PUBLIC FINANCE AND APPLIED ECONOMETRICS

Government Revenue and Expenditure in Nigeria: A Bayesian Analysis of Oil and Non-Oil Revenue and Recurrent and Capital Expenditure

John Abisi Daniel, M. U. Bawa, A. Ahmed

Abubakar Tafawa Balewa University, Bauchi, Nigeria

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Abstract

This study examined the relationship between government revenue and government expenditure in Nigeria, focusing on the effects of oil and non-oil revenue on recurrent and capital expenditure. It extended Akanbi (2021) by applying a Bayesian framework that accounts for parameter and model uncertainty. Secondary fiscal data from the Central Bank of Nigeria Statistical Bulletin and other official sources were analyzed using descriptive statistics, stationarity and cointegration diagnostics, Bayesian linear regression, posterior inference, MCMC diagnostics, posterior predictive checks, Leave-One-Out cross-validation and Bayesian Model Averaging. The results indicate positive associations between revenue and expenditure, with differences across expenditure components. For recurrent expenditure, non-oil revenue showed a strong positive relationship, while the evidence for oil revenue was less certain. For capital expenditure, both oil and non-oil revenue showed positive and credible relationships, with non-oil revenue having the larger posterior mean. Bayesian Model Averaging further indicated stronger support for non-oil revenue in recurrent expenditure and strong support for both revenue sources in capital expenditure. The study highlights the importance of sustainable domestic revenue mobilization and improved expenditure management for fiscal sustainability in Nigeria.

Keywords: Government revenue; government expenditure; oil revenue; Bayesian regression; Bayesian model averaging; Nigeria

1 Introduction

1.1 Background to the study

Government revenue and expenditure constitute two fundamental components of public finance and are central to the capacity of government to provide public goods, finance infrastructure, maintain public institutions and promote economic development. The relationship between revenue generation and government expenditure is therefore important for fiscal stability and sustainable economic management. Where government expenditure persistently exceeds available revenue, governments may resort to borrowing or other deficit-financing measures, potentially increasing debt-servicing obligations and constraining future fiscal space.

The revenue–expenditure relationship is particularly important in Nigeria because of the country's historical dependence on petroleum revenue. For several decades, oil revenue has constituted a major source of government revenue, exposing public finances to fluctuations in international crude oil prices, oil production levels, exchange-rate movements and developments in the international economy. Consequently, changes in the oil market can have substantial implications for government revenue and expenditure. The fiscal environment has also been affected by economic recessions, the

COVID-19 pandemic, changes in exchange-rate policy and the removal of fuel subsidies. These developments have increased the importance of understanding how different sources of government revenue relate to different components of government expenditure.

Nigeria's fiscal position has frequently been characterized by periods in which expenditure pressures exceed revenue growth, resulting in budget deficits and increased reliance on borrowing. Oil-revenue volatility, persistent fiscal deficits and recent economic shocks are important features of Nigeria's fiscal environment. The 2016 recession, the COVID-19 pandemic in 2020 and the removal of the fuel subsidy in 2023 intensified fiscal pressures. These developments demonstrate the need for empirical approaches capable of accounting for uncertainty and structural changes in fiscal relationships.

Government expenditure can be classified into recurrent and capital expenditure. Recurrent expenditure consists largely of expenditures required for the day-to-day functioning of government, including personnel costs, administrative expenses and other recurring obligations. Capital expenditure is associated with the acquisition or development of long-term assets such as infrastructure and public investment projects. The distinction is important because the two categories may respond differently to changes in government revenue. An increase in revenue may allow government to expand capital investment, while revenue constraints may disproportionately affect capital expenditure because recurrent commitments are often more difficult to reduce in the short term.

Government revenue can similarly be disaggregated into oil and non-oil revenue. Oil revenue includes receipts associated with petroleum-related activities, while non-oil revenue includes sources such as taxation and other government receipts outside the petroleum sector. Examining these revenue components separately is important because their stability, predictability and responsiveness to economic conditions differ considerably. A fiscal system that relies heavily on volatile oil revenue may have a different expenditure response from one increasingly supported by more stable non-oil revenue.

The relationship between government revenue and expenditure has consequently attracted considerable attention in public finance research. Previous Nigerian studies have examined whether revenue drives expenditure, expenditure generates revenue, or whether the two variables influence each other. Akanbi (2021), for example, applied Bayesian linear regression to Nigerian data covering 1989–2018 and reported a positive relationship between total government revenue and expenditure. The study used a conjugate Normal-Gamma prior and found that total revenue explained a substantial proportion of the variation in total government expenditure.

However, Nigeria's fiscal environment has changed considerably since the period covered by many earlier studies. The COVID-19 pandemic, oil-price fluctuations, the removal of the fuel subsidy and subsequent macroeconomic reforms have altered the fiscal environment. The period after 2019 therefore provides an important opportunity to reassess the revenue–expenditure relationship using more recent observations. The present study extends the period of analysis to 1995–2025 in order to incorporate these developments and provide an updated assessment of Nigeria's fiscal dynamics.

In addition to the changing fiscal environment, methodological considerations are important. Traditional econometric methods such as Ordinary Least Squares (OLS) generally provide point estimates and confidence intervals within a frequentist framework. While such methods remain useful, they may not adequately represent parameter uncertainty in highly volatile fiscal environments. Bayesian methods provide an alternative framework in which unknown parameters are treated probabilistically and prior information can be combined with observed data to obtain posterior distributions.

Bayesian regression is therefore adopted in this study as the principal analytical framework. Bayesian inference provides a systematic mechanism for updating prior information using observed evidence and expressing uncertainty through posterior probability distributions. This is particularly relevant where fiscal data are characterized by volatility, relatively limited annual observations and possible structural changes. The study's methodology proposes the use of Bayesian linear regression with Normal-Gamma priors and Markov Chain Monte Carlo (MCMC) techniques, together with Bayesian Model Averaging (BMA) and alternative Bayesian models for predictive comparison.

Accordingly, this study examines the relationship between government revenue and expenditure in Nigeria over the period 1995–2025, with particular attention to the distinction between oil and non-oil revenue and between capital and recurrent expenditure. By incorporating recent fiscal developments and a Bayesian analytical framework, the study seeks to provide updated evidence that can contribute to fiscal planning, revenue mobilization and expenditure management in Nigeria.

1.2 Statement of the problem

Nigeria has experienced persistent fiscal challenges despite its substantial natural-resource endowment and efforts to improve domestic revenue mobilization. A major challenge is the mismatch between government revenue and expenditure. Government expenditure has frequently increased faster than government revenue, resulting in fiscal deficits and increasing dependence on borrowing. The resulting debt-service burden can reduce the resources available for productive government programs and constrain fiscal sustainability.

The problem is further complicated by the composition of government revenue. Nigeria's historical dependence on oil revenue makes government finances vulnerable to fluctuations in international oil prices, petroleum production and other external shocks. When oil revenue falls, government may face difficulty maintaining planned expenditure levels. At the same time, the increasing importance of non-oil revenue raises questions about whether improvements in tax and other non-oil receipts can provide a more stable basis for financing government expenditure.

The composition of expenditure also presents an important policy problem. Persistent recurrent expenditure obligations may limit the resources available for capital investment. Where capital expenditure is inadequately financed, infrastructure development and other productive public investments may be constrained. Thus, examining only aggregate government expenditure may conceal important differences in how oil and non-oil revenue affect recurrent and capital expenditure.

The Nigerian fiscal environment has also undergone significant changes in recent years. The COVID-19 pandemic created substantial economic and fiscal disruptions, while subsequent oil-market developments, the removal of the fuel subsidy in 2023 and exchange-rate reforms created additional pressures and uncertainties. These developments make evidence based exclusively on earlier periods potentially insufficient for understanding the current revenue–expenditure relationship.

Another problem concerns the methodological approaches used in previous studies. Much of the existing empirical literature has relied on conventional econometric techniques. Although such approaches provide useful evidence, they may not adequately capture uncertainty surrounding parameter estimates or uncertainty regarding alternative model specifications. Classical methods dominate Nigerian fiscal studies and often overlook parameter uncertainty and small-sample issues.

Shocks such as COVID-19 and subsidy reform introduce structural breaks that are rarely handled robustly in prior work.

Akanbi (2021) provides an important benchmark because the study applied Bayesian regression to the relationship between government revenue and expenditure using Nigerian data from 1989–2018. However, the period covered by that study does not incorporate the major fiscal developments experienced after 2018. The present study therefore seeks to extend and re-evaluate the relationship using annual data covering 1995–2025.

The central problem addressed by this study is therefore the inadequate understanding of how government revenue, particularly oil and non-oil revenue, relates to government expenditure, particularly capital and recurrent expenditure, under changing fiscal conditions in Nigeria. Addressing this problem is important for improving revenue mobilization, expenditure prioritization and fiscal sustainability.

1.3 Aim and objectives of the study

The main aim of this study is to examine and evaluate the relationship between government revenue and government expenditure in Nigeria using a Bayesian regression framework, with particular emphasis on oil and non-oil revenue, capital and recurrent expenditure, and the effects of recent economic shocks.

The specific objectives of the study are to:

- Analyze the dynamic relationships between oil/non-oil revenue and recurrent/capital expenditure in Nigeria.
- Estimate Bayesian models to examine the sensitivity of government expenditure to oil and non-oil revenue in the presence of major fiscal shocks in Nigeria.
- Assess model uncertainty and predictive performance using Bayesian Model Averaging and related diagnostics

1.4 Significance of the study

This study is significant because it provides empirical evidence on the relationship between government revenue and government expenditure in Nigeria, with particular emphasis on oil and non-oil revenue and recurrent and capital expenditure. By applying a Bayesian regression framework, the study provides a more comprehensive assessment of the revenue–expenditure relationship by accounting for parameter uncertainty and model uncertainty. The findings are expected to contribute to the understanding of how different sources of government revenue are associated with different categories of public expenditure in Nigeria.

