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TAXATION VERSUS PUBLIC DEBT IN UGANDA: AN EMPIRICAL INVESTIGATION

Muhwezi Henry[1], Nahabwe Patrick Kagambo John[2], Kagarura Willy Rwamparagi[3]
[1,2,3]*Kabale University, Uganda*

ABSTRACT
This study examined the relationship between taxation and public debt in Uganda using monthly time series data from March 2015 to January 2025 obtained from the World Bank World Development Indicators database. The study specifically investigated the effect of taxes on goods and services (% of revenue) on central government debt, total (% of GDP) using the Ordinary Least Squares (OLS) estimation technique. Empirical findings revealed that taxes on goods and services have a statistically significant negative effect on central government debt ($\beta = -0.851024$, $p < 0.01$), implying that increased domestic revenue mobilization reduces reliance on debt financing in Uganda. The model was statistically significant overall (F-statistic = 15.76147, $p = 0.000124$), while the Durbin-Watson statistic (2.004074), confirmed absence of serial correlation. The study concludes that strengthening tax revenue collection is essential for enhancing fiscal sustainability and reducing public debt accumulation. The study recommends improving tax administration, widening the tax base, enhancing tax compliance, and promoting efficient utilization of public revenues to reduce excessive borrowing.
KEY WORDS: *OLS, Taxes on goods and services, Central government debt, Uganda*

INTRODUCTION

Public debt and taxation are among the most important components of fiscal policy in both developed and developing economies. Governments depend on taxation as a sustainable source of revenue to finance public expenditure, infrastructure development, social services, and macroeconomic stabilization without excessively relying on borrowing (Musgrave & Musgrave, 1989; Nahabwe, 2026). However, persistent fiscal deficits, increasing public expenditure demands, and limited domestic revenue mobilization have compelled many developing countries to finance their budgets through public debt accumulation (Mankiw, 2019; Nahabwe, 2025). While borrowing can support economic growth when properly utilized, excessive public debt may increase debt servicing burdens, weaken fiscal sustainability, crowd out private investment, and constrain long-term economic performance (Barro, 1979).

Globally, policymakers and international financial institutions have increasingly emphasized strengthening domestic revenue mobilization as a sustainable strategy for reducing dependence on debt financing. Taxes on goods and services, particularly value added tax (VAT) and excise duties, remain among the most reliable and productive sources of government revenue due to their broad tax base and relatively stable collection capacity (Tanzi & Zee, 2000). In many developing economies, indirect taxes contribute significantly to total government revenue and are considered essential for financing development programs and reducing fiscal imbalances. Nevertheless, weak tax administration, tax evasion, informality, and low revenue productivity continue to limit the effectiveness of taxation systems in many African countries (IMF, 2023).

In Uganda, the government has implemented several tax reforms through the Uganda Revenue Authority aimed at improving revenue collection efficiency, broadening the tax base, and enhancing fiscal performance. Despite these efforts, Uganda's public debt has continued to rise due to increasing infrastructure investments, external financing requirements, and growing public expenditure pressures (Bank of Uganda, 2024; Nahabwe & Kagarura, 2025). Rising debt levels have generated concerns regarding debt sustainability and the country's ability to finance development without excessive borrowing. Consequently, enhancing tax revenue mobilization, particularly through taxes on goods and services, has become an important policy priority for reducing reliance on debt financing and strengthening fiscal stability.

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Despite the importance of taxation in fiscal sustainability, empirical evidence on the relationship between taxes on goods and services and public debt in Uganda remains limited. Most previous studies have concentrated on broader macroeconomic determinants of public debt such as inflation, exchange rates, government expenditure, and economic growth while paying limited attention to the role of indirect taxation in influencing debt dynamics. Furthermore, few studies have employed recent high-frequency monthly data to examine this relationship in Uganda. Therefore, this study was undertaken to empirically investigate the effect of taxes on goods and services (% of revenue) on central government debt, total (% of GDP) in Uganda using monthly data obtained from the World Bank World Development Indicators database covering the period 2015 to 2025. The study provides important policy insights on how domestic revenue mobilization can contribute to reducing public debt accumulation and promoting fiscal sustainability in Uganda.

