

NEXUS BETWEEN FIRM CHARACTERISTICS AND CAPITAL STRUCTURE OF LISTED OIL AND GAS COMPANIES IN NIGERIA

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ABSTRACT

Capital structure decisions determine how capital-intensive and price-exposed firms fund investment, yet evidence on Nigerian oil and gas companies remained dated and inconsistent. This study examined the effect of firm characteristics on the capital structure of listed oil and gas firms in Nigeria. An ex post facto panel research design was adopted. The scope covered eight firms listed on the Nigerian Exchange over 2016–2025, giving 80 firm-year observations. Data were obtained from audited annual reports, with Brent price from the U.S. Energy Information Administration and exchange-rate and inflation series from the Central Bank of Nigeria. Total debt to total assets was the dependent variable. Data were analysed using descriptive statistics, pooled, fixed-effects and random-effects estimators, model-selection and residual diagnostics, and robustness checks with wild cluster bootstrap and Driscoll–Kraay standard errors. Pooled OLS was preferred. Profitability ($\beta = -1.566$, $p < 0.05$), liquidity ($\beta = -0.140$, $p < 0.05$) and non-debt tax shields ($\beta = -3.792$, $p < 0.05$) reduced leverage, while firm size ($\beta = 0.038$, $p < 0.05$), tangibility ($\beta = 0.434$, $p < 0.05$) and growth opportunities ($\beta = 0.396$, $p < 0.05$) increased it. Sub-sector had no significant effect ($\beta = 0.006$, $p > 0.05$). The findings supported pecking-order and trade-off behaviour. The managers should use retained earnings and keep liquidity, lenders should match credit with collateral and size, and the policy makers should bring the depreciation related tax incentives into alignment.

Keywords: Firm Characteristics, Capital Structure, Leverage, Oil and Gas, Nigeria.

INTRODUCTION

Among the most discussed topics in corporate finance is the capital structure, which refers to the proportions of debt and equity financing a company uses to finance its assets and thus influences its risk, cost of capital and consequently firm value. It was established that under the perfect market scenario, financing mix does not impact the value of the firm in the foundational irrelevance proposition (Modigliani & Miller, 1958). Despite such real-world complications as taxes, bankruptcy costs, agency conflicts and information asymmetry, financing decisions are still important, and structural factors are associated with leverage (Frank & Goyal, 2009; Rajan & Zingales, 1995; Titman & Wessels, 1988). The question is particularly relevant for companies in emerging markets, which are different in terms of their characteristics, institutions and financial systems from companies in advanced economies (Ahmed et al., 2023; Habibniya et al., 2026).

Theories are put to a challenging test by oil and gas companies. They are subject to commodity prices and exchange rate dependence, their projects are large and long-term and their financing requirements are lumpy. The features in Nigeria are associated with structural change. The Petroleum Industry Act restructured the governance, fiscal and commercial structure of the upstream and downstream operations of the industry (Federal Republic of Nigeria [FRN] 2021), Crude price cycles are still affecting cash flows in both the upstream and downstream parts of the industry (U.S. Energy Information Administration [EIA] 2025), and exchange rate adjustment and monetary tightening have also impacted the cost and availability of credit (Central Bank of Nigeria [CBN] 2024). Tighter monetary conditions are known to reshape corporate debt structure through liquidity and refinancing risk (Harford et al., 2020; Jeenas, 2023), so one would expect listed oil and gas firms to recalibrate their financing mix in this environment.

Empirical studies on Nigerian firms have produced mixed conclusions. Profitability is reported to reduce leverage among industrial and consumer goods firms (Akosile & Ojo, 2025; Sitdang et al., 2023), whereas it is positive but insignificant for financial firms (Essien & Udeh, 2025). Liquidity raises leverage in consumer goods companies (Akosile & Ojo, 2025) but is insignificant or negative elsewhere (Essien & Udeh, 2025; Khan et al., 2020; Sitdang et al., 2023). Size carries a positive sign in some samples and switches sign across static and dynamic estimators in others (Ibrahim et al., 2023). Such divergence suggests that findings are sector- and method-specific and cannot be transplanted to oil and gas firms without direct testing.

Three gaps follow from this evidence. First, sector-specific work on Nigerian oil and gas leverage is scarce and dated. One of most closely related works cover 2006–2016 and finds that profitability and growth reduce leverage while tangibility, liquidity and size raise it (Umar, 2018); it predates the pandemic, the 2023 currency and subsidy reforms and the Petroleum Industry Act. More recent oil and gas work addresses debt maturity rather than the level of leverage (Abdulumumin et al., 2025), as does much of the wider Nigerian and emerging-market evidence (Elsa & Butar, 2022; Khan et al., 2022; Mohammed & Musa-Mubi, 2020; Paseda & Olowe, 2018), and other Nigerian studies concentrate on manufacturing, consumer goods, cement and financial firms (Abdullahi & Suleiman, 2020; Akosile & Ojo, 2025; Essien & Udeh, 2025; Ibrahim et al., 2023; Sambo et al., 2023). Second, most studies ignore macro-energy conditions that plausibly shape financing in a commodity-exposed sector, even though macroeconomic factors are linked to debt structure in Nigerian non-financial firms (Musa et al., 2023) and institutional and macro conditions matter for firms in Africa (Etudaiye-Muhtar et al., 2017; Lemma & Negash, 2021). Third, the econometric treatment is often limited to a single leverage proxy and static estimators, despite evidence that leverage adjusts gradually toward targets and that static and dynamic results can diverge (Dangl & Zechner, 2021; Ibrahim et al., 2023). This study therefore asks: how do firm characteristics affect the capital structure of listed oil and gas companies in Nigeria, and does the relationship differ between upstream and downstream firms and across macro-energy regimes? It makes the following contributions. First, it offers current evidence on a sector which is not sufficiently represented in the literature on the capital structure of companies in Nigeria for the period 2016 – 2025. Secondly, it simultaneously models the firm-level determinants and macro-energy controls, which is a gap in previous studies. Third, it

