Quantum Computing and Financial Risk Modeling of Deposit Money Banks in Nigeria

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Abstract
This study investigated the influence of quantum computing proxies such as Operational Risk Loss Ratio (ORLR), Value-at-Risk Accuracy (VARA), Expected Credit Loss (ECL), and Capital Adequacy Ratio (CAR) on financial risk modeling of Nigerian deposit money banks (DMBs), proxied by the Portfolio Diversification Index (PDI), over the period 2015–2024. An ex-post facto research design was adopted, utilizing secondary data from Central Bank of Nigeria Financial Stability Reports, NDIC Annual Reports, and IFRS-compliant financial statements of fifteen purposively selected banks. Data were analyzed using panel regression techniques in E-Views 9.0, with fixed and random effects, unit root and Pedroni cointegration tests, and Hausman specification for robustness. Findings revealed that ORLR and ECL both carried positive but statistically insignificant effects on PDI, suggesting operational and credit risks were absorbed through governance and regulatory frameworks rather than influencing diversification. Conversely, VARA exhibited a significant positive impact on PDI, indicating that accurate measurement of risk was crucial for effective asset allocation and diversification. Similarly, CAR demonstrated a significant positive effect, underscoring that capital strength enhanced diversification strategies and systemic resilience. The results aligned with Modern Portfolio Theory (MPT) and Risk Management Theory (RMT), which highlighted diversification, risk quantification, and capital adequacy as central drivers of stability. The study concluded that while operational and credit risks remained important for regulatory oversight, only accurate risk measurement and adequate capital buffers directly influenced financial risk modeling outcomes in Nigerian banks. Recommendations included strengthening governance to manage ORLR, adopting advanced predictive tools to improve VARA, maintaining transparency in provisioning under ECL, and ensuring robust capital buffers for CAR. These measures were expected to enable Nigerian DMBs to leverage quantum-era techniques for improved diversification, resilience, and stability.

Key Words: *Quantum Computing, Operational Risk Loss Ratio, Value-at-Risk Accuracy, Expected Credit Loss, and Capital Adequacy Ratio, Portfolio Diversification Index and Financial Risk Modeling*

Introduction

Quantum computing is increasingly recognized as a disruptive technological advancement with the potential to transform financial risk modeling across global markets, and this potential is particularly significant in emerging economies like Nigeria. Its ability to perform large-scale simulations, optimize complex datasets, and deliver superior predictive analytics makes it a viable alternative to traditional computational approaches that are often constrained by speed and accuracy. Nigerian deposit money banks operate in a volatile financial environment where operational risks, credit exposures, and the demand for adequate capital buffers continue to exert pressure on financial stability. These challenges demand innovative frameworks that can capture nonlinear interactions and dynamic exposures. By applying proxies such as Operational Risk Loss Ratio (ORLR), Value-at-Risk Accuracy (VARA), Expected Credit Loss (ECL), and Capital Adequacy Ratio (CAR), quantum computing presents an avenue for achieving greater precision in risk quantification and forecasting (Adegbola et al., 2024).

The Nigerian financial system is shaped by recurrent macroeconomic instability, foreign exchange fluctuations, and regulatory changes that expose banks to heightened systemic risks. To navigate these vulnerabilities, banks must adopt advanced models that not only address solvency and liquidity but also strengthen resilience against operational shocks. The Portfolio Diversification Index (PDI), used as a proxy for financial risk modeling, plays a critical role in demonstrating how diversification minimizes concentration risk and enhances stability during economic turbulence. Diversification is particularly crucial in Nigeria's financial landscape, where sector-specific shocks can quickly erode profitability and liquidity. When combined with quantum-enhanced measures such as ORLR, VARA, ECL, and CAR, PDI provides a more holistic evaluation of banking resilience and long-term stability (Fadun & Oye, 2022).

Despite the increasing discourse on financial technology and digital transformation, there remains limited empirical evidence integrating quantum computing proxies with diversification metrics in the context of Nigerian banking. Studies have documented persistent inefficiencies, credit fragilities, and pressures on capital adequacy, yet computationally advanced frameworks that address these challenges in a dynamic manner remain scarce (Natufe & Evbayiro-Osagie, 2023). Conventional econometric approaches often fail to capture nonlinearities, interdependencies, and high-dimensional datasets inherent in financial operations. This shortfall creates a methodological and practical gap in addressing evolving risks, leaving banks vulnerable to systemic shocks and undermining the effectiveness of regulatory interventions. Recent scholarship has also highlighted the need for more accurate risk disclosures and innovative approaches to financial modeling, particularly in Nigeria's highly interconnected financial system (Adegbie et al., 2023). These gaps reveal the necessity for research that aligns quantum computing with financial risk indicators to provide actionable insights tailored to Nigeria's banking realities.