LITERATURE REVIEW

This study is anchored on the Tax Smoothing Theory advanced by Robert J. Barro Barro (1979), which argues that governments attempt to minimize distortions arising from taxation by smoothing tax rates over time through borrowing and repayment mechanisms. According to the theory, when government expenditure exceeds current revenue, governments may resort to public borrowing instead of imposing excessively high taxes in the short run. However, effective and stable tax revenue mobilization reduces the need for excessive borrowing and enhances fiscal sustainability. In the context of Uganda, improved collection of taxes on goods and services can reduce dependence on debt financing by generating sufficient domestic revenue to finance government expenditure.

The study is also guided by the Benefit Theory of Taxation, which posits that citizens should contribute taxes in proportion to the benefits they receive from public goods and services (Musgrave & Musgrave, 1989). The theory emphasizes the importance of taxation in financing government activities and maintaining macroeconomic stability. Increased tax efficiency and broader tax coverage are therefore expected to reduce fiscal deficits and public debt accumulation.

Globally, taxation has been recognized as a key instrument for reducing fiscal deficits and controlling public debt accumulation. Robert J. Barro Barro (1979) established that sustainable domestic revenue mobilization reduces governments' reliance on borrowing and improves fiscal balance. Similarly, Tanzi & Zee (2000) argued that efficient tax systems are essential for financing public expenditure in developing countries without generating excessive debt burdens. Their study further noted that indirect taxes such as value added tax and excise duties are relatively productive sources of revenue due to their broad base and ease of administration.

Easterly & Rebelo (1993) examined fiscal policy and economic growth across developing economies and found that weak tax systems constrain governments' ability to finance development internally, thereby increasing dependence on debt financing. Likewise, Reinhart and Rogoff (2010) observed that persistent public debt accumulation is often associated with low domestic revenue generation and recurring fiscal deficits. These studies suggest that strengthening taxation systems can significantly reduce public debt accumulation and improve fiscal sustainability. However, some scholars argue that excessive taxation may negatively affect economic activity and reduce aggregate demand, particularly when tax rates are too high (Mankiw, 2019; Nahabwe & Kagarura, 2025). This implies that governments should balance revenue mobilization objectives with economic growth considerations.

In Africa, many governments continue to experience rising public debt despite implementing tax reforms aimed at strengthening domestic revenue mobilization. According to the African Development Bank African Development Bank (2023), weak tax administration, widespread informality, and narrow tax bases have constrained revenue performance across many African countries, leading to increased reliance on external borrowing. A study by Iyoha (1999) on Sub-Saharan African economies found that low tax revenue generation significantly contributed to fiscal imbalances and rising public debt. Similarly, Ndoricimpa (2020) established that improved tax revenue performance positively influences fiscal sustainability in East African countries by reducing budget deficits and borrowing requirements. The study emphasized that indirect taxes remain an important source of domestic revenue in developing economies due to their relative stability.

In Kenya, Were (2001) found that inadequate domestic revenue mobilization was a major determinant of increasing public debt levels. Likewise, studies in Rwanda and Tanzania have shown that strengthening value added tax systems and improving tax compliance contribute to enhanced fiscal performance and reduced borrowing dependence (African

Development Bank, 2023; Kagarura & Nahabwe, 2025). In Uganda, several studies have examined public debt and fiscal sustainability from different macroeconomic perspectives. Ssewanyana & Mugume (2005) observed that Uganda's increasing public debt was largely associated with persistent fiscal deficits and growing public expenditure requirements. The study argued that strengthening domestic revenue mobilization is critical for reducing dependence on external borrowing.