uses a number of leverage measures and incorporates a bias-corrected dynamic specification that is well suited to a small panel with adjustment dynamics concerns (Hwang et al. 2021; Wu et al. 2022).

LITERATURE REVIEW

Theoretical Review

The trade-off theory argues that the tax benefit of debt is traded off by the expected distress costs, and as a result, optimal leverage increases with collateral and firm size and decreases with earnings volatility (Kraus & Litzenberger, 1973; Frank & Goyal, 2009). In addition, agency theory suggests that debt will pressure management but can lead to conflicts between shareholders and creditors if growth opportunities are high in value (Jensen & Meckling, 1976). However, adverse selection costs suggest a financing hierarchy of retained earnings, debt and equity, as the pecking order theory predicts profitable firms would borrow less (Myers, 1984; Myers & Majluf, 1984). Non-debt tax shield item like depreciation may offset the tax advantage of debt, and thus depress the incentive to borrow (DeAngelo & Masulis, 1980). Dynamic trade-off models incorporate this additional aspect: firms trade-off only partially toward the target leverage level as adjustment is costly (Flannery & Rangan, 2006; Dangl & Zechner, 2021).

Theories make conflicting predictions which are only confirmed or disconfirmed through empirical evidence, and the context of the institution is important. Antoniou et al. (2008) argue that determinants work differently but not in the same way in market-oriented and bank-oriented economies while Ezeani et al. (2022) find that a firm's capital structure is a reflection of the governance context in which a firm operates. In a bank-owned and commodity-dependent environment, the pecking order logic could be strengthened for Nigeria; and the trade-off logic could be more dominant for big and asset-rich firms. This study is thus not intended to prioritize one over the other, but rather indicates which mechanism predominates by the sign of the coefficient.

Empirical Review and Hypothesis Development

Profitability

According to the pecking order theory, it is expected that there is a negative relationship between the two since the profitable firms have ample internal funds. In the industrial sector, a positive change in profitability is linked with a significant drop in the debt to asset ratio (DAT) in Nigerian industries (Sitdang et al., 2023), listed consumer goods firms (Akosile & Ojo, 2025) and oil and gas firms (Umar, 2018). Evidence from advanced economies shows similarities (Antoniou et al., 2008) and evidence from Indonesia shows similarities (Albart et al., 2020). However, contrary findings exist as profitability is positive for Pakistani listed firms (Khan et al., 2020) while it is positive but insignificant for Nigerian financial firms (Essien & Udeh, 2025), showing the trade-off argument that the more profitable firms can service more debts. Given the preference for capital-intensive oil and gas companies with cyclical energy prices, limited access to internal funds is likely to be preferred:

H1: Profitability has a negative effect on the leverage of listed oil and gas companies in Nigeria.

Firm Size

A size–leverage relationship, as predicted by Titman & Wessels (1988), is positive, with larger firms being more diversified, having lower bankruptcy risk, and

better access to credit (Antoniou et al., 2008). For Nigerian financial firms, positive impact is reported by Essien & Udeh (2025), while for the Indonesian firms, Albart et al. (2020) found positive impact and for Nigerian oil and gas firms, Umar (2018) reported positive impact. However, Khan et al. (2020) conclude that the overall impact is negative in Pakistan, while Ibrahim et al. (2023) report a negative static and positive dynamic impact on the Nigerian manufacturers. Along with these findings, Ahmed et al. (2023) demonstrate that the type of financing decisions has a significant impact on profitability as suggested by trade-off theory, where the magnitude of the impacts depends on size. The study assumes that very large Nigerian oil and gas companies will have access to international/syndicated debt market, then:

H2: Firm size has a positive effect on the leverage of listed oil and gas companies in Nigeria.

Asset Tangibility

Tangible assets provide collateral that reduces lender risk and agency costs of debt. Tangibility raises leverage in Nigerian manufacturing firms (Ibrahim et al., 2023), in oil and gas firms and in cross-country samples (Antoniou et al., 2008; Habibniya et al., 2026), and it is among the strongest determinants of debt maturity in Nigerian oil and gas firms (Abdulumumin et al., 2025). Cassar and Holmes (2003) similarly identify asset structure as a key determinant in small and medium-sized enterprises, though the direction depends on the leverage measure. Sitdang et al. (2023) find tangibility insignificant for industrial companies, so the effect is not universal. Given the heavy fixed-asset base of upstream and downstream infrastructure:

H3: Asset tangibility has a positive effect on the leverage of listed oil and gas companies in Nigeria.