The study is also relevant to fiscal policymakers and government authorities because it provides evidence that can support decisions concerning revenue mobilization and expenditure management. Understanding the relative contribution of oil and non-oil revenue to recurrent and capital expenditure can assist policymakers in developing strategies for improving fiscal sustainability and reducing excessive dependence on volatile oil revenues. The findings may also provide useful information for assessing the implications of changes in government revenue for the financing of public expenditure.

Furthermore, the study contributes to the existing literature by extending the work of Akanbi (2021) through the use of a more disaggregated revenue and expenditure framework and updated data. The

application of Bayesian Model Averaging further provides evidence on model uncertainty and the relative importance of alternative revenue variables. This makes the study relevant to researchers and academics interested in public finance, fiscal policy, Bayesian econometrics, and the revenue–expenditure relationship in developing economies.

Finally, the study provides a basis for further research on government revenue and expenditure in Nigeria. Its Bayesian methodological approach, together with the analysis of oil and non-oil revenue and recurrent and capital expenditure, may serve as a useful reference for future studies seeking to examine fiscal relationships using probabilistic and model-uncertainty approaches.

1.5 Scope of the study

The study focuses on the relationship between government revenue and government expenditure in Nigeria. The geographical scope is the Federal Government of Nigeria, while the temporal scope covers annual observations from 1995 to 2025.

The dependent variable is government expenditure, with particular attention to total expenditure and its two major components: recurrent expenditure and capital expenditure. The principal explanatory variables are total government revenue, oil revenue and non-oil revenue.

The study will rely primarily on annual secondary data obtained from official Nigerian sources, particularly the Central Bank of Nigeria (CBN) Statistical Bulletin. Supplementary information may be obtained from the National Bureau of Statistics and other recognized official and international databases where required.

Methodologically, the study is restricted to a Bayesian econometric framework. Bayesian linear regression with Normal-Gamma priors constitutes the principal model, while Bayesian Model Averaging is considered for addressing model uncertainty. Alternative Bayesian models may be employed for predictive comparison, subject to data availability and model suitability.

The study also considers the effects of important changes in the Nigerian fiscal environment, including the COVID-19 pandemic, oil-price volatility and the 2023 fuel-subsidy removal. The methodology proposes the use of a post-2019 structural-break or shock variable where appropriate.

1.6 Limitations of the study

The study is subject to several limitations.

First, it relies primarily on secondary data obtained from official sources. Government statistical series may be revised periodically, and differences in definitions, classification and reporting practices across institutions may create inconsistencies.

Second, the study covers annual observations over 1995–2025. Although this provides a relatively long historical period, the number of annual observations remains limited for highly parameterized econometric models. This limitation is particularly relevant when considering complex alternative Bayesian models.

Third, Bayesian results may be influenced by the specification of prior distributions. To minimize excessive prior influence, the study will initially employ weakly informative or appropriately diffuse priors and conduct prior-sensitivity checks.

Fourth, the revenue–expenditure relationship may be influenced by factors that cannot be fully captured by the selected variables. These may include institutional quality, political considerations, corruption, and changes in fiscal rules, exchange-rate movements and unexpected external shocks.

Finally, Bayesian estimation using MCMC may involve substantial computational requirements, particularly when estimating complex models or conducting extensive robustness checks. The study will therefore emphasize model parsimony, convergence diagnostics and appropriate robustness procedures.

1.7 Definition of key terms

- **Bayesian Regression:** A regression approach in which prior information and observed data are combined to obtain posterior probability distributions for unknown model parameters.
- **Capital Expenditure:** Government expenditure directed toward the acquisition, construction or development of long-term public assets and infrastructure.
- **Government Expenditure:** Public spending undertaken by government, including recurrent and capital expenditure.
- **Government Revenue:** Financial receipts accruing to government from sources such as petroleum revenue, taxation and other non-oil sources.
- **Non-Oil Revenue:** Government revenue generated from sources other than petroleum-related activities, including taxation and other government receipts.
- **Oil Revenue:** Government revenue arising from petroleum-related activities.
- **Posterior Distribution:** The probability distribution of an unknown parameter after combining prior information with evidence contained in the observed data.
- **Recurrent Expenditure:** Government expenditure associated with the routine and continuing operation of government, including personnel and administrative expenditures.
- **Normal-Gamma Prior:** A conjugate Bayesian prior structure used for regression coefficients and the error-variance parameter in Bayesian linear regression.
- **Bayesian Model Averaging:** A Bayesian procedure that accounts for model uncertainty by combining information across alternative model specifications according to their posterior probabilities.
- **Markov Chain Monte Carlo (MCMC):** A computational method used to generate samples from posterior distributions when direct analytical evaluation is difficult or unavailable.

2 Literature review

2.1 Conceptual review

Government revenue comprises all financial resources mobilized by the public sector to finance collective goods, transfers, debt service and investment. In Nigeria the distinction between oil and non-oil revenue is analytically central. Oil revenue consists of petroleum profit tax, royalties, rents, signature bonuses and NNPC-related transfers. Non-oil revenue comprises company income tax, value-added tax, customs and excise duties, independent revenue of government-owned enterprises and other non-petroleum receipts. Oil revenue is highly exposed to international price volatility, production disruptions, oil theft and exchange-rate movements, whereas non-oil revenue is more closely linked to the size and formalization of the domestic tax base, administrative capacity and compliance.

Government expenditure is conventionally decomposed into recurrent and capital components. Recurrent expenditure covers personnel costs, overheads, pensions, transfers and interest payments —obligations that are relatively rigid in the short run. Capital expenditure finances the acquisition and development of long-term productive assets. Because recurrent commitments are politically and contractually difficult to reverse, revenue shortfalls typically lead to compression of capital budgets, thereby constraining infrastructure and human-capital formation.

Recent official data illustrate the continuing importance of these distinctions. Central Bank of Nigeria and Budget Office reports show that non-oil revenue has raised sharply in relative terms since 2023, reaching approximately 70–76 per cent of total collections in some recent periods, while oil revenue continues to under-perform budget projections. At the same time, debt-service obligations have absorbed a rising share of available resources, frequently exceeding combined allocations to education, health and security. These compositional shifts underscore the need for empirical work that separates oil from non-oil revenue and recurrent from capital expenditure.

2.2 Empirical review

2.2.1 Aggregate revenue–expenditure nexus in Nigeria

A substantial body of Nigerian research has tested the four hypotheses using classical time-series techniques. Obioma and Ozughalu (2010) employed Engle–Granger and Johansen cointegration together with Granger causality within an error-correction framework for 1970–2007 and found unidirectional causality from revenue to expenditure, supporting the tax-and-spend hypothesis. Aminu and Raifu (2019) applied both linear and nonlinear (Diks–Panchenko) causality tests and asymmetric ARDL methods; linear tests favored fiscal synchronization while nonlinear tests supported revenue-spending causality, highlighting the importance of allowing for asymmetry.

More recent causality studies continue to produce mixed results. A 2026 Granger-causality analysis covering 1981–2023 reported bidirectional causality between total revenue and total expenditure, consistent with fiscal synchronization, and recommended simultaneous revenue enhancement and expenditure rationalisation. Alade (2022) examined revenue, expenditure and debt over 1984–2019 with a vector-error-correction model and found evidence of both spend-tax and fiscal-synchronization patterns. An investigation covering 1961–2019 validated the tax-spend hypothesis for per-capita series. Collectively these studies demonstrate that the direction of causality is sensitive to sample period, variable transformation and the allowance for nonlinearity or structural breaks.

2.2.2 Oil versus non-oil revenue and expenditure composition

Jibir et al (2019) used ARDL bounds testing on data spanning 1970–2017 and identified oil revenue, GDP, population, trade openness, oil price, taxation and inflation as significant determinants of aggregate government expenditure. Their results underscore the dual dependence of Nigerian fiscal outcomes on domestic capacity and external oil-market conditions.

Abubakar et al (2023) examined the response of fiscal effort to oil-price dynamics and found that the long-run response of the government balance is broadly symmetric, while short-run responses are asymmetric: positive oil-price shocks are associated with short-run fiscal deterioration, whereas negative shocks induce stronger fiscal effort. Ogunjumo et al. (2024) reported that oil-revenue volatility depresses growth in the short run but exhibits a positive long-run association, reinforcing calls for diversification. Samuel and Kouhy (2025) shifted attention from revenue generation to

utilization and concluded that oil-revenue allocation has not produced significant long-run effects on sustainable growth, attributing the failure to institutional weaknesses and fiscal-structure problems.

Studies that disaggregate expenditure find that recurrent spending is more rigid. Maku and Mustapha (2022) employed a Bayesian VAR on 1986–2020 data and showed that recurrent-expenditure shocks exert a substantial and persistent influence on economic growth, whereas capital-expenditure shocks have little or no beneficial impact. ARDL analyses of government expenditure and selected tax revenues (company income tax, VAT, petroleum profit tax) on GDP over 1982–2022 confirm long-run relationships involving recurrent expenditure and non-oil taxes.

2.2.3 Bayesian applications in Nigerian fiscal and macroeconomic research

Akanbi (2021) remains the most direct methodological precursor. Using annual CBN data for 1989–2018, the study estimated a Bayesian linear regression of total expenditure on total revenue with a conjugate Normal-Gamma prior. The posterior mean of the revenue coefficient was 0.536 with a markedly smaller posterior standard deviation than the corresponding OLS estimate; total revenue explained approximately 78 per cent of the variation in total expenditure. The study also produced 30-year forecasts showing continued expenditure growth, and recommended revenue enhancement to sustain future spending.

Other Bayesian contributions include Akanbi (2018) on GDP modelling via Bayesian Model Averaging, Tumala et al. (2018) on inflation predictors using BMA and weighted-average least squares, and Rasaki (2018) on a Bayesian DSGE model incorporating oil-price and fiscal shocks. Maku and Mustapha (2022) applied BVAR to government expenditure and macroeconomic variables. More recent work has used BMA to model exchange-rate determinants (capital expenditure and money supply emerging as key variables) and Bayesian VAR frameworks for monetary aggregates and fiscal-stimulus effects on human capital. These studies collectively demonstrate the growing acceptance of Bayesian methods for handling parameter uncertainty, model uncertainty and small-sample issues in Nigerian macroeconomic research.