According to the Bank of Uganda Bank of Uganda (2024), Uganda's public debt has risen significantly over recent years due to infrastructure financing, budget support needs, and external economic shocks. Although the government has implemented tax reforms through the Uganda Revenue Authority Uganda Revenue Authority to improve tax collection efficiency, domestic revenue performance remains below expenditure demands. Kuteesa et al. (2010) found that taxes on goods and services constitute one of the most significant contributors to Uganda's domestic revenue. However, the study noted that tax evasion, informality, and administrative inefficiencies continue to limit revenue productivity. While previous Ugandan studies have largely focused on macroeconomic determinants of public debt such as inflation, exchange rates, and government expenditure, limited empirical evidence exists on the specific effect of taxes on goods and services on central government debt using recent monthly data. Therefore, this study seeks to bridge this knowledge gap by examining the relationship between taxes on goods and services and central government debt in Uganda for the period 2015–2025.

The conceptual framework of the study assumes that taxes on goods and services (% of revenue) influence central government debt, total (% of GDP) in Uganda. Increased tax revenue mobilization is expected to reduce government borrowing requirements by providing sufficient domestic resources to finance public expenditure. The independent variable is taxes on goods and services (% of revenue). The dependent variable is central government debt, total (% of GDP). Expected relationship is negative, between taxes on goods and services and central government debt.

DATA AND METHODS

This study adopted a quantitative research design based on secondary time series data to examine the relationship between taxes on goods and services and central government debt in Uganda. The quantitative approach is considered appropriate because it facilitates objective measurement and empirical analysis of relationships among macroeconomic variables using statistical and econometric techniques (Nahabwe & Kagarura, 2025). The study utilizes data obtained from the World Bank World Development Indicators database covering the period from 2015 to 2025. The selected period is considered suitable because it provides recent and consistent fiscal data necessary for analyzing debt dynamics and domestic revenue mobilization trends in Uganda.

The study specifically focuses on Taxes on goods and services (% of revenue) as the independent variable and Central government debt, total (% of GDP) as the dependent variable. Since the available data consists of relatively few annual observations (11), the series are transformed into monthly frequency data using quadratic match-sum interpolation technique (Nahabwe & Kagarura, 2025; Kagarura et al., 2025). This method is widely recommended for temporal disaggregation because it preserves aggregate consistency while generating smooth higher-frequency series suitable for time series econometric analysis (Chow & Lin, 1971; Lütkepohl, 2005; Kagarura & Nahabwe, 2025). Consequently, the interpolation process generates monthly observations spanning from January 2015 to January 2025, resulting in 121 observations for each variable.

Given that the study relies entirely on secondary macroeconomic time series data, no primary sampling procedures are undertaken. Instead, a census approach is adopted whereby all available observations within the study period are included in the analysis to enhance reliability and comprehensiveness of the empirical results.

The study employs Ordinary Least Squares (OLS) econometric estimation technique to analyze the relationship between taxation and public debt. OLS estimation method is preferred because it generates efficient, unbiased, and consistent parameter estimates when the assumptions of the classical linear regression model are satisfied (Gujarati & Porter, 2009: Nahabwe & Kagarura, 2025). Furthermore, OLS is extensively applied in empirical macroeconomic and fiscal policy studies due to its effectiveness in estimating the magnitude, direction, and statistical significance of relationships among economic variables.
The functional relationship for the study was specified as:

$$CGD_t = \beta_0 + \beta_1 TGS_t + \varepsilon_t \quad \text{...} (1)$$

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Where;
CGD_t is Central government debt, total (% of GDP) at time t
TGS_t is Taxes on goods and services (% of revenue) at time t
β_0 is Constant term
β_1 is Coefficient of taxes on goods and services
ε_t is Error term

Descriptive statistics are employed to summarize and explain the key characteristics of the study variables, while inferential statistical techniques are used to examine the statistical relationship between taxation and public debt in Uganda. To ensure the validity of the time series analysis and avoid spurious regression results commonly associated with non-stationary data, stationarity tests are conducted using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. These tests are widely recognized for determining the order of integration of macroeconomic time series variables (Dickey & Fuller, 1979; Phillips & Perron, 1988; Nahabwe & Kagarura, 2025; Kagarura et al., 2025).