Liquidity

Liquid firms may use internal resources before borrowing, implying a negative effect, but they may also be viewed as safer borrowers, implying a positive effect. Akosile and Ojo (2025) report a positive and significant effect for consumer goods firms, and Umar (2018) finds the same in oil and gas firms. Khan et al. (2020) obtain a negative effect in Pakistan, whereas Sitdang et al. (2023) and Essien and Udeh (2025) find insignificant effects in Nigeria. In the maturity literature, higher liquidity is linked to shorter-term financing because of lower refinancing risk (Do & Phan, 2022; Harford et al., 2020), though Abdulumumin et al. (2025) find a positive effect of liquidity on debt maturity in Nigerian oil and gas firms. Given this ambiguity, the study adopts the pecking order expectation and treats the sign as an empirical test:

H4: Liquidity has a negative effect on the leverage of listed oil and gas companies in Nigeria.

Growth Opportunities

Growth options increase underinvestment and asset-substitution problems, so lenders restrict credit to high-growth firms and these firms use less debt (Jensen & Meckling, 1976). Antoniou et al. (2008) and Umar (2018) report negative growth effects, and Cassar and Holmes (2003) identify growth as an important determinant. Khan et al. (2020), in contrast, find growth insignificant. Considering the investment cycles of oil and gas firms:

H5: Growth opportunities have a negative effect on the leverage of listed oil and gas

companies in Nigeria.

Non-debt Tax Shields

Depreciation and similar deductions substitute for interest tax shields (DeAngelo & Masulis, 1980). Ibrahim et al. (2023) and Abdulmumin et al. (2025) report negative effects of non-debt tax shields on capital structure adjustment and debt maturity in Nigerian firms, while Khan et al. (2020) find a negative effect on leverage in Pakistan. Hence:

H6: Non-debt tax shields have a negative effect on the leverage of listed oil and gas companies in Nigeria.

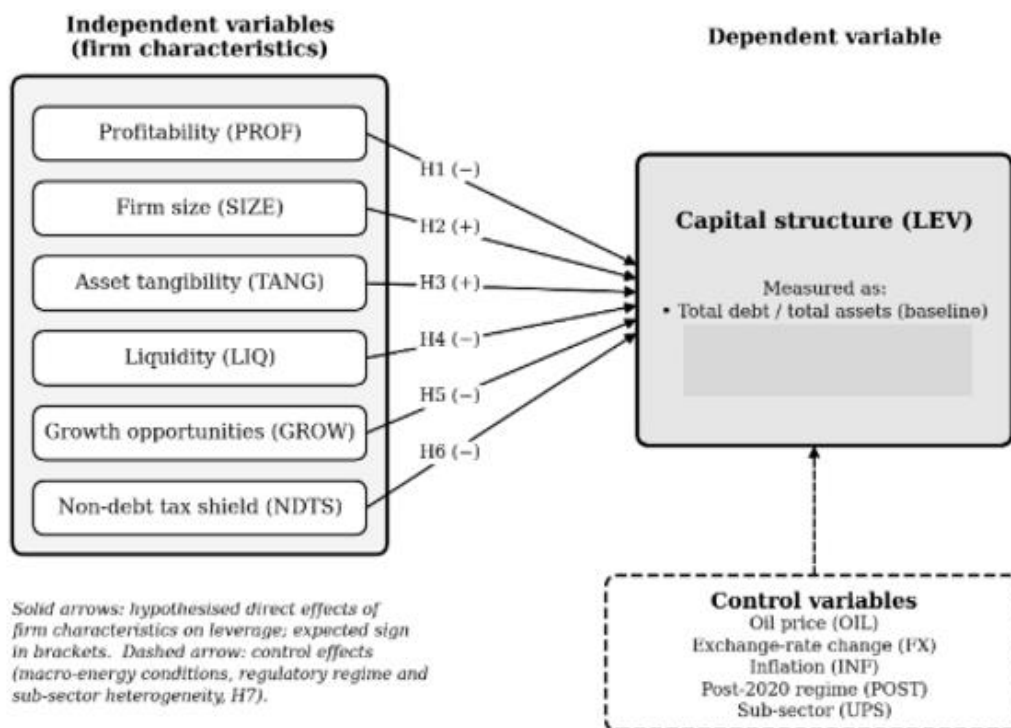
Sub-sector and Macro-energy Conditions

Upstream firms carry exploration and production risk and often rely on project and term financing, while downstream marketers rely on working capital and trade credit. Differences in leverage by industry are documented for listed firms (Khan et al., 2020), and sector-specific financing patterns are emphasised in Nigerian evidence (Abdullahi & Suleiman, 2020; Sambo et al., 2023). Debt structure also responds to monetary tightening and the business cycle (Deng & Fang, 2022, 2023; Jeenas, 2023), and to macroeconomic variables in Nigerian non-financial firms (Musa et al., 2023). The study therefore controls for oil price, exchange-rate change, inflation and a post-2020 regime indicator, and tests heterogeneity across sub-sectors:

H7: The leverage of upstream firms differs significantly from that of downstream firms after controlling for firm characteristics and macro-energy conditions.

Figure 1 summarises the conceptual framework.