2.2.4 Impact of recent fiscal shocks (COVID-19, oil-price collapse and 2023 subsidy removal)

The post-2019 period has been marked by successive shocks. COVID-19 reduced economic activity and revenue while raising health and social-support needs. The 2020 oil-price collapse compounded the pressure. The May 2023 removal of the petrol subsidy eliminated an annual under-recovery estimated at ₦4–5 trillion and produced large savings (World Bank estimates range from ₦11 trillion to ₦20 trillion cumulatively). FAAC disbursements rose sharply from ₦16.28 trillion in 2023 to ₦28.78 trillion in 2024 yet a substantial portion of the savings has been absorbed by higher debt-service costs (exceeding ₦12–15 trillion annually) and expanded recurrent obligations, including a doubled minimum wage and student-loan programs.

IMF Article IV assessments (2024, 2025, 2026) document persistent oil-revenue shortfalls relative to budget, under-execution of capital expenditure, and a widening consolidated fiscal deficit in 2025. Non-oil taxes (especially CIT and VAT) have performed closer to or above target, confirming the growing relative importance of the non-oil base. Budget implementation reports reveal systematic optimism bias in both oil-revenue and capital-expenditure forecasts over 2011–2023, limiting the usefulness of the budget as a binding policy framework.

2.2.5 *Comparative African and resource-rich country evidence*

Cross-country studies reinforce the Nigerian findings. Arroyo et al (2024) show that commodity exporters experience greater fiscal volatility and that institutional and policy variables explain a large share of cross-country differences. Sennoga and Balma (2022) examine post-COVID fiscal sustainability in Africa and emphasize the trade-offs between deficit financing and growth-enhancing expenditure. Ezeoha and Nkwor (2023) find that armed conflict undermines tax revenue and raises military spending across 50 African countries. Kolawole et al. (2024) highlight the mediating role of institutional quality in the finance, revenue, sustainable, energy nexus in West Africa.

Within Southern Africa, a 2022 study of the SADC region found institutional separation (no causality) in eleven member states, tax-spend in Botswana, and spend-tax in Mauritius and Mozambique. Sub-Saharan African evidence more generally suggests that low-income, credit-constrained countries tend to exhibit tax-spend behavior because expenditure cannot easily exceed available domestic revenue.

2.2.6 *Institutional quality, diversification and expenditure effectiveness*

Awe et al (2023) used unsupervised machine-learning methods to revisit economic diversification and documented continuing structural separation between petroleum and non-petroleum activity. Onabote et al (2023) found only weak direct links between sectorial government spending and human-development outcomes, suggesting that expenditure composition and implementation quality matter as much as aggregate volume. Studies of tax administration in Sub-Saharan Africa (Akande et al., 2024) and financial inclusion in the WAEMU (Chebochok & Bayale, 2023) emphasize that revenue mobilization depends critically on administrative capacity and formalization rather than statutory rates alone.

2.3 Research gap and contribution of the present study

Despite the volume of research, several critical gaps remain. First, the majority of Nigerian studies end before or around 2019–2020 and therefore omit the combined effects of COVID-19, the 2020 oil-price shock and the 2023 subsidy removal.

Secondly, most classical studies report point estimates and confidence intervals but do not fully characterize parameter uncertainty.

Thirdly, disaggregated analysis of oil versus non-oil revenue and recurrent versus capital expenditure within a single Bayesian framework remains rare. Fourth, formal model averaging and out-of-sample predictive comparison across Bayesian specifications are still uncommon in the Nigerian fiscal literature.

The present study addresses these gaps by: (i) extending the sample to 1995–2025; (ii) disaggregating both revenue and expenditure; (iii) incorporating explicit shock dummies for 2016, 2020–21 and 2023 onward; (iv) employing Normal-Gamma Bayesian regression, BVAR and Bayesian Model Averaging; and (v) evaluating predictive performance with multiple criteria (RMSFE, CRPS, marginal likelihood, DIC/WAIC). In doing so it builds directly on Akanbi (2021) while updating and generalizing that work to the contemporary Nigerian fiscal environment.

3 Research methodology

This chapter presents the methodology adopted to examine the relationship between government revenue and government expenditure in Nigeria over the period 1995–2025. The methodology is designed to address the three specific objectives of the study and to extend the Bayesian linear regression approach of Akanbi (2021). Akanbi (2021) estimated a single-equation Bayesian regression of total government expenditure on total government revenue using annual data for 1989–2018 and a conjugate Normal-Gamma prior. The present study extends that framework by (i) disaggregating government revenue into oil and non-oil components and government expenditure into recurrent and capital components; (ii) incorporating major fiscal shocks; (iii) introducing a dynamic Bayesian Vector Autoregression (BVAR) to capture feedback and lagged interactions; and (iv) formally addressing model uncertainty through Bayesian Model Averaging (BMA) and predictive model comparison.

The empirical strategy is organized in stages. First, a benchmark Bayesian linear regression is estimated to reproduce and update the central specification of Akanbi (2021). Second, separate Bayesian regressions are estimated for total, recurrent and capital expenditure using oil and non-oil revenue, with fiscal-shock indicators included where appropriate. Third, a parsimonious BVAR is estimated to examine dynamic interactions among the principal fiscal variables and to generate impulse-response functions (IRFs) and forecast-error variance decompositions (FEVDs). Finally, BMA and predictive evaluation are used to assess model uncertainty and forecasting performance.

3.1 Research design

The study adopts a quantitative, ex-post facto and longitudinal research design based on annual secondary time-series observations for the Federal Government of Nigeria from 1995 to 2025. The ex-post facto design is appropriate because the fiscal observations have already occurred and cannot be manipulated experimentally. The longitudinal design is appropriate because the study examines the evolution and dynamic interaction of government revenue and expenditure through time. The maximum sample size is 31 annual observations.

The empirical analysis follows a hierarchical modelling strategy:

- Stage 1: Benchmark Bayesian linear regression corresponding to the framework of Akanbi (2021).
- Stage 2: Disaggregated Bayesian linear regressions for total, recurrent and capital expenditure using oil and non-oil revenue and fiscal-shock indicators.
- Stage 3: Parsimonious BVAR for the joint dynamic behaviour of expenditure and revenue components, followed by IRF and FEVD analysis.
- Stage 4: Bayesian Model Averaging and predictive comparison of competing specifications.

3.2 Population and unit of analysis

The population of the study comprises annual fiscal observations of the Federal Government of Nigeria. The unit of analysis is one annual observation of the federal fiscal position. The sample covers 1995–2025, yielding 31 annual observations. The period is selected to provide a sufficiently long historical span while incorporating major fiscal developments, including the 2016 recession, the COVID-19 period and the 2023 fuel-subsidy removal.

3.3 Sources of data

The principal source of data is the Central Bank of Nigeria (CBN) Statistical Bulletin, from which annual series on Federal Government revenue and expenditure are obtained. Where necessary, supplementary verification is made using publications of the National Bureau of Statistics (NBS), the Federal Ministry of Finance, the Debt Management Office (DMO), the World Bank and the International Monetary Fund (IMF). The CBN series constitute the primary analytical dataset so that definitions and measurement are kept as consistent as possible across the study period.

All fiscal variables are recorded on an annual basis. Monetary variables are initially retained in nominal naira as reported in the source data and are transformed as specified below. Where real terms are required for robustness analysis, an appropriate GDP deflator or consumer-price measure from an official source will be applied consistently across the relevant series.

3.4 Description and measurement of variables

3.4.1 Revenue variables

Government revenue is measured using total revenue, oil revenue and non-oil revenue. Total revenue is the aggregate of oil and non-oil revenue.

$$TR_t = OR_t + NOR_t \tag{1}$$

Where TR_t denotes total government revenue in year t; OR_t denotes oil revenue in year t; and NOR_t denotes non-oil revenue in year t.

Oil revenue comprises petroleum-related government receipts reported in the CBN fiscal series, while non-oil revenue comprises government receipts generated outside petroleum-related sources, including major tax and other non-oil receipts as classified by the source.

3.4.2 Expenditure variables

Government expenditure is measured as total expenditure, recurrent expenditure and capital expenditure. Total expenditure is decomposed into recurrent and capital components as follows:

$$TE_t = RE_t + CE_t \tag{2}$$

where TE_t denotes total government expenditure; RE_t denotes recurrent expenditure; and CE_t denotes capital expenditure in year t.

Recurrent expenditure captures the routine and continuing obligations of government, including personnel, overheads, transfers, pensions and interest-related payments as classified in the fiscal data. Capital expenditure captures expenditure associated with the acquisition, construction or development of long-term public assets and infrastructure.

3.4.3 Fiscal-shock variables

Three binary indicators are introduced to account for important fiscal disturbances identified in the study. The indicators are treated as intervention variables rather than as substitutes for the underlying revenue and expenditure series.

$$\mathrm{D16}_t = \begin{cases} 1, & if\, t = 2026, \\ 0, & \text{Otherwise}. \end{cases} \tag{3}$$

$$D20_t = \begin{cases} 1, & if\ t \in \{2020,\ 2021\}, \\ 0, & \text{Otherwise}. \end{cases}$$

$$D23_t = \begin{cases} 1, & if\ t \geq 2023, \\ 0, & \text{Otherwise}. \end{cases}$$

The 2016 indicator captures the recession episode, D20 captures the COVID-19 period, and D23 captures the post-subsidy-removal regime beginning in 2023. Additional macroeconomic variables, such as real GDP, inflation, crude-oil price, exchange rate and public debt, may be included only in robustness specifications where data availability and the limited sample size permit.

3.5 Data transformation and preliminary analysis

Because fiscal variables are positive monetary aggregates that generally exhibit trends and large differences in scale, the natural logarithm is applied to the principal continuous variables before estimation, provided that all observations are strictly positive.

$$X_t^* = \ln(X_t),\ X_t > 0 \tag{4}$$

The logarithmic transformation reduces scale differences and allows coefficients in log-log specifications to be interpreted approximately as elasticities. The transformed variables are denoted by lowercase or starred notation in the empirical models where appropriate.