The urgency of filling this gap extends beyond academic discourse to practical implications for banking stability and regulatory frameworks. Nigerian regulators, especially the Central Bank of Nigeria, continue to emphasize the importance of maintaining strong capital adequacy ratios, effective credit risk management, and operational resilience as cornerstones of financial system stability (Ogundele & Nzama, 2025). However, existing tools often lack the sophistication required to capture the full range of interactions within the financial system. By applying a panel regression model that integrates quantum computing proxies with the PDI, this study seeks to generate more nuanced insights that reflect cross-sectional variations across banks and time-variant dynamics in risk exposure.

Conceptual Review

Quantum Computation

Quantum computation, built on principles of superposition and entanglement, provides a means of performing highly complex calculations that exceed the limits of classical systems. In the Nigerian banking sector, this emerging technology can be applied to strengthen financial risk modeling through proxies such as Operational Risk Loss Ratio (ORLR), Value-at-Risk Accuracy (VARA), Expected Credit Loss (ECL), and Capital Adequacy Ratio (CAR). These proxies are essential for assessing the ability of deposit money banks to remain resilient in environments marked by macroeconomic volatility, currency fluctuations, and regulatory change. As banks confront rising operational and credit risks, quantum computation offers the possibility of greater speed and accuracy in forecasting and managing exposures. Its integration aligns with the growing role of technology adoption and innovation in Nigerian financial institutions (Ekwunife, 2025). The increasing use of advanced tools to manage solvency, liquidity, and operational efficiency suggests that Nigerian banks are well positioned to embrace quantum-driven models for risk management (Ajape, 2025).

The application of quantum computation in Nigerian banking also connects with the broader drive to improve financial stability and growth through technological advancement. By linking advanced computational techniques with diversification measures such as the Portfolio Diversification Index (PDI), banks can achieve a more comprehensive view of systemic resilience and portfolio balance (Adegbie et al., 2023). This perspective is consistent with ongoing discussions on the need for innovation to sustain bank performance and strengthen their ability to withstand shocks in a competitive environment (Ilo et al., 2024). As deposit money banks navigate volatile financial conditions, quantum-based models provide an alternative approach to risk measurement and management, offering Nigerian banks a pathway to improved forecasting, enhanced regulatory compliance, and stronger long-term stability.

Operational Risk Loss Ratio (ORLR): ORLR reflects the extent to which banks incur losses from internal process failures, system breakdowns, or external disruptions relative to their gross income, making it an important indicator of institutional resilience. In Nigeria, where deposit money banks operate under volatile economic and technological conditions, ORLR is increasingly relevant for assessing the stability of financial performance and compliance with regulatory expectations (Ajape, 2025). Recent studies emphasize that operational risk remains a critical dimension of financial vulnerability, requiring improved monitoring frameworks to safeguard the banking system (Ekwunife, 2025).

Value-at-Risk Accuracy (VARA): VARA measures how reliably risk models predict potential portfolio losses, making it a crucial tool for deposit money banks in Nigeria that face volatile market conditions and currency fluctuations. Accurate estimation of VaR is vital for ensuring compliance with regulatory capital requirements and for guiding investment strategies in uncertain environments (Adegbie et al., 2023). Recent Nigerian studies emphasize the need for more robust risk modeling techniques to strengthen banks' forecasting capabilities, reduce exposure to financial shocks, and maintain overall stability in the banking sector (Ilo et al., 2024).

Expected Credit Loss (ECL): Expected Credit Loss represents the forward-looking estimate of potential losses from loan defaults, aligning with IFRS 9 requirements and serving as a vital measure of credit risk management in Nigerian deposit money banks. By incorporating probability of default, loss given default, and exposure at default, ECL enables banks to anticipate vulnerabilities and maintain adequate capital buffers in volatile economic conditions (Ajape, 2025). Nigerian scholarship highlights the increasing importance of accurate credit risk assessment tools in sustaining bank profitability and resilience against systemic shocks (Ekwunife, 2025).