Figure 1. Conceptual model



Source: Authors' conceptualisation based on Antoniou et al. (2008), Frank and Goyal (2009), Ibrahim et al. (2023)

Research Gaps Addressed

The review reveals four gaps that this study addresses. (i) Sector and period gap: the sole closely related oil and gas leverage study ends in 2016 (Umar, 2018), recent oil and gas work focuses on maturity (Abdulmumin et al., 2025), and other Nigerian studies cover different sectors (Akosile & Ojo, 2025; Essien & Udeh, 2025; Ibrahim et al., 2023; Sitdang et al., 2023). The present study covers 2016–2025 and the leverage level. (ii) Inconsistency gap: signs for profitability, liquidity and size differ across studies and estimators, and the question remains open for a sector with unique asset and revenue characteristics (Khan et al., 2020; Wu et al., 2022). (iii) Omitted-context gap: macro-energy conditions and regulatory change are rarely modelled alongside firm characteristics, despite evidence that macroeconomic and institutional factors shape African firms' debt decisions (Etudaiye-Muhtar et al., 2017; Lemma & Negash, 2021; Musa et al., 2023). (iv) Methodological gap: Leverage ratios, in particular, and static estimators in general do not consider partial adjustment or measurement sensitivity (Dangl & Zechner, 2021; Zeitun & Goaid, 2022). The study reacts to this by employing four leverage measures as well as sub-sector heterogeneity tests and a dynamic robustness check.

DATA AND METHODS

Research Design and Data

The study adopts ex post facto method of panel design employed in previous capital structure studies in Nigeria using audited financial reports (Akosile & Ojo, 2025; Essien & Udeh, 2025; Ibrahim et al., 2023). The population includes the eight companies on the Nigerian Exchange Group (NGX) that are involved in the oil and gas industry. A purposive sample of 8 firms was chosen based on 2 criteria: continuous listing with publicly available annual reports audited over the period 2016–2025 and being classified in the oil and gas sector. The oil and gas companies were selected purposively as is the case in earlier Nigerian study which selected eight of ten listed oil and gas companies and eight indigenous oil and gas companies (Arikewuyo et al., 2020). The resulting balance panel is of size 8 firms $\times$ 10 years = 80 observations. The samples of firms included in Table 1 are detailed below.

Table 1. Sampled listed oil and gas companies

S/N	Company	Sub-sector	Indicator (UPS)
1	Seplat Energy Plc	Upstream	1
2	Oando Plc	Integrated / upstream-oriented	1
3	Aradel Holdings Plc	Upstream	1
4	TotalEnergies Marketing Nigeria Plc	Downstream	0
5	MRS Oil Nigeria Plc	Downstream	0
6	Conoil Plc	Downstream	0
7	Eterna Plc	Downstream	0
8	Arдова Plc	Downstream	0

Note: Author's Computations (2026)

Firm-level data are extracted from audited annual reports and accounts and cross-checked with NGX filings. The price of Brent crude has been sourced from EIA (2025) while the exchange rate series and inflation have been sourced from CBN (2024). The period captures the 2016 recession, the 2020 pandemic shock, the

Petroleum Industry Act (Federal Republic of Nigeria, 2021) and subsequent reforms, which provides variation in both firm and macro conditions.

Measurement of Variables

Table 2 presents the variables, their measurement and the expected signs. Total debt to total assets is the baseline leverage measure, as in prior studies of Nigerian and Pakistani firms (Khan et al., 2020; Sitdang et al., 2023; Umar, 2018.). Long-term and short-term debt ratios are used because the determinants of leverage differ by maturity (Abdulummin et al., 2025; Nguyen, 2022; Wu et al., 2022), and debt-to-equity is included to reflect the measure used in recent Nigerian evidence (Akosile & Ojo, 2025). Book leverage is preferred because market values are unreliable for thinly traded Nigerian stocks, although this choice is acknowledged as a limitation relative to market leverage (Frank & Goyal, 2009).

Table 2. Variable definitions, measurement and expected signs

Variable	Sym bol	Measurement	Expected sign	Supporting studies
Leverage (baseline)	LEV	Total debt / total assets	Dependent	Khan et al. (2020); Sitdang et al. (2023)
Profitability	PRO F	Profit after tax / total assets (ROA)	-	Sitdang et al. (2023); Akosile & Ojo (2025)
Firm size	SIZE	Natural log of total assets	+	Antoniou et al. (2008); Essien & Udeh (2025)
Asset tangibility	TAN G	Property, plant and equipment / total assets	+	Ibrahim et al. (2023); Habibniya et al. (2026)
Liquidity	LIQ	Current assets / current liabilities	-	Khan et al. (2020); Abdulummin et al. (2025)
Growth opportunities	GRO W	(Sales _t - Sales _{t-1}) / Sales _{t-1}	-	Antoniou et al. (2008); Cassar & Holmes (2003)
Non-debt tax shield	NDT S	Depreciation / total assets	-	Ibrahim et al. (2023); DeAngelo & Masulis (1980)
Oil price	OIL	Brent price level	Control	EIA (2025)
Exchange- rate change	FX	Annual % change in average naira-dollar rate	Control	CBN (2024)
Inflation	INF	Annual consumer price inflation (%)	Control	Musa et al. (2023)
Post-2020 regime	POS T	1 for 2020–2025, 0 otherwise	Control	Federal Republic of Nigeria (2021)
Sub-sector	UPS	1 upstream/integrated, 0 = downstream	Heterogen eity	Khan et al. (2020)