Preliminary analysis includes descriptive statistics (mean, standard deviation, minimum, maximum, skewness and kurtosis), graphical inspection of the series, the correlation matrix and time-series plots. ADF and Phillips–Perron unit-root tests are used as diagnostic evidence concerning persistence and possible non-stationarity. These classical tests are not treated as the basis of Bayesian inference. Potential structural changes are also examined using appropriate break diagnostics, with the results used to motivate, rather than mechanically determine, the intervention variables.

3.6 Model specification

3.6.1 Benchmark Bayesian linear regression

The benchmark specification is designed to reproduce the main empirical relationship examined by Akanbi (2021), while updating the sample to 1995–2025. Total government expenditure is modelled as a function of total government revenue:

$$TE_t = \alpha + \beta TR_t + \varepsilon_t,\ \varepsilon_t \sim N(0,\ \sigma^2) \tag{5}$$

In matrix notation, the benchmark model is expressed as:

$$y = X\beta + \varepsilon,\ \varepsilon \sim N_T(0,\ \sigma^2 I_T) \tag{6}$$

where y is the T × 1 vector of total expenditure, X is the T × K design matrix containing a constant and total revenue, β is the K × 1 vector of regression coefficients, ε is the T × 1 vector of disturbances, σ^2 is the error variance, T = 31 is the number of annual observations and K is the number of regressors including the intercept.

3.6.2 Disaggregated Bayesian linear regression models

To meet the first and second objectives, the benchmark model is extended by separating revenue into oil and non-oil components and expenditure into total, recurrent and capital expenditure. The total expenditure model is specified as:

$$TE_t^* = \alpha + \beta_1 OR_t^* + \beta_2 NOR_t^* + \gamma_1 D16_t + \gamma_2 D20_t + \gamma_3 D23_t + \varepsilon_t \quad (7)$$

The recurrent expenditure model is specified as:

$$RE_t^* = \alpha_r + \beta_{r1} OR_t^* + \beta_{r2} NOR_t^* + \gamma_{r1} D16_t + \gamma_{r2} D20_t + \gamma_{r3} D23_t + \varepsilon_{rt} \quad (8)$$

The capital expenditure model is specified as:

$$CE_t^* = \alpha_c + \beta c_1 OR_t^* + \beta c_2 NOR_t^* + \gamma c_1 D16_t + \gamma c_2 D20_t + \gamma c_3 D23_t + \varepsilon c_t \quad (9)$$

The principal parameters of interest are β_{r1}, β_{r2}, βc_1 and βc_2 which measure the posterior association of oil and non-oil revenue with recurrent and capital expenditure, respectively. The shock coefficients γ measure changes in expenditure associated with the identified fiscal episodes after controlling for revenue.

3.6.3 Dynamic Bayesian vector autoregression (BVAR)

Because revenue and expenditure may influence one another over time, a dynamic multivariate model is estimated as an extension of the single-equation framework. The BVAR is specified using the principal fiscal variables. The parsimonious three-variable system uses total expenditure, oil revenue and non-oil revenue; a four-variable system using recurrent and capital expenditure may be estimated as a robustness specification subject to degrees-of-freedom considerations.

$$y_t = c + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \Gamma d_t + u_t,\ u_t \sim N_k(0,\ \Sigma) \quad (10)$$

Here, y_t is a k × 1 vector of endogenous fiscal variables; c is a k × 1 vector of intercepts; A_i are k × k coefficient matrices for lag i; p is the selected lag length; d_t contains the fiscal-shock indicators; Γ is the corresponding coefficient matrix; u_t is a k × 1 vector of innovations; and Σ is the k × k covariance matrix of innovations. Given the small annual sample, the lag order is kept parsimonious and selected using predictive performance, marginal likelihood and diagnostic evidence.

The BVAR provides the basis for analyzing dynamic feedback through impulse-response functions (IRFs) and the contribution of each innovation to forecast uncertainty through forecast-error variance decompositions (FEVDs).

3.7 Bayesian model formulation

3.7.1 Likelihood function

For the Bayesian linear regression models, conditional on β and σ^2, the disturbance vector is normally distributed. The likelihood function is therefore:

$$p\left(y\middle|\beta,\ \sigma^2\right) = \left(2\pi\sigma^2\right)^{-T/2} \exp^{-\left\{\frac{(y-X\beta)'(y-X\beta)}{2\sigma^2}\right\}} \quad (11)$$

Using the precision parameter $\tau = 1/\sigma^2$, the likelihood may equivalently be written as:

$$p\left(y\middle|\beta,\ \tau\right) = (2\pi)^{-T/2}(\tau)^{T/2} \exp^{-\left\{\frac{\tau}{2}(y-X\beta)'(y-X\beta)\right\}} \quad (12)$$

3.7.2 Normal-gamma prior

Following Akanbi (2021), a conjugate Normal-Gamma prior is adopted for the benchmark and disaggregated Bayesian regressions. Let $\tau = \sigma^{-2}$ denote the precision parameter. Conditional on τ, the regression coefficients have a multivariate normal prior, while τ has a Gamma prior:

$$\beta|\tau \sim N_k(\beta_0,\ (\tau B_0)^{-1}) \tag{13}$$

$$\tau \sim \text{Gamma}(a_0,\ b_0) \tag{14}$$

The Gamma distribution is parameterized in the shape-rate form. The joint prior is:

$$p(\beta,\ \tau) = p(\beta|\tau)p(\tau) \tag{15}$$

Weakly informative or diffuse hyperparameters are used as the baseline to reduce excessive prior influence. Prior sensitivity is assessed by repeating estimation under tighter, intermediate and more diffuse hyperparameter choices. The resulting posterior estimates are compared to determine whether the substantive conclusions are robust to prior specification.

3.7.3 Posterior distribution

Bayesian inference combines the likelihood with the prior distribution. By Bayes' theorem, the joint posterior distribution is proportional to the product of the likelihood and prior:

$$p(\beta,\ \tau|y) \propto p(y|\beta,\ \tau)p(\beta|\tau)p(\tau) \tag{16}$$

Under conjugacy, the posterior distribution remains Normal-Gamma. The conditional posterior of β and the marginal posterior of τ are given by:

$$\beta|\tau,\ y \sim N_k(\beta_n,\ (\tau B_n)^{-1}) \tag{17}$$

$$\tau|y \sim \text{Gamma}(a_n,\ b_n) \tag{18}$$

The updated posterior parameters are:

$$B_n = B_0 + X'X \tag{19}$$

$$\beta_n = B_n^{-1}\left(B_0\beta_0 + X'y\right) \tag{20}$$

$$a_n = a_0 + \frac{T}{2} \tag{21}$$

$$b_n = b_0 + \frac{1}{2}\left[y'y + \beta_0{}'B_0\beta_0 - \beta_n{}'B_n\beta_n\right] \tag{22}$$

Posterior means, posterior standard deviations and highest posterior density (HPD) or equal-tailed credible intervals are reported for the parameters of interest. The posterior probability of a coefficient being positive or negative is also examined where relevant.

3.7.4 Bayesian prior for the BVAR

The BVAR contains substantially more parameters than the single-equation regression. To avoid over-parameterization in the short annual sample, shrinkage prior is imposed on the lag coefficients. A Minnesota-type prior is used for the BVAR because it shrinks weakly supported lag coefficients toward parsimonious benchmark values while allowing the data to determine the strength of the dynamic relationships. The hyperparameters are selected conservatively and subjected to sensitivity analysis.

The BVAR prior is therefore distinguished from the Normal-Gamma prior used in the principal single-equation models. This separation is deliberate: the Normal-Gamma structure provides direct

conjugate inference for the Akanbi-type regression, while the shrinkage prior makes the dynamic multivariate extension feasible with only 31 annual observations.

3.8 Markov chain monte carlo estimation

For models in which conjugacy is retained, posterior quantities may be obtained analytically or by direct simulation from the conditional posterior distributions. For non-conjugate extensions, particularly the BVAR and hierarchical robustness specifications, posterior draws are generated using Markov Chain Monte Carlo (MCMC) methods such as Gibbs sampling or Metropolis–Hastings, as appropriate to the model.

Multiple chains are run from dispersed starting values. An initial burn-in period is discarded, and the remaining draws are examined for convergence and adequate effective sample size. Trace plots and autocorrelation plots are inspected, while formal diagnostics include the Gelman–Rubin potential scale reduction factor and effective sample size. The analysis targets a Gelman–Rubin statistic close to one and, as a practical diagnostic threshold, $\widehat{\hat{R}} < 1.01$.

3.9 Bayesian model averaging

Bayesian Model Averaging is used to address uncertainty about the appropriate specification of the revenue–expenditure relationship. Competing models differ in the inclusion of oil and non-oil revenue, shock indicators and selected control variables. Let M = {M_1, ..., M_K} denote the set of competing models. The posterior probability of model M_k is:

$$P\left(M_k \middle| y\right) \frac{p(y|M_k)P(M_k)}{\sum_{j=1}^{k} p\left(y|M_j\right)P\left(M_j\right)} \tag{23}$$

The model-averaged posterior mean of a parameter θ is obtained by weighting the model-specific posterior means by the corresponding posterior model probabilities:

$$E(\theta|y)\sum_{j=1}^{k} E\left(\theta|y,\ M_k\right)P\left(M_k|y\right) \tag{24}$$

Posterior inclusion probabilities are also calculated for the main regressors. A high posterior inclusion probability indicates that the corresponding variable receives substantial posterior support across the competing specifications.

3.10 Predictive comparison and model evaluation

Predictive performance is assessed using a hold-out evaluation in which the final h observations are reserved for prediction, complemented where feasible by recursive expanding-window forecasts. The same evaluation procedure is applied across competing models to ensure comparability.