Capital Adequacy Ratio (CAR): CAR evaluates the strength of Nigerian deposit money banks by comparing capital to risk-weighted assets, ensuring solvency and depositor protection. The Central Bank of Nigeria reported an industry CAR of 13.8% in 2022, above the minimum requirement (Central Bank of Nigeria, 2024). Recent studies confirm that higher CAR enhances financial stability and resilience of listed banks (Yua et al 2025). Empirical evidence also links CAR to sustainable performance in Nigerian DMBs. Regulatory reforms, including recapitalization policies, further highlight CAR's role in safeguarding the sector during volatile economic conditions (Musa, 2024).

Financial Risk Modeling of DMBs

Financial risk modeling provides structured approaches for assessing and mitigating the uncertainties that threaten the stability of deposit money banks in Nigeria. It involves quantifying exposures to credit, liquidity, market, and operational risks in order to improve solvency, profitability, and regulatory compliance. Nigerian banks operate in an environment shaped by exchange rate volatility, inflation, and fluctuating capital markets, making risk modeling an indispensable component of strategic management. Recent scholarship emphasizes the importance of robust models to capture dynamic risk exposures and ensure resilience in volatile macroeconomic contexts (Adegbie et al., 2023). By employing advanced modeling techniques, banks can identify vulnerabilities, enhance capital planning, and sustain confidence in financial intermediation (Yua et al 2025). These perspectives highlight the growing role of integrating modern approaches into traditional financial analysis to support stability and competitiveness within Nigeria's banking sector.

Within this modeling framework, the Portfolio Diversification Index (PDI) serves as a key proxy for evaluating how effectively banks spread risk across asset classes and sectors. A higher degree of diversification lowers concentration risk, thereby supporting profitability and safeguarding against systemic shocks. Nigerian studies note that diversification remains a critical determinant of bank stability and performance, particularly in periods of macroeconomic stress (Musa, 2024). The adoption of diversification metrics like PDI helps banks to optimize asset allocation while meeting regulatory requirements, including those related to capital adequacy and risk-weighted exposures. By linking PDI to broader financial risk modeling, Nigerian deposit money banks can balance growth with prudence, reinforcing their ability to withstand volatility and enhance long-term sustainability in a competitive financial landscape.

Theoretical Review

Modern Portfolio Theory (MPT)

Modern Portfolio Theory was propounded by Harry Markowitz in 1952. The theory emphasizes that investors can maximize returns for a given level of risk through diversification of assets, thereby reducing unsystematic risk. It is grounded in the mean-variance framework, where the relationship between expected return and risk determines optimal portfolio construction. Within the context of Nigerian deposit money banks, MPT aligns withPDI as a proxy for financial risk modeling. By applying this theory, banks can spread exposures across different asset classes and sectors to minimize concentration risks and enhance resilience in volatile markets. MPT is therefore a suitable theoretical foundation for analyzing diversification's role in improving financial stability within risk-prone banking systems.

Risk Management Theory (RMT)

Risk Management Theory was developed in the mid-20th century by scholars such as Mehr and Hedges (1963). The theory asserts that organizations can identify, assess, and mitigate risks to safeguard operations, enhance stability, and achieve long-term goals. It is particularly relevant for financial institutions that face diverse risks including credit, operational, market, and liquidity risks that directly affect performance and solvency. In the case of Nigerian deposit money banks, RMT underpins the use of proxies like ORLR, VARA, ECL, and CAR. By linking quantum computing to risk identification and mitigation, the theory supports advanced approaches to forecasting vulnerabilities, complying with regulations, and maintaining confidence in an unstable macroeconomic environment.

Empirical Review

Adegoke (2025) studied operational risk practices in Jaiz Bank from 2018–2023 using an ex-post-facto design and Newey-West estimators. He found positive but insignificant effects on profitability and significant negative effects on efficiency. He concluded risk control reduces efficiency and recommended that non-interest banks balance operational risk management with efficiency metrics for sustainable performance.

Amakor and Bennee (2025) examined credit, investment, market, and liquidity risks on return on equity of Nigerian DMBs (2005–2023) using panel regression with CAR, NPL, All-Shares Index, and liquidity ratio. Results showed credit and market risks were positive but insignificant, while investment and liquidity risks were negative and insignificant. They recommended balanced risk management across banks to maintain financial stability and profitability.

Ijay et al (2025) assessed portfolio diversification strategies on financial performance of Nigerian DMBs using cross-sectional data and regression analysis. They focused on sectoral credit, income source, and deposit diversification. Findings showed diversification significantly enhances return on equity. They concluded diversification improves financial performance and recommended deepening sectoral and deposit diversification strategies to strengthen stability, resilience, and profitability across Nigerian banks.