Note: Author's Computations (2026)

Model Specification

The general functional form of the leverage model is given in Equation 1:

$$\text{LEV} = f(\text{PROF}, \text{SIZE}, \text{TANG}, \text{LIQ}, \text{GROW}, \text{NDTS}, \text{Z}) \quad (1)$$

where Z is the vector of macro-energy and regime controls. The static panel model is specified in Equation 2:

$$\text{LEV}_{it} = \alpha + \beta_1 \text{PROF}_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 \text{TANG}_{it} + \beta_4 \text{LIQ}_{it} + \beta_5 \text{GROW}_{it} + \beta_6 \text{NDTS}_{it} + \beta_7 \text{OIL}_{it} + \beta_8 \text{FX}_{it} + \beta_9 \text{INF}_{it} + \beta_{10} \text{POST}_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

where i denotes the firm ($i = 1, \dots, 8$), t the year (2016–2025), μ_i the unobserved firm-specific effect and ε_{it} the idiosyncratic error.

H7 is tested by adding the sub-sector dummy UPS (1 = upstream, 0 = downstream) to the pooled OLS leverage regression and checking whether its coefficient differs significantly from zero.

Estimation Strategy and Diagnostics

The analysis proceeds in four stages. First, descriptive statistics and a pairwise correlation matrix describe the data, and variance inflation factors check for multicollinearity (Baltagi, 2021). Second, the baseline models are estimated by pooled OLS, fixed-effects and random-effects estimators. The choice between them is guided by the F-test for firm effects, the Breusch–Pagan Lagrange multiplier test and the Hausman test (Breusch & Pagan, 1980; Hausman, 1978). Third, residual diagnostics include the Wooldridge test for serial correlation (Drukker, 2003), a modified Wald test for groupwise heteroskedasticity and Pesaran's (2004) test of cross-sectional dependence, which is important given that all firms are exposed to the same oil price and exchange-rate shocks.

RESULTS

This chapter reports the results for eight listed Nigerian oil and gas companies over 2016–2025, a balanced panel of 80 firm-year observations. Total debt to total assets (LEV) is the dependent variable. The chapter presents descriptive statistics and multicollinearity checks, model-selection and residual diagnostics, panel regression estimates, robustness checks, and the test of hypotheses H1 to H7.

Descriptive Statistics and Multicollinearity

Table 3: Descriptive Statistics, Correlations with Leverage and Variance Inflation Factors

Variable	M	SD	Min	Max	Skew.	Kurt.	r with LEV	VIF
LEV	0.480	0.071	0.314	0.673	0.06	3.19	—	—
PROF	0.091	0.021	0.049	0.140	0.09	2.16	-.51***	1.11
SIZE	13.466	0.665	11.619	15.155	0.03	3.35	.26*	1.26
TANG	0.460	0.068	0.257	0.602	-0.30	2.84	.39***	1.08
LIQ	1.799	0.199	1.315	2.173	-0.24	2.58	-.31**	1.19
GROW	0.108	0.070	-0.046	0.255	-0.23	2.30	.19	1.17
NDTS	0.035	0.007	0.019	0.052	0.11	3.20	-.45***	1.15
OIL	67.930	17.283	41.960	100.930	0.13	2.41	-.19	1.49
FX	600.077	463.880	253.492	1,518.381	1.34	2.99	.01	3.55
INF	18.565	6.436	11.396	33.242	1.01	3.20	-.12	4.32

Variable	M	SD	Min	Max	Skew.	Kurt.	r with LEV	VIF
POST	0.600	0.493	0	1	-0.41	1.17	-.13	1.78
UPS	0.375	0.487	0	1	0.52	1.27	.19	1.16

Note. N = 80 for all variables (8 firms, 10 years). Skew. = skewness; Kurt. = kurtosis; r = Pearson correlation with LEV; VIF = variance inflation factor (mean VIF = 1.75). OIL is the Brent price level, FX the naira-dollar rate level and INF inflation in percent. * p < .05. ** p < .01. *** p < .001.

Table 3 shows that listed oil and gas firms financed on average 48.0% of their assets with debt (SD = 0.071), with leverage ranging from 31.4% to 67.3%. The variance between firms is small compared to the variance within firms over time (between SD = 0.024, within SD = 0.068) and the firms have similar average leverage, but are different across years. The mean profitability (ROA) is 9.1%, tangibility is 46.0%, the current ratio is 1.80, and the mean growth rate of sales is 10.8% while the average rate of non-debt tax shields is 3.5% of assets. The variables are approximately normal as the skewness values are between -0.30 and 0.11, with the kurtosis values ranging from 2.16 to 3.35. FX (1.34) and INF (1.01) are right-skewed as the last years were marked by a sharp depreciation and an inflation surge.

Leverage is significantly correlated with profitability ($r = -.51$, $p < .001$), non-debt tax shields ($r = -.45$, $p < .001$), tangibility ($r = .39$, $p < .001$), liquidity ($r = -.31$, $p < .01$) and size ($r = .26$, $p < .05$). There is no multicollinearity any concern since the largest VIF is 4.32 (INF) and the mean is 1.75 which is below the threshold VIF value of 10. The higher VIFs have been obtained for the two macro variables: FX and INF, which are strongly correlated ($r = .83$).