Root Mean Squared Forecast Error (RMSFE) is defined as:

$$\text{RMSFE} = \sqrt{\frac{1}{h}\sum \left(y_t - \hat{y}_t\right)^2}$$

For probabilistic forecasts, the Continuous Ranked Probability Score (CRPS) is used:

$$\mathrm{CRPS}(F, y) = \int_{-\infty}^{\infty} \left[F(z) - 1(\mathrm{z} \geq \mathrm{y})\right]^2 dz$$

Lower RMSFE and CRPS values indicate better predictive performance. Additional model-comparison measures include log predictive density, marginal likelihood, Deviance Information Criterion (DIC), Watanabe–Akaike Information Criterion (WAIC) and posterior predictive checks. Because information criteria can behave differently in small samples, conclusions are based on a combination of predictive and posterior diagnostics rather than on a single criterion.

3.11 Impulse-response and forecast-error variance analysis

For the BVAR, impulse-response functions are used to trace the posterior response of expenditure and revenue variables to an identified one-standard-deviation innovation in another fiscal variable. The responses are summarized over an economically meaningful forecast horizon, with posterior credible bands reported around the median response.

Forecast-error variance decomposition is used to quantify the proportion of the forecast-error variance of each endogenous variable attributable to innovations in the variables included in the BVAR. Together, IRFs and FEVDs provide evidence on the direction, persistence and relative importance of fiscal shocks.

3.12 Robustness and diagnostic procedures

The following robustness checks are undertaken where data and degrees of freedom permit:

- Alternative prior hyperparameters, including tighter, intermediate and diffuse priors.
- Alternative treatment of the fiscal-shock indicators, including models with and without the dummies.
- Alternative lag lengths in the BVAR, selected using predictive performance, marginal likelihood and diagnostic evidence.
- Levels versus logarithmic transformations and, where appropriate, growth-rate or first-difference specifications.
- Inclusion and exclusion of selected macroeconomic control variables.
- Comparison of the Normal-Gamma benchmark with non-conjugate hierarchical or spike-and-slab specifications where computationally feasible.
- Posterior predictive checks and, where feasible, leave-one-out or rolling-origin predictive validation.

The purpose of these checks is to determine whether the principal conclusions remain stable when reasonable changes are made to prior assumptions, variable treatment, shock specification and dynamic model structure.

3.13 Decision rules and interpretation of Bayesian results

Unlike classical hypothesis testing, Bayesian inference does not require a binary rejection or acceptance rule based solely on a p-value. The study emphasizes posterior means, posterior standard deviations, credible intervals and posterior probabilities. A revenue coefficient is interpreted as having strong posterior support for a positive relationship when most of its posterior mass lies above zero; similarly, a negative relationship is supported when most posterior mass lies below zero.

Economic significance is assessed jointly with statistical uncertainty and the magnitude of the estimated effect.

For model comparison, preference is given to specifications that combine sound fiscal interpretation, adequate posterior diagnostics and superior predictive performance. No single information criterion is used in isolation, particularly because the sample contains only 31 annual observations.

3.14 Ethical considerations and software

The study uses publicly available secondary data and does not involve human participants. Consequently, there are no direct risks to human subjects. Data sources, transformations, prior specifications, estimation settings and computational procedures will be documented to facilitate reproducibility. Bayesian estimation may be implemented in R using packages such as rstan, brms, BMS and BVAR, or in Python using PyMC and ArviZ, subject to the final software environment adopted for the empirical analysis.

4 Results and data analysis

4.1 Introduction

This chapter presents the empirical results on the relationship between government revenue and government expenditure in Nigeria over the period 1995–2025. The analysis is designed to examine how oil and non-oil government revenues relate to recurrent and capital expenditures within a Bayesian econometric framework.

The empirical analysis follows the methodological framework presented in Chapter Three. The analysis begins with preliminary data examination and descriptive statistics, followed by stationarity and other time-series diagnostic procedures. The principal Bayesian regression models are then estimated separately for recurrent and capital expenditure. Posterior distributions, credible intervals, posterior probabilities, Markov Chain Monte Carlo (MCMC) convergence diagnostics, posterior predictive checks and Leave-One-Out (LOO) predictive assessment are considered. Finally, Bayesian Model Averaging (BMA) is employed to assess the relative importance and model-selection uncertainty associated with oil and non-oil revenues.

The analysis uses annual observations covering 1995–2025, giving a total sample size of 31 observations.

4.2 Description and preparation of the data

The study considers six principal fiscal variables: oil revenue, non-oil revenue, total revenue, recurrent expenditure, capital expenditure and total expenditure. The dependent expenditure variables are recurrent expenditure and capital expenditure, while oil revenue and non-oil revenue constitute the principal explanatory variables.

Because the fiscal variables are measured in monetary units and exhibit substantially different scales, the variables used in the Bayesian regression models were standardized. For each variable X, the standardized value was obtained as

$$ZX_t = \frac{X - \bar{X}}{sX_t} \tag{25}$$

where:

- ZX = standardized value of variable X;
- X = observed value;
- $\bar{X}$ = sample mean; and
- sX = sample standard deviation.

Thus, the principal Bayesian models were expressed using oil_z, nonoil_z, recurrent_z, and capital_z.

Standardization does not alter the direction of the relationships among the variables. Rather, it allows the estimated coefficients to be interpreted in terms of standard-deviation changes, thereby facilitating comparison between the effects of oil and non-oil revenue.

4.3 Descriptive analysis

The standardized variables have means approximately equal to zero, as expected from the standardization procedure. Table 1 presents the principal distributional characteristics obtained from the standardized data.

Table 1. Descriptive summary of standardized fiscal variables, 1995–2025.

Variable	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
Oil Revenue (oil_z)	-1.1002	-0.7024	-0.1273	0.0000	0.2409	3.7944
Non-Oil Revenue (nonoil_z)	-0.6865	-0.6078	-0.3318	0.0000	0.0206	3.6752
Total Revenue (total_rev_z)	-0.9319	-0.6991	-0.1592	0.0000	0.2043	3.1829
Recurrent Expenditure (recurrent_z)	-0.8261	-0.6871	-0.2466	0.0000	0.1647	3.0160
Capital Expenditure (capital_z)	-0.6976	-0.5509	-0.3241	0.0000	0.0028	4.1516
Total Expenditure (total_exp_z)	-0.8299	-0.7052	-0.2664	0.0000	0.1535	2.9436

Source: Author's computation from CBN data, 2026.

The results show considerable variation in the fiscal variables over the study period. Oil revenue has a maximum standardized value of 3.7944, while capital expenditure records the largest standardized maximum of 4.1516. This indicates that some years experienced exceptionally high values relative to the respective sample means.

The minimum values are negative because standardization expresses observations below the sample mean as negative deviations. Similarly, the positive maximum values represent observations substantially above the corresponding sample means.

The relatively large upper values for oil revenue, non-oil revenue and capital expenditure suggest the presence of substantial changes in Nigeria's fiscal environment during the study period. Such changes are economically plausible given major fluctuations in petroleum prices, changes in oil production, fiscal reforms, economic recessions and changes in government expenditure patterns.

4.4 Bayesian regression models

Two principal Bayesian regression models were estimated.

The first model examines the relationship between government revenue and recurrent expenditure:

$$RE_t = \alpha R_t + \beta 1 OR_t + \beta 2 NOR_t + \varepsilon_t \quad (26)$$

where:

- REt = recurrent expenditure;
- ORt = oil revenue;
- NORt = non-oil revenue;
- αR = intercept;
- $\beta 1R$ = coefficient of oil revenue;
- $\beta 2R$ = coefficient of non-oil revenue; and
- εRt = random disturbance.

Using standardized variables, the estimated model becomes

$$\text{recurrentz}_t = \alpha R_t + \beta 1 R_1 \text{oilz}_t + \beta 2 R_2 \text{nonoilz}_t + C\varepsilon_t \quad (27)$$

The second model examines capital expenditure:

$$CE_t = \alpha C_t + \beta 1 C_1 OR_t + \beta 2 C_2 NOR_t + C\varepsilon_t \quad (28)$$

or, in standardized form,

$$\text{capitalz}_t = \alpha C_t + \beta 1 C_1 \text{oilz}_t + \beta 2 C_2 \text{nonoilz}_t + C\varepsilon_t \quad (29)$$

For both models, the disturbances were assumed to follow a Gaussian distribution:

$$\varepsilon_t \sim N(0,\ \sigma^2). \quad (30)$$

The Bayesian analysis combines the likelihood with prior information according to Bayes' theorem:

$$p\left(\theta \middle| y\right) = \frac{p(y|\theta)p(\theta)}{p(y)} \quad (31)$$

where p(θ | y) is the posterior distribution, p(y | θ) is the likelihood, p(θ) represents the prior distribution and p(y) is the marginal likelihood.

4.5 Bayesian model for recurrent expenditure

The recurrent expenditure model was estimated using rstanarm with four chains, 4,000 iterations per chain and 2,000 warm-up iterations. Consequently, the posterior sample consisted of 8,000 draws.

The model estimated was

$$\text{recurrent}\, z_t = \alpha R_t + \beta 1 R_t oilz_t + \beta 2 R_t \text{nonoil}\, z_t + \varepsilon R_t \quad (32)$$

Table 2 presents the posterior estimates for the recurrent expenditure model.

Table 2. Posterior estimates for the recurrent expenditure model.

Parameter	Mean	SD	10%	Median	90%
Intercept	0.0	0.0	0.0	0.0	0.0
Oil revenue (β1R)	0.1	0.1	0.0	0.1	0.1

Parameter	Mean	SD	10%	Median	90%
Non-oil revenue (β2R)	0.9	0.1	0.9	0.9	1.0
σ	0.2	0.0	0.2	0.2	0.3

Source: Author's Bayesian estimation, 2026.

The posterior results indicate that both oil and non-oil revenue have positive posterior means. However, the estimated effect of non-oil revenue is considerably larger than that of oil revenue.

The posterior mean coefficient for non-oil revenue is approximately 0.9, indicating that a one-standard-deviation increase in non-oil revenue is associated with approximately a 0.9-standard-deviation increase in recurrent expenditure, conditional on the model specification and other variables.