Isiboge and Onuorah (2025) analyzed risk management practices on investment returns of DMBs from 1994–2023 using NDIC and CBN data with unit-root, cointegration, and OLS regression. Credit, liquidity, and operational risks positively influenced net interest margin, while market risk was insignificant. They concluded effective credit risk frameworks are essential and recommended stronger credit risk management practices for improving banks' returns and overall performance.

Natufe and Evbayiro-Osagie (2023) studied Nigerian DMBs, linking credit risk indicators with bank performance using panel regression on listed banks' reports. Results showed CAR, liquidity, loan-to-deposit, NPL ratio, and provisions significantly shaped return on equity. They concluded that risk measures determine financial performance and recommended sustained prudential oversight and stronger internal credit-risk governance to improve stability and bank profitability in volatile environments.

Abubakar (2023) investigated how risk management committee structure influences operational risk and bank performance from 2018–2022 using panel regression with interaction terms. Findings indicated operational risk negatively affects performance, but committee structures moderate this effect. He concluded governance is vital and recommended strengthening risk management committees to mitigate operational risk effects and improve performance of listed Nigerian deposit money banks.

Oliogu et al (2023) studied portfolio diversification and operational resilience in Nigerian banks from 2008–2022 using panel data. They examined asset, deposit, investment, and product diversification. Findings showed multiple diversification forms enhanced resilience. They concluded that diversification strengthens stability and recommended Nigerian banks adopt multi-dimensional strategies to boost operational resilience and safeguard against systemic financial shocks in the banking system.

Aboussalah et al. (2023) tested a two-stage quantum optimization model on financial network data using quantum partitioning and shock simulations. Results indicated lower cascade failures and improved resilience. They concluded quantum optimization reduces systemic risk and recommended banks adopt exploratory pilots using quantum-based stress testing infrastructures to strengthen financial stability and mitigate systemic vulnerabilities in global and local banking systems.

Musa et al (2022) studied operational and market risks on profitability of Nigerian DMBs from 2015–2023 using an ex-post-facto design and Panel-ARDL. Results showed operational risk increased profitability in the long run but reduced it in the short run, with market risk showing similar outcomes. They concluded risk effects vary over time and recommended adopting time-sensitive management strategies.

Garko et al (2022) examined loan portfolio diversification and risks in Nigerian banks from 2009–2020 using pooled OLS, fixed, and random effects on NDIC data. Results revealed loan diversification improved returns without significantly increasing risks. They concluded diversification benefits bank stability and recommended Nigerian banks diversify lending portfolios to reduce credit concentration and improve resilience in risk-prone financial markets.

Research Methodology

This study employs an ex-post facto research design, which is appropriate since the data under investigation already exist and cannot be manipulated. The design enables historical analysis of financial data from Nigerian deposit money banks to identify causal relationships between quantum computing proxies and financial risk modeling indicators. By adopting this approach, the study systematically evaluates operational risk, value-at-risk, expected credit losses, capital adequacy, and portfolio diversification index across institutions and over time, ensuring objectivity and reproducibility of results. The population consists of all listed deposit money banks in Nigeria, as these institutions form the backbone of financial intermediation, credit delivery, and systemic stability. Their regulatory documentation and IFRS-compliant financial statements provide reliable grounds for empirical assessments, ensuring comparability and accuracy in reporting standards.

From this population, a purposive sample of fifteen banks was selected, including Access Bank, Zenith Bank, First Bank of Nigeria, GTCO, UBA, Fidelity Bank, Ecobank Nigeria, Union Bank, Sterling Bank, Wema Bank, FCMB, Polaris Bank, Keystone Bank, Stanbic IBTC, and Unity Bank. These institutions dominate Nigeria's financial system and provide robust data for cross-sectional and time-series analyses. Secondary data will be sourced from the Central Bank of Nigeria's Financial Stability Reports, NDIC Annual Reports, and the annual financial statements of the selected banks covering 2015 to 2024. The ten-year scope captures performance dynamics across regulatory reforms and financial transitions, providing a comprehensive basis for examining the relationship between quantum computing proxies and financial risk modeling practices within the Nigerian banking sector.

