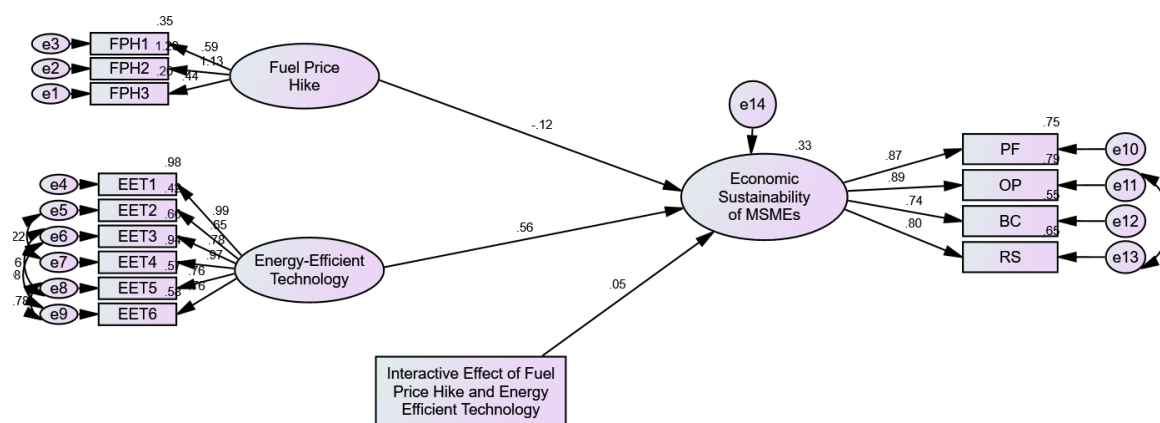


Figure 3: SEM Results

Source: Extracts from SPSS Amos

The SEM results in Table 8 and Figure 3 present information on the direct and moderating effects of fuel price hikes on the economic sustainability of MSMEs (ESM) in Benue State, alongside the role of energy-efficient technologies (EETN). The standardized path coefficient of fuel price hikes (FPHN) on economic sustainability (ESM) is -0.115, with a critical ratio (CR) of -2.197 and a p-value of 0.028, indicating statistical significance at the 5% critical level. This suggests that fuel price hikes negatively and significantly affect the economic sustainability of MSMEs in Benue State. It implies that rising fuel prices adversely affect MSMEs' ability to sustain profitable and stable operations over time. These results validate Hypothesis 1 (H_{01}) and suggest that fuel price volatility poses a significant threat to business resilience, especially in fuel-dependent economies such as Nigeria. Theoretically, this finding aligns with the neoclassical cost theory, which posits that rising input costs, such as fuel, increase marginal costs and reduce producer surplus. MSMEs, due to their relatively narrow profit margins and limited capital buffers, are especially vulnerable to such cost escalations. Additionally, the Resource-Based View (RBV) of the firm supports this result by emphasizing that external shocks to essential resources (such as affordable energy) can disrupt firm performance when internal capabilities (e.g., energy diversification, cost-absorbing mechanisms) are lacking.

Conversely, energy-efficient technology (EETN) shows a positive and highly significant standardized effect of 0.558 on economic sustainability (CR = 6.677, $p < 0.001$). This coefficient indicates that adopting or integrating energy-efficient practices and systems substantially enhances the economic sustainability of MSMEs. Energy-efficient innovations

such as solar power systems, fuel-efficient equipment, or digital optimization tools not only reduce operating costs but also offer MSMEs a strategic advantage by stabilizing energy consumption and mitigating risks from external fuel price shocks. This finding is theoretically grounded in Innovation Diffusion Theory (Rogers, 2003), which posits that the adoption of innovations improves organizational performance by enhancing efficiency and reducing uncertainty. Additionally, the Sustainable Livelihood Framework supports this relationship by emphasizing the importance of technological assets in building adaptive capacity and economic stability, especially in resource-constrained environments.

However, the interaction term representing the moderating effect of energy-efficient technology on the relationship between fuel price hikes and economic sustainability (FPHVEET) yields a non-significant coefficient of 0.049 (CR = 0.82, $p = 0.412$). This implies that while energy-efficient technology independently contributes to business sustainability, it does not significantly moderate or buffer the direct adverse effect of fuel price hikes on MSMEs in this model. This result may suggest that the mere presence of energy-efficient practices is insufficient to counteract the broader macroeconomic implications of steep fuel cost increases, particularly if adoption is uneven, capital access is limited, or businesses still rely on fossil-fuel-based supply chains.