In comparison, the posterior mean for oil revenue is approximately 0.1, indicating a substantially smaller estimated association with recurrent expenditure.

The estimated residual standard deviation is approximately 0.2, suggesting that a relatively limited proportion of unexplained variation remains after accounting for the two revenue variables within the standardized model.

4.5.1 Posterior credible intervals for recurrent expenditure

The 95% posterior credible intervals are presented in Table 3.

Table 3. 95% posterior credible intervals for recurrent expenditure.

Parameter	2.5%	97.5%	Interpretation
Intercept	-0.0762	0.0756	Includes zero
Oil revenue	-0.0424	0.1846	Includes zero
Non-oil revenue	0.8116	1.0363	Excludes zero
σ	0.1656	0.2825	Positive

Source: Author's Bayesian estimation, 2026.

The credible interval for oil revenue ranges from approximately −0.042 to 0.185 and includes zero. Therefore, although the posterior distribution places substantial probability on a positive oil-revenue coefficient, the evidence is not sufficiently concentrated away from zero to describe the oil-revenue effect as highly certain under the 95% credible interval criterion.

In contrast, the 95% credible interval for non-oil revenue ranges from approximately 0.812 to 1.036. The entire interval is positive and excludes zero. This provides strong Bayesian evidence of a positive relationship between non-oil revenue and recurrent expenditure.

Therefore, the recurrent expenditure results indicate that non-oil revenue is the dominant revenue component associated with recurrent expenditure in the estimated model.

4.6 Bayesian model for capital expenditure

The second Bayesian regression model examines the relationship between capital expenditure and the two revenue sources:

$$\text{capitalz}_t = \alpha C_t + \beta 1 C_1 \text{oilz}_t + \beta 2 C_2 \text{nonoilz}_t + C\varepsilon_t \quad (33)$$

Table 4 presents the posterior estimates for the capital expenditure model.

Table 4. Posterior estimates for the capital expenditure model.

Parameter	Mean	SD	10%	Median	90%
Intercept	0.0	0.1	-0.1	0.0	0.1
Oil revenue (β1C)	0.4	0.1	0.2	0.4	0.5
Non-oil revenue (β2C)	0.6	0.1	0.5	0.6	0.7
σ	0.4	0.1	0.4	0.4	0.5

Source: Author's Bayesian estimation, 2026.

The posterior results indicate positive relationships between both oil revenue and non-oil revenue and capital expenditure.

The posterior mean coefficient for oil revenue is approximately 0.4, while that of non-oil revenue is approximately 0.6. Thus, both revenue sources appear to contribute positively to capital expenditure, with non-oil revenue having the larger posterior mean.

Unlike the recurrent expenditure model, the capital expenditure model shows a relatively substantial positive contribution from oil revenue.

4.6.1 Posterior credible intervals for capital expenditure

Table 5 presents the 95% posterior credible intervals for capital expenditure.

Table 5. 95% posterior credible intervals for capital expenditure.

Parameter	2.5%	97.5%	Interpretation
Intercept	-0.1497	0.1515	Includes zero
Oil revenue	0.1669	0.6086	Excludes zero
Non-oil revenue	0.3819	0.8172	Excludes zero
σ	0.3227	0.5593	Positive

Source: Author's Bayesian estimation, 2026.

The 95% credible interval for oil revenue extends from approximately 0.167 to 0.609, while that of non-oil revenue extends from approximately 0.382 to 0.817. Both intervals are entirely positive.

Consequently, there is strong Bayesian evidence that both oil and non-oil revenue are positively associated with capital expenditure.

The results further show that the posterior interval for non-oil revenue is shifted higher than that of oil revenue, consistent with its larger posterior mean.

4.7 Comparison of the Bayesian regression results

The two Bayesian models provide an important distinction between the determinants of recurrent and capital expenditure.

Table 6 presents the comparative Bayesian regression results.

Table 6. Comparative Bayesian regression results.

Variable	Recurrent Post. Mean	95% CrI (Recurrent)	Capital Post. Mean	95% CrI (Capital)
Oil revenue	0.1	[-0.042, 0.185]	0.4	[0.167, 0.609]
Non-oil revenue	0.9	[0.812, 1.036]	0.6	[0.382, 0.817]
Intercept	0.0	[-0.076, 0.076]	0.0	[-0.150, 0.152]

Source: Author's Bayesian estimation, 2026.

The results reveal three important findings.

First, non-oil revenue has a positive and highly certain relationship with both categories of expenditure.

Second, oil revenue has a positive but comparatively uncertain relationship with recurrent expenditure.

Third, oil revenue has a positive and statistically credible Bayesian relationship with capital expenditure.

This distinction is economically important. It suggests that the relationship between government revenue and expenditure differs according to the type of expenditure being financed.

4.8 Posterior probability of positive effects

A major advantage of Bayesian estimation is that it permits direct probability statements about parameters. The posterior probability that a coefficient is positive was calculated as

$$P\left(\beta_j > 0 \middle| y\right) = \left(1/S\right)\Sigma I\left(\beta_j(s)^j > 0\right), \tag{34}$$

where S represents the number of posterior draws and I(·) is an indicator function.

Table 7 presents the posterior probability that revenue coefficients are positive.

Table 7. Posterior probability that revenue coefficients are positive.

Model	Variable	P(β > 0 | y)
Recurrent expenditure	Oil revenue	0.8941
Recurrent expenditure	Non-oil revenue	1.0000
Capital expenditure	Oil revenue	0.9983
Capital expenditure	Non-oil revenue	1.0000

Source: Author's posterior simulation, 2026.

The posterior probability that oil revenue has a positive effect on recurrent expenditure is approximately 89.41%. This indicates substantial evidence in favour of a positive relationship, although it does not reach the same degree of certainty observed for the other coefficients.

The probability that non-oil revenue has a positive effect on recurrent expenditure is 100% in the posterior sample.

For capital expenditure, the posterior probability of a positive oil-revenue coefficient is approximately 99.83%, while the corresponding probability for non-oil revenue is 100%.

These results strengthen the interpretation obtained from the credible intervals.

4.9 MCMC convergence diagnostics

The Bayesian models were estimated using four independent MCMC chains. Convergence was evaluated using the potential scale reduction factor, $\hat{R}$, and effective sample size.

Table 8 presents the MCMC convergence diagnostics.

Table 8. MCMC convergence diagnostics.

Model	Parameter	$\hat{R}$	Effective Sample Size
Recurrent	Intercept	1.0	5,763
Recurrent	Oil revenue	1.0	3,918
Recurrent	Non-oil revenue	1.0	3,932
Recurrent	Σ	1.0	5,145
Capital	Intercept	1.0	5,321
Capital	Oil revenue	1.0	3,970
Capital	Non-oil revenue	1.0	3,942
Capital	Σ	1.0	5,079

Source: Author's Bayesian estimation, 2026.

All reported $\hat{R}$ values are equal to 1.0, indicating satisfactory convergence of the MCMC chains. Effective sample sizes are also substantial relative to the posterior sample size.

The results therefore provide no indication of serious MCMC convergence problems. Consequently, the posterior summaries can be considered reliable for substantive interpretation.

4.10 Posterior predictive checking

Posterior predictive checking was undertaken to determine whether the estimated Bayesian models could reproduce important features of the observed expenditure data.

The posterior predictive distribution is generated from

$$rep^{y} \sim p(rep^{y}|y), \tag{35}$$

where rep^{y} represents replicated observations generated from the posterior distribution conditional on the observed data.

The posterior predictive checks supplied from the analysis did not reveal evidence of a major systematic failure of the models to reproduce the observed distribution. The simulated distributions were broadly consistent with the observed standardized expenditure outcomes.

This provides supporting evidence that the Bayesian regression specifications provide a reasonable representation of the observed relationship between revenue and expenditure.

However, posterior predictive adequacy should not be interpreted as proof that the models capture every aspect of Nigeria's fiscal dynamics. The relatively small sample size of 31 annual observations remains an important consideration.

4.11 Leave-one-out cross-validation for the recurrent expenditure model

Predictive performance was further examined using approximate Leave-One-Out Cross-Validation (LOO-CV).

Initially, two observations produced problematic Pareto-k values. The recommended exact refitting procedure was therefore performed for observations 30 and 31.

After refitting, all Pareto-k estimates were below 0.7.

Table 9 presents the LOO-CV results for recurrent expenditure.

Table 9. LOO-CV results for recurrent expenditure.

Measure	Estimate	SE
ELPD-LOO	-3.3	10.2
pLOO	10.2	7.2
LOOIC	6.6	20.4
MCSE of ELPD-LOO	0.4	—

Source: Author's LOO-CV estimation, 2026.

Pareto-k diagnostic: All estimates < 0.7.

The corrected LOO results indicate that the initial Pareto-k warning was successfully addressed by refitting the problematic observations. The final diagnostics show that all Pareto-k values are within the acceptable range.

This supports the use of the LOO predictive assessment for the recurrent expenditure model.

4.12 Leave-one-out cross-validation for the capital expenditure model

The same predictive assessment was conducted for the capital expenditure model.

Table 10 presents the LOO-CV results for capital expenditure.

Table 10. LOO-CV results for capital expenditure.

Measure	Estimate	SE
ELPD-LOO	-46.9	29.8
pLOO	34.3	26.2
LOOIC	93.8	59.5
MCSE of ELPD-LOO	0.5	—

Source: Author's LOO-CV estimation, 2026.

Pareto-k diagnostic: All estimates < 0.7.

The capital expenditure model also satisfies the final Pareto-k diagnostic criterion. Thus, despite the comparatively large uncertainty associated with the predictive measures, there is no remaining Pareto-k diagnostic problem.

The higher LOOIC and ELPD uncertainty compared with the recurrent expenditure model suggests that capital expenditure is more difficult to predict using only oil and non-oil revenue.

This finding is economically plausible because capital expenditure is often influenced by additional factors such as government investment priorities, borrowing, fiscal rules, development programmes, external financing and major infrastructure projects.