Table 4: Upstream Versus Downstream Firms: Group Means and Independent-Samples t Tests

Variable	Downstream M (SD)	Upstream (SD)	M	t(78)	p	Difference
LEV	0.470 (0.075)	0.497 (0.063)	-1.68	.096		Not significant
PROF	0.090 (0.022)	0.093 (0.020)	-0.66	.513		Not significant
SIZE	13.313 (0.606)	13.720 (0.691)	-2.76	.007		Upstream larger
TANG	0.457 (0.071)	0.465 (0.064)	-0.52	.606		Not significant
LIQ	1.793 (0.202)	1.809 (0.196)	-0.34	.735		Not significant
GROW	0.104 (0.071)	0.114 (0.068)	-0.66	.514		Not significant
NDTS	0.036 (0.007)	0.034 (0.007)	0.99	.326		Not significant

Note. Downstream: 5 firms, 50 firm-years. Upstream (including integrated): 3 firms, 30 firm-years. p values are two-tailed.

Table 4 compares the two sub-sectors. Upstream firms carry 2.7 percentage points more debt than downstream firms (0.497 versus 0.470), but the difference is not significant at the 5% level, $t(78) = -1.68$, $p = .096$. Firm size is the only characteristic that differs significantly between the groups: upstream firms are larger, $t(78) = -2.76$, $p = .007$.

Model Selection and Diagnostic Tests

Table 5 Model-Selection and Residual Diagnostic Tests

Test	Statistic	p	Conclusion
Model selection			
F-test for firm effects (H_0 : $F(7, 62) = 0.26$ no firm effects)		.967	Fixed effects not needed
Breusch–Pagan LM (H_0 : $\chi^2(01) = 0.00$ $\text{Var}(u) = 0$)		1.000	Random effects not needed
Hausman test, classic	$\chi^2(9) = 1.24$	.999	No systematic difference
Hausman test, sigmamore	$\chi^2(6) = 1.89$	.930	No systematic difference
Residual diagnostics			
Wooldridge serial correlation	$F(1, 7) = 19.86$	.003	Serial correlation present
Modified Wald, groupwise heteroskedasticity	$\chi^2(8) = 3.90$	.866	Homoskedastic across firms
Breusch–Pagan/Cook–Weisberg	$\chi^2(1) = 0.52$	.473	Constant variance
White's test	$\chi^2(71) = 77.33$	.284	Constant variance
Pesaran CD test	14.87	<.001	Cross-sectional dependence
Friedman test	63.11	<.001	Cross-sectional dependence
Frees test	5.09 (1% critical = 0.52)	<.01	Cross-sectional dependence
Ramsey RESET	$F(3, 65) = 1.35$	.266	No misspecification
Shapiro–Wilk, residuals	pooled $W = 0.971$	.070	Normal
Skewness/kurtosis, pooled residuals	$\chi^2(2) = 2.94$	.231	Normal
Shapiro–Wilk, residuals	FE $W = 0.976$	.130	Normal

Note. The Hausman statistics are reported as produced, but the differenced variance matrix was not positive definite, so the test is uninformative; it is moot because pooled OLS is preferred. Cook's distance exceeded $4/N$ (0.050) for one observation only (Eterna Plc, 2019; $D = 0.065$).

The first block of Table 5 identifies the estimator. The F-test for firm effects ($F(7, 62) = 0.26$, $p = .967$) and the Breusch–Pagan Lagrange multiplier test ($\chi^2 = 0.00$, $p = 1.000$) both fail to reject the null of no firm-specific effects. The Hausman test, which compares fixed and random effects, is not needed, and its output ($p = .999$) is non-informative.

The second block shows that the residuals are free of heteroskedasticity (all three tests $p > .25$), functional-form error (RESET $p = .266$) and non-normality (all $p > .05$). Two violations are present. The Wooldridge test detects first-order serial

correlation, $F(1, 7) = 19.86$, $p = .003$, and the Pesaran, Friedman and Frees tests all detect cross-sectional dependence (Pesaran CD = 14.87, $p < .001$; mean absolute residual correlation = 0.89). The cross-sectional dependence is expected because all firms are exposed to the same oil price, exchange rate and inflation shocks. Conventional standard errors are therefore unreliable, and Section 4.5 re-examines inference with estimators that allow for these features.

Panel Regression Results

Table 6 Determinants of Leverage: Pooled OLS, Fixed-Effects and Random-Effects Estimates

Variable	Pooled OLS	Fixed effects	Random effects
PROF	-1.566*** (0.136)	-1.593*** (0.146)	-1.566*** (0.136)
SIZE	0.038*** (0.005)	0.037*** (0.005)	0.038*** (0.005)
TANG	0.434*** (0.042)	0.447*** (0.049)	0.434*** (0.042)
LIQ	-0.140*** (0.015)	-0.142*** (0.017)	-0.140*** (0.015)
GROW	0.396*** (0.043)	0.395*** (0.046)	0.396*** (0.043)
NDTS	-3.792*** (0.454)	-3.691*** (0.504)	-3.792*** (0.454)
OIL	-0.00057** (0.00020)	-0.00055** (0.00021)	-0.00057** (0.00020)
FX	0.00002 (0.00001)	0.00002 (0.00001)	0.00002 (0.00001)
INF	-0.00102 (0.00090)	-0.00106 (0.00094)	-0.00102 (0.00090)
POST	-0.011 (0.008)	-0.012 (0.008)	-0.011 (0.008)
UPS	0.006 (0.006)	—	0.006 (0.006)
Constant	0.304*** (0.072)	0.320*** (0.081)	0.304*** (0.072)
R ² (overall)	.897	.894	.897
Adjusted R ²	.880	—	—
R ² (within)	—	.887	.887
Test of model	F(11, 68) = 53.66***	F(10, 62) = 48.69***	$\chi^2(11) = 590.24***$
N (firms)	80	80 (8)	80 (8)