Further analysis of model variables shows that the economic sustainability construct (ESM) is strongly and significantly explained by its key dimensions (profitability (PF), operational costs (OP), business continuity (BC), and resilience to economic shocks (RS)). The standardized coefficients for these relationships are remarkably high: PF (0.869), OP (0.886), BC (0.743), and RS (0.804), all of which are statistically significant at $p < 0.001$. This confirms the conceptual validity of the ESM construct and highlights that fuel price increases impact MSMEs through both profitability erosion and operational cost pressures. At the same time, long-term sustainability is closely tied to continuity planning and resilience capabilities.

The model fit indices offer further validation of the analysis. The Chi-Square (CMIN) is 1729.822 ($p < 0.001$), which is statistically significant. While a non-significant chi-square is desirable in SEM, it is common to observe significance in large sample sizes such as this. More importantly, the Normed Fit Index (NFI = 0.913), Incremental Fit Index (IFI = 0.921), Comparative Fit Index (CFI = 0.920), and the Root Mean Square Error of Approximation (RMSEA = 0.063) all fall within acceptable ranges, indicating a good model fit. The Standardized Root Mean Square Residual (SRMR) is particularly low (0.0331), indicating excellent fit. The Tucker-Lewis Index (TLI = 0.836) and the Relative Fit Index (RFI = 0.827) are slightly below the conventional threshold of 0.90 but still within acceptable tolerance levels. Collectively, these indices confirm that the structural model is appropriately specified and valid, albeit with room for slight improvement in explanatory efficiency.

From an economic standpoint, these findings imply that the negative impact of fuel price hikes on MSMEs reaffirms the argument that energy cost volatility remains a critical barrier to business sustainability, particularly in developing regions with heavy reliance on fossil fuels and weak alternative energy infrastructure.

CONCLUSION

This study set out to investigate the impact of fuel price hikes on the economic sustainability of MSMEs in Benue State, while also examining the role of energy-efficient technologies as a potential moderating factor. The study concludes that fuel price hikes have a significant adverse effect on MSME sustainability. This validates the concern that rising input costs erode profitability, increase operational expenses, and threaten the continuity of enterprises with narrow profit margins. The study also concludes that adopting energy-efficient technologies has a positive, highly significant effect on MSME sustainability. These technologies reduce energy costs and enhance resilience, explaining their importance as strategic assets for MSMEs. However, the moderating effect of energy-efficient technologies on the relationship between fuel price hikes and sustainability was found to be insignificant. Therefore, the findings confirm that fuel price hikes remain a significant barrier to MSME sustainability. At the same time, energy-efficient technologies represent a viable pathway to improved resilience, though not a complete moderating solution.

The study makes several contributions to both scholarship and practice. It advances the literature on MSME resilience by providing empirical evidence from a subnational context in Nigeria, thereby addressing a gap where previous studies often focused on national-level aggregates or treated energy shocks in isolation from technology adoption. It also provides practical guidance on how MSMEs can leverage energy-efficient systems to enhance sustainability in fuel-dependent economies.

Nevertheless, the study has some limitations. The cross-sectional design limits the ability to capture long-term dynamics of fuel price hikes and technology adoption. Furthermore, the focus on Benue State restricts the generalizability of the findings to other regions with different energy and economic structures. Future research should employ longitudinal designs and expand to other geographical areas to validate and extend the findings presented in this study.

Policy Recommendations

Based on the above study findings, the following policy recommendations were made:

- i. Since the analysis confirmed that rising fuel prices have a significant adverse effect on MSME sustainability, government interventions should directly target cost relief for MSMEs. A targeted fuel-cost relief mechanism, such as rebates or partial reimbursements, for enterprises in energy-intensive sectors could help cushion operational costs during periods of steep price increases. This aligns with the evidence that fuel-cost pressures directly erode profitability and long-term sustainability.
- ii. The strong positive effect of energy-efficient technologies on MSME sustainability suggests that policy should prioritize wider diffusion of such technologies as a pathway to strengthening enterprise resilience. At the state level, programs that subsidize or co-finance the acquisition of solar systems, inverters, and energy-saving equipment

- can enhance MSMEs' capacity to reduce operating costs and improve financial stability, independent of fuel price fluctuations.
- iii. Although energy-efficient technologies significantly enhance sustainability on their own, the study found no significant moderating effect between fuel price hikes and sustainability. This points to structural and institutional barriers such as high upfront costs, uneven adoption, and limited financing that weaken their buffering role. Policies should therefore go beyond promoting adoption to include affordable financing instruments, capacity-building for MSMEs, and supportive regulatory frameworks that make clean energy alternatives more accessible and scalable.

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