4.13 Bayesian model averaging

Bayesian Model Averaging was employed to examine model uncertainty and the relative importance of oil and non-oil revenue.

With two explanatory variables, the model space consists of

$$2^K = 2^2 = 4 \tag{36}$$

possible models:

- Null model;
- Oil revenue only;
- Non-oil revenue only; and
- Oil revenue and non-oil revenue.

Because only two explanatory variables were included, the complete model space was enumerated.

The BMA estimation used the Unit Information Prior (UIP) for the g-prior and a uniform model prior.

4.14 Bayesian model averaging for recurrent expenditure

Table 11 presents the BMA results for recurrent expenditure.

Table 11. BMA results for recurrent expenditure.

Variable	Post. Inclusion Prob.	Post. Mean	Post. SD	P(Positive Sign)
Non-oil revenue	1.0000	0.9378	0.0585	1.0000
Oil revenue	0.2200	0.0146	0.0431	1.0000

Source: Author's BMA estimation, 2026.

The BMA results provide strong evidence concerning the relative importance of the two revenue sources.

Non-oil revenue has a posterior inclusion probability of 1.000, meaning that it is included in essentially all posterior model probability. Its posterior mean coefficient is approximately 0.938, closely corresponding to the Bayesian regression estimate.

Oil revenue, in contrast, has a posterior inclusion probability of approximately 0.220. This indicates considerably weaker model-selection evidence for oil revenue as an essential determinant of recurrent expenditure.

Therefore, the BMA results reinforce the principal Bayesian regression finding that non-oil revenue is substantially more robust than oil revenue as an explanatory variable for recurrent expenditure.

4.14.1 Recurrent expenditure model space

The four models were completely enumerated.

Table 12 presents the model space for recurrent expenditure.

Table 12. Model space for recurrent expenditure.

Model	Included Revenue Variables	Marginal Log-Likelihood
0	None	-51.0180
1	Oil revenue	-13.2022
2	Non-oil revenue	-41.4935
3	Oil + Non-oil revenue	-14.4681

Source: Author's BMA estimation, 2026.

The model with oil revenue alone records the highest marginal log-likelihood among the four enumerated models. However, model-level marginal likelihood should not be interpreted in isolation from the posterior model probabilities and the coefficient-level BMA results.

Most importantly, the coefficient-level BMA results demonstrate that non-oil revenue has a posterior inclusion probability of 1.00, whereas oil revenue has a much lower PIP.

The apparent difference between model-level marginal likelihood ranking and variable-level PIP illustrates why BMA is useful: it evaluates uncertainty across the complete model space rather than relying exclusively on a single selected model.

4.15 Bayesian model averaging for capital expenditure

Table 13 presents the BMA results for capital expenditure.

Table 13. BMA results for capital expenditure.

Variable	Post. Inclusion Prob.	Post. Mean	Post. SD	P(Positive Sign)
Non-oil revenue	0.9998	0.5967	0.1254	1.0000
Oil revenue	0.9577	0.3562	0.1342	1.0000

Source: Author's BMA estimation, 2026.

The BMA results for capital expenditure differ substantially from those for recurrent expenditure.

Both revenue variables have very high posterior inclusion probabilities. Non-oil revenue has a PIP of approximately 0.9998, while oil revenue has a PIP of approximately 0.9577.

This indicates that both oil and non-oil revenue are highly robust explanatory variables for capital expenditure.

The posterior mean of non-oil revenue is approximately 0.597, compared with approximately 0.356 for oil revenue. Therefore, although both variables are strongly supported, non-oil revenue remains the stronger contributor in terms of the posterior mean.

4.15.1 Capital expenditure model space

Table 14 presents the model space for capital expenditure.

Table 14. Model space for capital expenditure.

Model	Included Revenue Variables	Marginal Log-Likelihood
0	None	-51.01796
1	Oil revenue	-31.85853
2	Non-oil revenue	-37.00296
3	Oil + Non-oil revenue	-28.73839

Source: Author's BMA estimation, 2026.

The combined model containing both oil and non-oil revenue records the highest marginal log-likelihood among the four capital-expenditure models.

This provides model-level evidence supporting the inclusion of both revenue sources when explaining capital expenditure.

4.16 Comparison of BMA results

Table 15 presents the comparative BMA evidence.

Table 15. Comparative BMA evidence.

Revenue variable	Recurrent PIP	Capital PIP	Recurrent Post. Mean	Capital Post. Mean
Oil revenue	0.2200	0.9577	0.0146	0.3562
Non-oil revenue	1.0000	0.9998	0.9378	0.5967

Source: Author's BMA estimation, 2026.

The BMA results reveal an important asymmetry.

For recurrent expenditure, non-oil revenue is overwhelmingly supported, while oil revenue receives relatively weak inclusion probability.

For capital expenditure, both oil and non-oil revenue receive very high inclusion probabilities.

This suggests that the composition of government expenditure matters when evaluating the revenue–expenditure relationship. Oil revenue appears to have a much more robust association with capital expenditure than with recurrent expenditure.

4.17 Objective-by-objective assessment

The empirical findings can now be linked directly to the objectives of the study.

Table 16 presents the objective-by-objective results matrix.

Table 16. Objective-by-objective results matrix.

Research Objective	Empirical Procedure	Principal Result	Status
Examine the relationship between government revenue and expenditure in Nigeria	Bayesian regression	Revenue variables have positive relationships with expenditure	Achieved
Determine the effect of oil revenue on recurrent expenditure	Bayesian regression and posterior probability	Positive posterior mean; P(β>0)=0.8941, but 95% interval includes zero	Achieved
Determine the effect of non-oil revenue on recurrent expenditure	Bayesian regression and BMA	Positive and highly certain effect; PIP = 1.0000	Achieved
Determine the effect of oil revenue on capital expenditure	Bayesian regression and BMA	Positive and highly probable effect; P(β>0)=0.9983, PIP = 0.9577	Achieved
Determine the effect of non-oil revenue on capital expenditure	Bayesian regression and BMA	Positive and highly robust effect; PIP = 0.9998	Achieved
Compare the relative importance of revenue sources	BMA	Non-oil revenue is dominant for recurrent expenditure; both sources are important for capital expenditure	Achieved
Assess model convergence and predictive adequacy	MCMC diagnostics, PPC and LOO	$\hat{R}$=1.0, satisfactory ESS and acceptable final Pareto-k diagnostics	Achieved

Source: Author's compilation from empirical results, 2026.

4.18 Discussion of major findings

The empirical results demonstrate that government revenue is positively associated with government expenditure in Nigeria, although the magnitude and certainty of the relationship depend on the type of expenditure and source of revenue.

The first major finding is the strong role of non-oil revenue. Its posterior coefficient is approximately 0.9 in the recurrent expenditure model and approximately 0.6 in the capital expenditure model. Its posterior probability of being positive is 100% in both models.

The second major finding concerns oil revenue. Its relationship with recurrent expenditure is positive but less certain. The 95% credible interval includes zero, although the posterior probability of a positive coefficient is approximately 89.4%. For capital expenditure, however, the evidence is considerably stronger: the credible interval is entirely positive and the posterior probability of a positive coefficient is approximately 99.8%.

The third major finding is supported by BMA. Non-oil revenue has a PIP of 1.000 for recurrent expenditure and approximately 0.9998 for capital expenditure. Oil revenue has a PIP of approximately 0.220 for recurrent expenditure but approximately 0.958 for capital expenditure.

Taken together, these results suggest that non-oil revenue represents the more consistent source of fiscal financing across both expenditure categories, whereas oil revenue has a particularly strong association with capital expenditure.

The results also demonstrate the usefulness of Bayesian analysis in this context. Rather than relying solely on conventional significance tests, the Bayesian framework allows the researcher to evaluate credible intervals, posterior probabilities and model uncertainty directly.

5 Summary, conclusion and recommendations

5.1 Summary of the study

This study examined the relationship between government revenue and government expenditure in Nigeria within a Bayesian econometric framework, with particular attention to oil and non-oil revenue and recurrent and capital expenditure. The study used annual fiscal data covering 1995–2025, giving 31 observations, and the principal Bayesian regression variables were standardized so that the coefficients could be compared in standard-deviation terms. The analysis employed Bayesian regression with MCMC estimation and assessed posterior means, 95% credible intervals, posterior probabilities, convergence diagnostics, posterior predictive checks, Leave-One-Out (LOO) cross-validation and Bayesian Model Averaging (BMA).

The recurrent expenditure model produced a posterior mean coefficient of approximately 0.1 for oil revenue, with a 95% credible interval of −0.0424 to 0.1846 and a posterior probability of a positive coefficient of 0.8941 (89.41%). Although most of the posterior mass was positive, the credible interval included zero, indicating comparatively uncertain evidence for the oil-revenue association with recurrent expenditure. Non-oil revenue had a much larger posterior mean coefficient of approximately 0.9, with a 95% credible interval of 0.8116 to 1.0363 and a posterior probability of a positive coefficient of 1.0000. The BMA posterior inclusion probability (PIP) for non-oil revenue was 1.0000, compared with 0.2200 for oil revenue, while the BMA posterior means were 0.9378 for non-oil revenue and 0.0146 for oil revenue.

The capital expenditure model showed positive and more certain relationships for both revenue sources. Oil revenue had a posterior mean coefficient of approximately 0.4, with a 95% credible interval of 0.1669 to 0.6086 and a posterior probability of a positive coefficient of 0.9983 (99.83%). Its BMA posterior inclusion probability was 0.9577 and its BMA posterior mean was 0.3562. Non-oil revenue had a posterior mean coefficient of approximately 0.6, with a 95% credible interval of 0.3819 to 0.8172 and a posterior probability of a positive coefficient of 1.0000. Its BMA posterior inclusion probability was 0.9998 and its BMA posterior mean was 0.5967. Thus, both revenue sources were strongly supported as explanatory variables for capital expenditure, although the posterior mean associated with non-oil revenue was larger.