Note. Dependent variable: LEV. Conventional standard errors in parentheses. OIL, FX and INF are reported to five decimals because of their scale. The random-effects estimates equal the pooled estimates because the estimated firm-effect variance is zero. ** $p < .01$. *** $p < .001$.

Table 6 reports the three static estimators. The coefficients are almost identical across them, which confirms the conclusion of Section 4.3 that unobserved firm effects add nothing. The pooled model is highly significant, $F(11, 68) = 53.66$, $p < .001$, and explains 89.7% of the variance in leverage (adjusted $R^2 = .880$). The results below refer to the pooled model.

Profitability has a significant negative effect on leverage ($B = -1.566$, $SE = 0.136$, $p < .001$): a one-percentage-point rise in ROA lowers leverage by about 1.6 percentage points. Firm size ($B = 0.038$, $SE = 0.005$, $p < .001$) and tangibility ($B = 0.434$, $SE = 0.042$, $p < .001$) raise leverage; a ten-point increase in the PPE share is associated with 4.3 points more debt. Liquidity reduces leverage ($B = -0.140$, $SE =$

0.015, $p < .001$), and non-debt tax shields have a strong negative effect ($B = -3.792$, $SE = 0.454$, $p < .001$). Growth opportunities have a significant positive effect ($B = 0.396$, $SE = 0.043$, $p < .001$), which is the opposite of the expected sign. Among the controls, only the oil price is significant ($B = -0.00057$, $SE = 0.00020$, $p = .005$): a \$10 rise in Brent is associated with 0.6 percentage points less leverage. Exchange rate, inflation, the post-2020 regime and sub-sector (UPS) are not significant (all $p > .10$).

Robustness Checks

Because Section 4.3 found serial correlation and cross-sectional dependence, and because only eight clusters are available, inference was re-examined with three alternatives (Table 7): cluster-robust standard errors by firm, the wild cluster bootstrap with Webb weights (Cameron et al., 2008), and Driscoll–Kraay standard errors with a two-lag Bartlett kernel (Driscoll & Kraay, 1998). Table 6 then checks sensitivity to the sample by excluding 2020 and by dropping one firm at a time.

Table 7: Pooled OLS Coefficients and p Values Under Alternative Inference Methods

Variable	B	Conventional	Firm-cluster robust	Wild cluster bootstrap	Driscoll–Kraay
PROF	−1.566	<.001	<.001	.003	<.001
SIZE	0.038	<.001	<.001	.002	<.001
TANG	0.434	<.001	<.001	.003	<.001
LIQ	−0.140	<.001	<.001	<.001	<.001
GROW	0.396	<.001	<.001	.002	<.001
NDTS	−3.792	<.001	<.001	.003	<.001
OIL	−0.00057	.005	<.001	.001	.255
FX	0.00002	.109	.001	.001	.135
INF	−0.00102	.259	.016	.018	.417
POST	−0.011	.135	.018	.011	.395
UPS	0.006	.347	.077	.071	.001†

Note. Entries are two-tailed p values. Bootstrap p values are for the restricted wild cluster bootstrap t statistic (8 firm clusters). Driscoll–Kraay p values use t with 9 degrees of freedom (10 years). † UPS is constant within firms, so its Driscoll–Kraay standard error is unreliable with only 10 time periods and should not be interpreted. Firm-cluster and bootstrap methods ignore common year shocks, so their p values for OIL, FX, INF and POST (which take one value per year) are too small.

The six firm characteristics are significant at the 1% level under every method (Table 5). The macro-energy variables are not robust: the very small firm-cluster and bootstrap p values for OIL, FX, INF and POST arise because clustering by firm treats the common year shocks as independent evidence, which the cross-sectional dependence tests reject. When Driscoll–Kraay standard errors, which allow for cross-sectional dependence, are used, none of the four is significant (all $p > .13$). The sub-sector indicator UPS is marginal under cluster-based inference ($p \approx .07$ –.08) and not significant under conventional standard errors ($p = .347$).