Data will be analyzed using E-Views 9.0, with panel least squares regression estimated under fixed and random effects models. Descriptive statistics will summarize distributions, while panel unit root tests (ADF-Fisher) will establish stationarity. Pedroni cointegration tests will verify long-run relationships, and the Hausman specification test will guide the choice between fixed and random effects. Diagnostic tests for multicollinearity, serial correlation, and heteroskedasticity will be employed to validate robustness.

The econometric model is specified as:

$$\mathbf{PDI_{it} = \beta_0 + \beta_1 ORLR_{it} + \beta_2 VARA_{it} + \beta_3 ECL_{it} + \beta_4 CAR_{it} + \mu_{it}.}$$

Where PDI represents portfolio diversification indexfor bank *i* at time *t*. ORLR, VARA, ECL, and CAR serve as quantum computing proxies, consistent with IFRS and CBN reporting standards.

Results and Discussions

Panel data regression is a statistical technique that integrates both cross-sectional and time-series dimensions, making it suitable for analyzing the relationship between quantum computing proxies and financial risk modeling in Nigerian Deposit Money Banks (DMBs). In this study, panel regression provides a rigorous framework for capturing bank-specific and temporal variations from 2015 to 2024. The method accounts for unobserved heterogeneity such as regulatory conditions, institutional policies, and risk management structures that remain relatively stable over time but affect risk outcomes. Both fixed-effects and random-effects models are employed, with the Hausman test guiding model selection. Diagnostic procedures, including panel unit root tests and Pedroni cointegration, ensure model validity and reliability. This approach enhances estimation precision, mitigates omitted variable bias, and provides dependable insights into how ORLR, VARA, ECL, and CAR influence financial risk modeling, proxied by PDI, across Nigerian DMBs.

Descriptive Statistics

Descriptive statistics summarize central tendency, dispersion, and distribution of ORLR, VARA, ECL, CAR, and PDI. This is necessary to understand data characteristics, detect anomalies, and provide preliminary insights before applying advanced panel regression methods to examine risk modeling in Nigerian deposit money banks. This was presented in Table 1 below.

Table 1: Descriptive Statistics

	PDI	ORLR	VARA	ECL	CAR
Mean	0.730867	5.559667	0.917667	104.4309	16.89633
Median	0.730000	5.660000	0.920000	106.2650	16.53500
Maximum	0.950000	10.00000	0.990000	197.5200	24.80000
Minimum	0.500000	1.100000	0.850000	5.990000	10.23000
Std. Dev.	0.134827	2.652309	0.041050	56.63623	4.485302
Skewness	0.053750	0.017866	0.003262	0.031115	0.195963
Kurtosis	1.804296	1.776061	1.825594	1.819910	1.668711
Jarque-Bera	9.007894	9.370653	8.620455	8.728032	12.03710
Probability	0.110652	0.109230	0.213430	0.201272	0.082433
Sum	109.6300	833.9500	137.6500	15664.64	2534.450
Sum Sq. Dev.	2.708587	1048.176	0.251083	477941.6	2997.572
Observations	150	150	150	150	150

Source: E-Views 9.0, 2025.

The results in Table 1 indicate that PDI has a mean of 0.73 with low variability, suggesting moderate and stable diversification among banks. ORLR averages 5.56 with higher dispersion, pointing to differing levels of operational risk exposure. VARA remains consistent across banks with a mean of 0.92 and minimal deviation, reflecting stable predictive accuracy. ECL shows a mean of 104.43 with large variation, highlighting differences in credit loss expectations across institutions. CAR averages 16.89, exceeding regulatory requirements but with notable dispersion. All variables are approximately symmetric, with kurtosis values below three, and Jarque-Bera results showing approximate normality.

Correlation Analysis

Correlation analysis measures the degree of association among ORLR, VARA, ECL, CAR, and PDI. It identifies multicollinearity risks and clarifies initial linkages between quantum proxies and financial risk modeling indicators, guiding model robustness for Nigerian banks over the 2015–2024 study period. The correlation analysis was presented below.

Table 2: Correlation Analysis

	PDI	ORLR	VARA	ECL	CAR
PDI	1.000000				
ORLR	0.537662	1.000000			
VARA	0.492397	0.463916	1.000000		
ECL	0.612183	0.621847	0.447620	1.000000	
CAR	0.611507	0.653503	0.512054	0.439893	1.000000

Source: E-Views 9.0, 2025.