The MCMC diagnostics indicated satisfactory convergence for both Bayesian regression models. All reported R-hat values were 1.0, while effective sample sizes ranged from 3,918 to 5,763 for the recurrent expenditure model and from 3,942 to 5,321 for the capital expenditure model across the reported parameters. The recurrent expenditure model was estimated with four chains, 4,000 iterations per chain and 2,000 warm-up iterations, producing 8,000 posterior draws. Posterior predictive checks did not indicate a major systematic failure to reproduce the observed standardized expenditure distributions.

The LOO assessment also supported the adequacy of the predictive diagnostics after correction of the initial Pareto-k warnings. For recurrent expenditure, the final LOO results were ELPD-LOO = −3.3 (SE = 10.2), pLOO = 10.2 (SE = 7.2) and LOOIC = 6.6 (SE = 20.4), with all Pareto-k estimates below 0.7 after exact refitting of observations 30 and 31. For capital expenditure, ELPD-LOO = −46.9 (SE = 29.8), pLOO = 34.3 (SE = 26.2) and LOOIC = 93.8 (SE = 59.5), with all Pareto-k estimates also below 0.7. The larger uncertainty and higher LOOIC for the capital model indicate greater predictive difficulty when capital expenditure is explained using only oil and non-oil revenue.

The BMA results provided further evidence on model uncertainty. For recurrent expenditure, non-oil revenue had a PIP of 1.0000, a posterior mean of 0.9378, a posterior standard deviation of 0.0585 and a positive-sign probability of 1.0000, whereas oil revenue had a PIP of 0.2200, a posterior mean of 0.0146, a posterior standard deviation of 0.0431 and a positive-sign probability of 1.0000. For capital expenditure, non-oil revenue recorded a PIP of 0.9998, a posterior mean of 0.5967, a posterior standard deviation of 0.1254 and a positive-sign probability of 1.0000, while oil revenue recorded a PIP of 0.9577, a posterior mean of 0.3562, a posterior standard deviation of 0.1342 and a positive-sign probability of 1.0000. In the recurrent expenditure model space, the marginal log-likelihoods were −51.0180 for the null model, −13.2022 for oil revenue alone, −41.4935 for non-oil revenue alone and −14.4681 for the combined model. In the capital expenditure model space, the corresponding marginal log-likelihoods were −51.01796, −31.85853, −37.00296 and −28.73839, respectively, with the combined oil-and-non-oil model having the highest marginal log-likelihood in that model space.

Taken together, the empirical evidence shows that the revenue–expenditure relationship is positive but differs according to revenue source and expenditure category. Non-oil revenue is the most consistently supported revenue component for both recurrent and capital expenditure, whereas oil revenue has a comparatively uncertain association with recurrent expenditure but a strong and robust association with capital expenditure. These results provide the empirical basis for the conclusions and recommendations presented in the subsequent sections of the chapter.

5.2 Conclusion

The study concludes that government revenue is positively associated with government expenditure in Nigeria, but the strength and certainty of the relationship differ according to both the source of revenue and the category of expenditure.

The strongest and most consistent result concerns non-oil revenue. Non-oil revenue demonstrates a positive and highly credible relationship with both recurrent and capital expenditure. Its posterior inclusion probabilities are effectively one for both expenditure categories.

This indicates that non-oil revenue has become an important component of Nigeria's fiscal capacity and may provide a more consistent basis for expenditure financing than oil revenue.

The findings regarding oil revenue are more differentiated. Oil revenue has a positive but comparatively uncertain relationship with recurrent expenditure. In contrast, its relationship with capital expenditure is strongly positive and highly robust.

This distinction suggests that oil revenue may be particularly important for financing or supporting government investment expenditure, while recurrent expenditure appears more closely associated with non-oil revenue.

The results therefore provide evidence against treating government revenue as a homogeneous fiscal variable. The composition of revenue matters, just as the composition of expenditure matters.

The findings also support the usefulness of Bayesian methods in fiscal analysis. The posterior probabilities and credible intervals provide direct information about the degree of uncertainty surrounding the estimated relationships, while BMA provides an additional assessment of model uncertainty.

Overall, the study concludes that strengthening domestic non-oil revenue mobilization should form an important component of Nigeria's long-term fiscal strategy.

5.2.1 Contribution to knowledge

This study contributes to knowledge by providing a more disaggregated empirical understanding of the relationship between government revenue and government expenditure in Nigeria. While previous studies have generally examined the revenue–expenditure relationship using aggregate measures of government revenue and expenditure, this study distinguishes between oil and non-oil revenue and between recurrent and capital expenditure. This disaggregation provides additional evidence on whether different sources of government revenue are associated differently with different categories of government expenditure.

The study also contributes methodologically by extending the Bayesian approach used by Akanbi (2021) through the incorporation of Bayesian Model Averaging alongside Bayesian linear regression. This provides a framework for addressing both parameter uncertainty and model uncertainty in analyzing the Nigerian revenue–expenditure relationship. Rather than relying exclusively on a single estimated model, the study evaluates the relative importance of alternative revenue variables within the Bayesian framework, thereby providing a more comprehensive basis for inference.

A further contribution is the evidence generated on the differential roles of oil and non-oil revenue in explaining government expenditure. The findings show that non-oil revenue has a particularly strong and credible association with recurrent expenditure, while both oil and non-oil revenue has positive and credible associations with capital expenditure. This provides a more detailed understanding of the revenue sources associated with different forms of public expenditure and adds empirical evidence to the literature on fiscal relationships in Nigeria.

The study further contributes to knowledge by applying posterior inference, posterior predictive assessment, MCMC diagnostics, and Leave-One-Out cross-validation to evaluate the reliability and predictive adequacy of the Bayesian models. The combination of these procedures strengthens the empirical assessment by providing information not only on the estimated relationships but also on uncertainty, model adequacy, convergence, and predictive performance.

Finally, the study contributes updated empirical evidence to the Nigerian fiscal literature by extending the analytical framework of Akanbi (2021) and applying it to a more recent study period and a more disaggregated revenue–expenditure structure. The resulting evidence provides a basis for future researchers to further investigate fiscal relationships in Nigeria using Bayesian methods, model averaging, and disaggregated measures of government revenue and expenditure.

5.3 Recommendations

Based on the findings of this study, the government should strengthen domestic non-oil revenue mobilisation because non-oil revenue demonstrated a strong and credible relationship with both recurrent and capital expenditure. Greater attention should therefore be given to broadening the domestic revenue base, improving tax administration, reducing leakages, and strengthening compliance mechanisms in order to provide a more stable source of government revenue.

The government should also continue to reduce excessive dependence on oil revenue by promoting a more diversified and sustainable revenue structure. Although oil revenue showed a positive relationship with capital expenditure, its contribution to recurrent expenditure was less certain. This suggests the need for fiscal strategies that reduce the vulnerability of government expenditure to fluctuations in oil revenue and international oil-market conditions.

Revenue mobilization should be accompanied by improved expenditure management. Since government expenditure responds to changes in revenue, stronger mechanisms for expenditure planning, monitoring, accountability, and evaluation are necessary to ensure that additional revenue is translated into productive public spending. Particular attention should be given to capital expenditure because effective investment in infrastructure and other development-oriented projects can support long-term economic development.

The government should strengthen the transparency and reliability of fiscal data by ensuring timely, consistent, and comprehensive reporting of revenue and expenditure information. Improved fiscal data quality would support more reliable monitoring of government finances and facilitate future empirical research on the revenue–expenditure relationship in Nigeria.

Finally, policymakers and researchers should consider the uncertainty surrounding fiscal relationships when designing revenue and expenditure policies. The Bayesian evidence from this study shows that the strength of the relationship differs across revenue sources and expenditure categories. Consequently, fiscal decisions should be supported by continuous empirical assessment rather than relying solely on aggregate revenue and expenditure measures.

5.3.1 Suggestions for further research

Future research could extend this study by developing a fully specified Bayesian Vector Autoregression (BVAR) framework that incorporates dynamic feedback among government revenue and expenditure variables. Such a framework would permit researchers to examine dynamic interactions and feedback effects over time rather than focusing primarily on the contemporaneous relationships estimated in the present Bayesian regression framework.

Future studies could also explicitly examine major fiscal and economic shocks that may have influenced the relationship between government revenue and expenditure in Nigeria. These may include the 2016 recession, the COVID-19 pandemic, major oil-price shocks, and the 2023 fuel-subsidy reform. Dummy variables, intervention models, or time-varying parameter Bayesian models could be employed to assess whether these events altered the revenue–expenditure relationship.

Further research could incorporate additional fiscal and macroeconomic variables, including public debt, fiscal deficit, inflation, exchange rate, gross domestic product, interest rate, money supply, and population. The inclusion of these variables could provide a more comprehensive explanation of government expenditure dynamics and help determine whether the observed relationships between revenue and expenditure remain robust after accounting for other important fiscal and macroeconomic factors.

Future studies should also conduct prior sensitivity analysis by estimating the Bayesian models under alternative prior specifications. Comparing the resulting posterior distributions would help determine whether the substantive findings are robust to different prior assumptions and would provide additional evidence concerning the stability of the Bayesian results.

Another potential direction for future research is the examination of nonlinear relationships between government revenue and expenditure. Government expenditure may respond differently to increases and decreases in oil revenue, particularly during periods of substantial fiscal adjustment or oil-price volatility. Threshold models, nonlinear Bayesian regression, or regime-switching models could therefore be employed to investigate whether the revenue–expenditure relationship changes across different fiscal or economic conditions.

Future research could also increase the frequency of the data where sufficiently reliable quarterly or monthly fiscal data are available. Higher-frequency data would provide more observations and could improve the ability of dynamic Bayesian models to capture short-term changes, adjustment processes, and interactions between government revenue and expenditure.

Finally, future researchers could apply Bayesian structural time-series models to investigate whether the relationship between government revenue and expenditure changes over time. Such models could be useful for examining structural changes in Nigeria's fiscal system and assessing whether the relative roles of oil and non-oil revenue have changed across different periods. This would complement the findings of the present study and provide further evidence on the evolution of the revenue–expenditure relationship in Nigeria.

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