Table 8 Sensitivity of Pooled OLS Estimates to Sample Selection

Variable	Full sample B	Excluding 2020 B	Dropping one firm: range of B	Significant in 8 of 8 runs
PROF	-1.566	-1.630***	-1.716 to -1.491	Yes
SIZE	0.038	0.039***	0.035 to 0.042	Yes
TANG	0.434	0.436***	0.396 to 0.487	Yes
LIQ	-0.140	-0.135***	-0.155 to -0.132	Yes
GROW	0.396	0.396***	0.379 to 0.430	Yes
NDTS	-3.792	-3.587***	-4.090 to -3.235	Yes
OIL	-0.00057	-0.00089**	-0.00061 to -0.00049	Yes
FX	0.00002	0.00001	0.00002 to 0.00002	No
INF	-0.00102	-0.00143	-0.00125 to -0.00072	No
POST	-0.011	0.003	-0.014 to -0.009	No
UPS	0.006	0.006	0.002 to 0.008	No

Note. Conventional standard errors. Excluding 2020 leaves 72 observations; each leave-one-firm-out run leaves 70. ** $p < .01$. *** $p < .001$.

Table 8 shows that no single year or firm drives the results. Excluding the pandemic year leaves the signs, sizes and significance of the six firm characteristics virtually unchanged, and each of them remains significant when any one firm is dropped (including Eterna Plc, the only influential case in Section 4.3). The oil price effect also survives under conventional standard errors but should be treated cautiously in light of Table 5. FX, INF, POST and UPS are never significant, and the sign of POST reverses when 2020 is excluded.

Hypothesis Testing and Discussion

Table 9 Summary of Hypothesis Tests (Pooled OLS, Dependent Variable: LEV)

	Hypothesis	Expected B	p	Robust?	Decision	
H1	PROF → LEV	-	-1.566	<.001	Yes	Supported
H2	SIZE → LEV	+	0.038	<.001	Yes	Supported
H3	TANG → LEV	+	0.434	<.001	Yes	Supported
H4	LIQ → LEV	-	-0.140	<.001	Yes	Supported
H5	GROW → LEV	-	0.396	<.001	Yes	Not supported
H6	NDTS → LEV	-	-3.792	<.001	Yes	Supported
H7	UPS differs from 0	≠ 0	0.006	.347	No	Not supported

Note. p values are two-tailed and from conventional standard errors; "Robust?" indicates whether the conclusion holds under all methods in Tables 7 and 8.

H1 (profitability). The negative effect supports the pecking-order theory: profitable firms use retained earnings before borrowing. This agrees with evidence from Nigerian industrial, consumer goods and oil and gas firms (Akosile & Ojo, 2025; Sitdang et al., 2023; Umar, 2018).

H2 and H3 (size and tangibility). Larger firms and firms with more fixed assets carry more debt, as the trade-off theory predicts. Large firms are more diversified

and have better access to credit, including international and syndicated markets, while PPE provides collateral that lowers lenders' risk (Antoniou et al., 2008; Ibrahim et al., 2023; Titman & Wessels, 1988).

H4 (liquidity). The negative effect is consistent with the pecking-order view that firms with liquid assets use internal resources before borrowing (Khan et al., 2020).

H5 (growth opportunities). Growth has a significant positive effect, contrary to the agency-theory expectation of a negative relation (Jensen & Meckling, 1976). A plausible explanation is that sales growth in capital-intensive oil and gas firms creates financing needs that internal funds do not cover, so expansion is partly debt-financed. This explanation is not tested here and should be treated as an interpretation.

H6 (non-debt tax shields). The negative effect supports the substitution argument of DeAngelo and Masulis (1980): firms with larger depreciation deductions have less incentive to use the interest tax shield. The coefficient is large because NDTS varies only between 1.9% and 5.2% of assets.

H7 (sub-sector). Upstream and downstream firms do not differ significantly in leverage after controlling for firm characteristics ($B = 0.006$, $SE = 0.006$, $p = .347$), and the raw difference in means is also not significant ($p = .096$). The raw sub-sector gap shrinks once firm characteristics are controlled (from 0.027 to 0.006), which may partly reflect the fact that upstream firms are significantly larger (Table 2). With only three upstream firms, this test has low power.

Macro-energy controls. Leverage falls as the oil price rises, which is consistent with higher crude prices raising operating cash flows and reducing borrowing needs, but the effect is significant only under conventional standard errors. Exchange rate, inflation and the post-2020 regime show no reliable effect.

CONCLUSION AND RECOMMENDATIONS

This study investigated the effect of firm characteristics on capital structure of eight listed oil and gas firms in Nigeria over the period (2016-2025). No significant firm-specific effects were detected and hence pooled OLS was used. The results were checked with bootstrap and Driscoll–Kraay inference, exclusion of 2020, and dropping one firm at a time. H1-H4 and H6 are supported by profitability, leverage is lower with non-debt tax shields and larger firms and larger asset tangibility increases leverage. Growth opportunities raised leverage (as opposed to H5), indicating some debt-financed growth. The number of cases in sub-sector did not significantly affect and was rejected, as H7. There was no consistent effect for exchange rate, inflation and the post-2020 regime. The data supports the idea of pecking order behaviour as well as trade-off considerations. Managers should use retained earnings and ensure that there is sufficient liquidity to minimise debt exposure. Credit should be tied to actual assets and to growth stage of the firm and lenders should provide well-designed long-term facilities to expanding firms. A policy maker should appreciate that tax allowances influence borrowings, and plan allowances accordingly. They should also make the macroeconomic situation stable, thereby minimizing financing uncertainty. The eight firms and the book-value leverage and static nature of the study constitute its limitations. Further studies should expand the sample, employ the market leverage approach, analyze dynamic models of partial adjustment, incorporate governance indicators and expand the analysis to other sectors and countries.

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