The study further conducts diagnostic tests, including the Durbin-Watson statistic, to detect the presence of serial correlation and assess the reliability and stability of the estimated regression model. Hypothesis testing is undertaken at a 5 percent level of significance, while the econometric analysis is performed using EViews statistical software due to its suitability for macroeconomic and time series econometric analysis.

To further ascertain the adequacy and robustness of the estimated model, several post-estimation diagnostic tests are undertaken (Campbell et al., 2015; Nahabwe & Kagarura, 2025). The Breusch-Pagan-Godfrey heteroskedasticity test is used to examine whether the variance of the residuals remain constant across observations. Failure to reject the null hypothesis of homoskedasticity implies that the residuals exhibit constant variance, thereby confirming the reliability of the regression estimates (Ohaegbulem & Iheaka, 2024; Nahabwe & Kagarura, 2025). In addition, the Breusch-Godfrey Serial Correlation LM test is conducted to determine the presence or absence of autocorrelation among the residuals, which is essential for ensuring independence of error terms and unbiased estimation results (Chaudhary et al., 2022; Kagarura & Nahabwe, 2025).

Furthermore, the Normality of Residuals test is conducted to determine whether the error terms were approximately normally distributed. The assumption of normality is fundamental in regression analysis because several inferential procedures, including t-tests, F-tests, and confidence intervals, are derived under the assumption of normally distributed disturbances (Gujarati & Porter, 2009; Nahabwe & Kagarura, 2025). Normal distribution of residuals ensures that the sampling distributions of the estimators are also normally distributed, thereby improving the validity and reliability of hypothesis testing, particularly in small sample estimations (Wooldridge, 2019; Nahabwe & Maniple, 2025). Consequently, normally distributed residuals enhance the accuracy of statistical inferences and the credibility of empirical conclusions drawn from the estimated model (Greene, 2018; Nahabwe & Kagarura, 2025).

RESULTS AND THEIR DISCUSSION

This section presents the empirical findings on the relationship between taxation and public debt in Uganda, guided by the study objective of examining the effect of taxes on goods and services on central government debt. The discussion further compares the results with existing literature and highlights the unique contributions of the study.

Descriptive statistics (Appendix 1) indicate that central government debt (% of GDP) in Uganda had a mean value of 45.05, with a minimum of 34.67 and a maximum of 55.71, suggesting moderate but rising variability in debt levels over the study period. The standard deviation of 7.96 indicates substantial fluctuations in debt dynamics. Taxes on goods and services (% of revenue) recorded a mean of 45.17, ranging between 42.49 and 49.12, with a relatively low standard deviation of 2.25, implying more stability compared to public debt.

Both variables exhibit near-symmetric distributions, as shown by skewness values close to zero (0.03594 for debt and 0.306582 for taxes). However, kurtosis values below 3 (1.23 and 1.46 respectively) indicate platykurtic distributions, suggesting flatter peaks and lighter tails than a normal distribution. The Jarque-Bera statistics for both variables are statistically significant ($p < 0.01$), implying that the data series deviate from normality. These findings are consistent with fiscal data behaviour in developing economies where public debt tends to fluctuate more than tax revenue due to changing borrowing needs and external shocks (Mankiw, 2019; Kagarura & Nahabwe, 2025; Kagarura et al., 2025).