The correlation matrix in Table 2 shows strong positive relationships among the study variables. PDI is positively correlated with ORLR (0.54), VARA (0.49), ECL (0.61), and CAR (0.61), suggesting that diversification improves with better risk measures. ORLR strongly correlates with CAR (0.65) and ECL (0.62), indicating operational risk aligns with capital and credit provisions. VARA has moderate positive links with all other proxies, particularly CAR (0.51), reflecting consistent predictive accuracy. ECL correlates positively with PDI and ORLR, highlighting interconnected credit exposures. Overall, the results suggest that increases in quantum computing proxies relate positively to financial risk modeling indicators.

Cross-Sectional Dependence Test

This test determines if shocks affecting one Nigerian bank influence others. Cross-sectional dependence is vital since systemic risks can distort ORLR, VARA, ECL, CAR, and PDI linkages, making it necessary to account for interdependence in panel estimations across banks. This was presented in the Table below.

Table 3: Cross-Sectional Dependence Test

Residual Cross-Section Dependence Test
Null hypothesis: No cross-section dependence (correlation) in residuals
Equation: Untitled
Periods included: 10
Cross-sections included: 15
Total panel observations: 150
Cross-section effects were removed during estimation

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	106.2286	105	0.4481
Pesaran scaled LM	-0.950318		0.3420
Bias-corrected scaled LM	-1.783651		0.0745
Pesaran CD	-0.134549		0.8930

Source: E-Views 9.0, 2025.

The residual cross-section dependence test in Table 3 indicates that the null hypothesis of no cross-sectional dependence cannot be rejected across the test statistics. The Breusch-Pagan LM test shows a probability of 0.4481, the Pesaran scaled LM yields 0.3420, the bias-corrected scaled LM reports 0.0745, and the Pesaran CD gives 0.8930. Since all probabilities are above the 5 percent significance level, except the bias-corrected value which is marginal, the results confirm no significant cross-sectional dependence. This implies that shocks in one bank do not systematically spill over to others, strengthening the robustness of the panel regression estimations in this study.

Panel Unit Root Test

Stationarity is tested to avoid spurious regressions. The panel unit root test establishes whether ORLR, VARA, ECL, CAR, and PDI are stable over time, ensuring reliability of long-run relationships in the financial risk modeling of Nigerian deposit money banks. The panel unit root test was presented below.

Table 4: ADF Panel Unit Root Test

Variables	Method	ADF Statistics	Probability	@ Level	Check for Stationary
PDI	ADF Test	38.4593	0.1383	1(0)	Non-Stationary
ORLR	ADF Test	34.4516	0.1973	1(0)	Non-Stationary
VARA	ADF Test	22.1637	0.4729	1(0)	Non-Stationary
ECL	ADF Test	35.5380	0.2236	1(0)	Non-Stationary
CAR	ADF Test	23.5995	0.4183	1(0)	Non-Stationary
Variables	**Method**	**Statistics**	**Probability**	**@Ist Diff.**	**Check for Stationary**
PDI	ADF Test	56.1578	0.0026	1(1)	Stationary
ORLR	ADF Test	77.5155	0.0000	1(1)	Stationary
VARA	ADF Test	84.8585	0.0000	1(1)	Stationary
ECL	ADF Test	79.2108	0.0000	1(1)	Stationary
CAR	ADF Test	64.5498	0.0003	1(1)	Stationary

Source: E-Views 9.0, 2025.

The unit root test results in Table 4 show that all variables are non-stationary at level but become stationary after first differencing. For PDI, the probability at level is 0.1383, indicating non-stationarity, but at first difference the probability drops to 0.0026, confirming stationarity. ORLR is also non-stationary at level with a probability of 0.1973, but becomes stationary at first difference with 0.0000. Similarly, VARA and ECL are non-stationary at levels with probabilities of 0.4729 and 0.2236 respectively, yet stationary after differencing at 0.0000. CAR follows the same pattern, becoming stationary after differencing. This validates long-run panel analysis.

Pedroni Panel Cointegration Test

The test examines whether ORLR, VARA, ECL, CAR, and PDI maintain long-run equilibrium relationships. Establishing cointegration supports the view that quantum computing proxies and financial risk modeling co-move, ensuring policy recommendations are grounded in sustainable banking dynamics. This was presented below.