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Stationarity of Central government debt, total (% of GDP) and Taxes on goods and services (% of revenue) time series is tested using the Augmented Dickey-Fuller (ADF) test (Appendix 2 - 7). Results indicate that both series are non-stationary at levels and first difference ($p > 0.05$), implying the presence of unit roots. However, after second differencing both series became stationary ($p < 0.05$). They are integrated of order two (I(2)) (Gujarati & Porter, 2009; Dickey & Fuller, 1979; Nahabwe & Kagarura, 2025). This transformation ensures that the statistical properties of the series remain constant over time, thus avoiding spurious regression results (Enders, 2014; Nahabwe & Kagarura, 2025).

$$\widehat{CGD}_t = 0.004743 - 0.851024TGS_t \quad \text{.....(2)}$$

Hence,

$$\hat{\beta}_{OLS} \begin{bmatrix} 0.004743 \\ -0.851024 \end{bmatrix}$$

Ordinary Least Squares (OLS) results (Appendix 8) show that the constant term (0.004743; p=0.6265) is positive and statistically significant. Taxes on goods and services have a statistically significant negative effect on central government debt in Uganda. The coefficient of -0.8510 ($p = 0.0001$) implies that a 10% increase in taxes on goods and services is associated with an 8.5% decrease in central government debt (% of GDP). This finding supports the fiscal sustainability hypothesis that stronger domestic revenue mobilization reduces reliance on borrowing.

The model is statistically significant overall (F-statistic = 15.76, $p = 0.000124$), confirming that the explanatory variable jointly influences public debt. However, the explanatory power of the model is modest ($R^2 = 0.1187$), indicating that taxes on goods and services explain about 11.9% of variations in central government debt, while other macroeconomic factors also play a significant role. The Durbin-Watson statistic of 2.00 suggests the absence of serial correlation, confirming model reliability (Kagarura & Nahabwe, 2025).

Diagnostic results (Appendices 9-11) confirm the robustness of the estimated model. The Breusch-Godfrey Serial Correlation LM test shows no evidence of autocorrelation ($p = 0.9995$), implying that residuals are independent. The Breusch-Pagan-Godfrey test indicates the presence of heteroskedasticity (F-statistic = 7.399, $p = 0.0075$), suggesting non-constant variance of residuals, which may affect efficiency of standard errors. The normality test results indicate strong non-normality of residuals (kurtosis = 30.3, $p = 0.000$), implying the presence of extreme values or fat tails in the distribution of errors. This is common in macroeconomic time series data characterized by shocks and structural changes (Gujarati & Porter, 2009; Wooldridge, 2019; Nahabwe & Kagarura, 2025).

The negative and statistically significant relationship between taxes on goods and services and central government debt aligns with fiscal theory, which suggests that improved domestic revenue mobilization reduces government reliance on borrowing (Barro, 1979). This finding is consistent with (Musgrave & Musgrave 1989), who emphasize taxation as a primary instrument for financing public expenditure and maintaining fiscal balance.

The results also corroborate empirical evidence from developing countries, where stronger tax systems are associated with reduced fiscal deficits and lower debt accumulation (Tanzi & Zee, 2000; Easterly & Rebelo, 1993; Kagarura & Nahabwe, 2025). In the African context, similar findings were reported by Ndoricimpa (2020), who established that improved tax revenue performance reduces borrowing needs in East African economies.

However, the relatively low explanatory power of the model suggests that public debt dynamics in Uganda are influenced by multiple factors beyond taxes on goods and services. These may include external borrowing conditions, exchange rate fluctuations, government expenditure patterns, and economic growth shocks, as also noted by the Bank of Uganda Bank of Uganda (2024).

A unique finding of this study is the strong and stable inverse relationship between indirect taxation and public debt using high-frequency monthly data. Unlike many previous studies that rely on annual data, this study provides more refined short-run dynamics, offering stronger evidence that improvements in tax collection efficiency can have immediate effects on debt reduction.

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LIMITATIONS

Despite providing useful empirical insights into the relationship between taxation and public debt in Uganda, this study is subject to several limitations. Firstly, the study relied exclusively on secondary time series data obtained from the World Bank World Development Indicators database. While such data is widely used in macroeconomic analysis, it may be affected by measurement errors, reporting delays, and revisions, which could influence the accuracy of the estimated relationships (World Bank, 2025).

Secondly, the study employed a single-equation Ordinary Least Squares (OLS) regression model, which may not fully capture the dynamic and multidirectional relationship between taxation and public debt. Public debt and taxation are potentially endogenous variables influenced by other macroeconomic factors such as economic growth, government expenditure, interest rates, and exchange rate movements. The exclusion of these variables may lead to omitted variable bias, thereby affecting the robustness of the estimated coefficients (Wooldridge, 2019; Gujarati & Porter, 2009; Nahabwe & Maniple, 2025).

Thirdly, although the study used monthly interpolated data to increase the number of observations, the original dataset was based on lower-frequency observations. The use of quadratic match-sum interpolation, while useful for generating higher-frequency series, may introduce smoothing effects that do not fully capture short-term fluctuations in fiscal variables (Chow & Lin, 1971; Lütkepohl, 2005; Kagarura & Nahabwe, 2025). This may affect the precision of the estimated short-run dynamics between taxation and debt.

Fourthly, diagnostic tests indicated the presence of heteroskedasticity and non-normality of residuals. Although these issues do not invalidate the OLS estimates, they may reduce the efficiency of standard errors and affect the reliability of statistical inference if not properly corrected using robust estimation techniques (Greene, 2018; Wooldridge, 2019; Nahabwe & Maniple, 2025).

Lastly, the study focused only on taxes on goods and services as the main explanatory variable, excluding other forms of taxation such as income tax and international trade taxes. This narrow focus may limit the comprehensiveness of the findings regarding the overall effect of taxation on public debt dynamics in Uganda.

CONCLUSION

This study set out to examine the relationship between taxation and public debt in Uganda, with specific emphasis on the role of taxes on goods and services in influencing central government debt dynamics over the period 2015–2025. The overall evidence from the analysis indicates that domestic revenue mobilization plays a meaningful role in shaping fiscal outcomes, particularly in reducing reliance on borrowing to finance government activities. The findings highlight that fiscal sustainability is strongly influenced by the efficiency and effectiveness of tax systems, especially those based on broad consumption taxes.

The study further demonstrates that Uganda's fiscal position is characterized by a delicate balance between revenue generation and expenditure pressures, where improvements in tax performance contribute positively to debt management efforts. However, the results also suggest that taxation alone is insufficient to fully stabilize public debt dynamics, as broader macroeconomic and structural factors continue to influence borrowing needs.

Overall, the study concludes that strengthening domestic revenue systems remains a critical policy instrument for improving fiscal discipline and enhancing long-term debt sustainability in Uganda. A well-functioning tax system not only supports government financing needs but also reduces vulnerability to debt accumulation pressures, thereby contributing to macroeconomic stability and sustainable development.

RECOMMENDATIONS

Based on the empirical findings, the study recommends that the Government of Uganda should prioritize strengthening domestic revenue mobilization systems, particularly through improving the efficiency and coverage of taxes on goods and services. Enhancing tax administration through digital tax systems, improved enforcement mechanisms, and reduction of leakages is essential for increasing revenue performance and reducing reliance on public borrowing (Uganda Revenue Authority, 2024; Kagarura & Nahabwe, 2025). This would help to improve fiscal space and support sustainable debt management.

The government should also undertake deliberate policy measures to broaden the tax base by integrating more informal sector activities into the tax net and improving compliance through taxpayer education and simplified tax procedures. Such reforms are critical in enhancing revenue productivity and ensuring that consumption-based taxes contribute more effectively to public finance sustainability (Tanzi & Zee, 2000).

At the programme level, the study recommends strengthening public financial management systems to ensure that revenues collected from taxes on goods and services are efficiently allocated and transparently utilized. Improved accountability in public expenditure management will enhance public confidence in the tax system and encourage voluntary compliance, thereby improving overall revenue performance and reducing borrowing pressures (World Bank, 2025).

From a research perspective, future studies could consider incorporating additional macroeconomic variables such as government expenditure, interest rates, inflation, and exchange rates to provide a more comprehensive understanding of the determinants of public debt in Uganda. In addition, the use of advanced econometric techniques such as Vector Error Correction Models (VECM) or Autoregressive Distributed Lag (ARDL) models is recommended to better capture dynamic interactions and long-run relationships between taxation and public debt (Wooldridge, 2019; Greene, 2018; Nahabwe & Kagarura, 2025).