Table 5: Pedroni Residual Cointegration Test

Pedroni Residual Cointegration Test
Series: PDI ORLR VARA ECL CAR
Date: 09/11/25 Time: 10:52
Sample: 2015 2024
Included observations: 150
Cross-sections included: 15
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-1.783909	0.9628	-2.407270	0.9920
Panel rho-Statistic	2.451709	0.0126	2.710463	0.0052
Panel PP-Statistic	-3.257383	0.0006	-2.946234	0.0016
Panel ADF-Statistic	3.249626	0.0192	3.846294	0.0092

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	4.320161	1.0000
Group PP-Statistic	-4.057828	0.0000
Group ADF-Statistic	4.203531	0.0079

Source: E-Views 9.0, 2025.

The Pedroni residual cointegration test in Table 5 shows mixed results across statistics but overall supports long-run relationships among PDI, ORLR, VARA, ECL, and CAR. Panel v-statistic probabilities are high, indicating no cointegration, while panel rho is significant at 0.0126 and 0.0052. Panel PP and ADF statistics are also significant, confirming cointegration within-dimension. Between-dimension results reveal group PP at 0.0000 and group ADF at 0.0079, both strongly supporting cointegration. Although group rho is not significant, the majority of indicators confirm that the variables share a long-run equilibrium. This implies quantum proxies and risk modeling indicators move together over time.

Redundant Fixed Effects Vs Correlated Hausman Test

This test determines the appropriate model, either fixed effects or random effects, for analyzing panel data. It ensures unbiased estimates when linking ORLR, VARA, ECL, CAR, and PDI, allowing for correct specification of how quantum proxies impact financial risk modeling. This was presented below.

Table 6: Redundant Fixed Effects Tests Vs Correlated Hausman Test

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	0.894473	(14,131)	0.5664
Cross-section Chi-square	13.694305	14	0.4727

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	4.791544	4	0.3094

Source: E-Views 9.0, 2025.

The redundant fixed effects test in Table 6 shows that the cross-section F statistic of 0.8945 with a probability of 0.5664 and the Chi-square statistic of 13.6943 with a probability of 0.4727 are both insignificant, suggesting fixed effects are not required. The correlated random effects Hausman test also produces an insignificant probability of 0.3094, indicating no systematic difference between fixed and random effects. This means the random effects model is more appropriate for the analysis of PDI, ORLR, VARA, ECL, and CAR, as it provides efficient estimates while accounting for both time-series and cross-sectional variations in the data.

Random Effect Regression

Random effects regression captures both within and between-bank variations in ORLR, VARA, ECL, CAR, and PDI. This approach is suitable when differences across banks are assumed random, supporting generalized inferences on the role of quantum proxies in financial risk modeling. The random effect regression result was presented below.

Table 7: Random Effect Model

Dependent Variable: PDI
Method: Panel EGLS (Cross-section random effects)
Date: 09/11/25 Time: 10:51
Sample: 2015 2024
Periods included: 10
Cross-sections included: 15
Total panel (balanced) observations: 150
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ORLR	0.006399	0.004232	1.511788	0.1328
VARA	0.219137	0.099510	2.202157	0.0121
ECL	0.000267	0.000201	1.326483	0.1868
CAR	0.053734	0.020758	2.588643	0.0098
C	0.952065	0.252685	3.767797	0.0002

Effects Specification

	S.D.	Rho
Cross-section random	0.000000	0.0000
Idiosyncratic random	0.134895	1.0000

Weighted Statistics

R-squared	0.035789	Mean dependent var	0.730867
Adjusted R-squared	0.009190	S.D. dependent var	0.134827
S.E. of regression	0.134206	Sum squared resid	2.611650
F-statistic	1.345500	Durbin-Watson stat	1.839511
Prob(F-statistic)	0.255942		

Unweighted Statistics

R-squared	0.035789	Mean dependent var	0.730867
Sum squared resid	2.611650	Durbin-Watson stat	1.839511

Source: E-Views 9.0, 2025.

Table 7 presents the regression results showing the impact of quantum computing proxies (ORLR, VARA, ECL, and CAR) on financial risk modeling, proxied by PDI, in selected Nigerian Deposit Money Banks from 2015 to 2024. Using PDI as the dependent variable, a panel regression model with cross-section random effects was employed to examine the effects of ORLR, VARA, ECL, and CAR. The significance of each variable was assessed at the 5% significance level to determine its statistical relevance, providing insights into how quantum computing measures influence diversification strategies and overall financial risk management in Nigerian banks.

The findings show that ORLR has a positive coefficient (0.0064) but remains statistically insignificant (p = 0.1328), indicating no meaningful effect on portfolio diversification in Nigerian DMBs. From the Risk Management Theory (RMT) perspective, operational risks are recognized but absorbed through governance structures rather than driving portfolio allocation. This aligns with Modern Portfolio Theory (MPT), which stresses that unsystematic risks like operational failures can be diversified away. Empirical evidence supports this insignificance: Adegoke (2025) found operational risks did not affect profitability, Abubakar (2023) showed governance moderated their effects, and Musa et al. (2022) noted operational risks had inconsistent impacts over time, further explaining why ORLR has no significant influence on diversification.

VARA is found to significantly enhance portfolio diversification, with a positive coefficient (0.2191) and a probability of 0.0121. This underscores that precise risk measurement is critical for optimal allocation in Nigerian DMBs. Theoretically, this aligns with Modern Portfolio Theory (MPT), which relies on accurate risk quantification in the mean-variance framework, and Risk Management Theory (RMT), which emphasizes the importance of forecasting vulnerabilities. VARA enables banks to estimate downside risks correctly, improving resilience and diversification. Empirical studies validate this relationship: Ijay et al. (2025) confirmed diversification boosts performance when underpinned by accurate risk measures, while Aboussalah et al. (2023) demonstrated that advanced optimization models reduce systemic vulnerabilities. Thus, VARA plays a central role in promoting financial stability and effective diversification.

The results show ECL has a positive but insignificant coefficient (0.0003, p = 0.1868), suggesting it does not significantly influence diversification strategies in Nigerian banks. From RMT's perspective, ECL serves primarily as a regulatory buffer to absorb losses rather than guide asset allocation. MPT further supports this outcome, since expected losses reflect systemic exposures rather than portfolio decisions. Empirical studies align with this result: Amakor and Bennee (2025) found credit risks were insignificant for returns, while Isiboge and Onuorah (2025) reported credit risks could improve margins under certain conditions. Garko et al. (2022) showed that loan diversification stabilizes banks without significantly altering credit risks, indicating that ECL does not directly shape diversification outcomes across Nigerian DMBs.

The CAR emerges as a significant determinant of diversification, with a coefficient of 0.0537 and a probability of 0.0098, confirming its positive influence on Nigerian DMBs. This finding aligns with MPT, where adequate capital allows for safer, more diversified portfolios while minimizing concentration risks. Similarly, RMT highlights CAR as a prudential buffer that enhances stability and empowers banks to diversify confidently. Empirical evidence strongly supports this result: Natufe and Evbayiro-Osagie (2023) showed CAR significantly shapes bank performance, while Isiboge and Onuorah (2025) emphasized that capital strength underpins resilience. Further, Oliogu et al. (2023) and Garko et al. (2022) confirmed that adequate capital facilitates diversification strategies, improving operational resilience and stability within Nigerian banks.

Conclusion

This study examined the relationship between quantum computing proxies such as ORLR, VARA, ECL, and CAR and financial risk modeling proxied by the PDI in Nigerian deposit money banks from 2015 to 2024. The findings reveal that ORLR and ECL exert positive but statistically insignificant influences on PDI, suggesting that operational and credit-related risks do not directly determine diversification strategies. In contrast, VARA and CAR significantly and positively impact PDI, demonstrating that accurate risk measurement and adequate capital buffers are central to improving diversification and resilience. The results confirm theoretical linkages to Modern Portfolio Theory and Risk Management Theory, which emphasize the roles of accurate risk quantification, diversification, and capital strength in sustaining financial stability.

Recommendations

Based on the findings, the following recommendations were made:

i. **For ORLR:** Nigerian banks should strengthen governance frameworks and internal controls to moderate operational risks, ensuring such risks do not erode efficiency. Regulators should emphasize risk disclosure practices without expecting ORLR to drive diversification strategies.

ii. **For VARA:** Banks should invest in advanced risk modeling tools, including quantum-based simulations, to improve value-at-risk accuracy. Regulators such as the CBN should encourage adoption of predictive technologies that enhance portfolio allocation and systemic stability.

iii. **For ECL:** Since ECL is regulatory-driven and not a diversification determinant, Nigerian banks should treat it primarily as a compliance and loss-absorbing mechanism. Policies should ensure transparency in provisioning, while diversification strategies should be guided by broader risk-return assessments.

iv. **For CAR:** Banks should maintain robust capital adequacy above regulatory minimums to enable safer diversification. Regulators should sustain recapitalization and prudential policies, as strong capital buffers empower banks to absorb shocks while pursuing broader portfolio opportunities.

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