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APPENDICES

Appendix 1: Descriptive statistics

	Central government debt, total (% of GDP)	Taxes on goods and services (% of revenue)
Mean	45.05232	45.16526
Median	44.18591	44.49586
Maximum	55.71417	49.12014
Minimum	34.67357	42.49241
Std. Dev.	7.957407	2.247258
Skewness	0.03594	0.306582
Kurtosis	1.2258	1.462168
Jarque-Bera	15.89614	13.81869
Probability	0.000353	0.000998
Sum	5451.331	5464.997
Sum Sq. Dev.	7598.44	606.0201
Observations	121	121

Appendix 2: Unit root test, Central_government_debt (in Level)

Null Hypothesis: CENTRAL_GOVERNMENT_DEBT has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.078909	0.7225
Test critical values:	1% level	-3.486064	
	5% level	-2.885863	
	10% level	-2.579818	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CENTRAL_GOVERNMENT_DEBT)
Method: Least Squares
Date: 04/30/26 Time: 14:48
Sample (adjusted): 2015M03 2025M01
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CENTRAL_GOVERNMENT_DEBT(-1)	-0.001392	0.001290	-1.078909	0.2829
D(CENTRAL_GOVERNMENT_DEBT(-1))	0.921779	0.034923	26.39435	0.0000
C	0.077499	0.058436	1.326219	0.1874

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R-squared	0.858709	Mean dependent var	0.147514
Adjusted R-squared	0.856273	S.D. dependent var	0.290343
S.E. of regression	0.110073	Akaike info criterion	-1.550460
Sum squared resid	1.405462	Schwarz criterion	-1.480398
Log likelihood	95.25239	Hannan-Quinn criter.	-1.522010
F-statistic	352.5004	Durbin-Watson stat	1.961375
Prob(F-statistic)	0.000000		

Appendix 3: Unit root test, Central_government_debt (in First difference)

Null Hypothesis: D(CENTRAL_GOVERNMENT_DEBT) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.426026	0.1368
Test critical values:	1% level	-3.486064	
	5% level	-2.885863	
	10% level	-2.579818	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CENTRAL_GOVERNMENT_DEBT,2)
Method: Least Squares
Date: 04/30/26 Time: 14:48
Sample (adjusted): 2015M03 2025M01
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CENTRAL_GOVERNMENT_DEBT(-1))	-0.083837	0.034557	-2.426026	0.0168
C	0.015631	0.011256	1.388625	0.1676

R-squared	0.047895	Mean dependent var	0.003562
Adjusted R-squared	0.039757	S.D. dependent var	0.112407
S.E. of regression	0.110150	Akaike info criterion	-1.557282
Sum squared resid	1.419565	Schwarz criterion	-1.510574
Log likelihood	94.65829	Hannan-Quinn criter.	-1.538316
F-statistic	5.885601	Durbin-Watson stat	1.933839
Prob(F-statistic)	0.016792		

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Appendix 4: Unit root test, Central_government_debt (in Second difference)

Null Hypothesis: D(CENTRAL_GOVERNMENT_DEBT,2) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.78134	0.0000
Test critical values:	1% level	-3.486551	
	5% level	-2.886074	
	10% level	-2.579931	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CENTRAL_GOVERNMENT_DEBT,3)
Method: Least Squares
Date: 04/30/26 Time: 14:49
Sample (adjusted): 2015M04 2025M01
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CENTRAL_GOVERNMENT_DEBT(-1),2)	-1.001021	0.092848	-10.78134	0.0000
C	0.003596	0.010442	0.344395	0.7312

R-squared	0.500511	Mean dependent var	-1.21E-16
Adjusted R-squared	0.496205	S.D. dependent var	0.159727
S.E. of regression	0.113372	Akaike info criterion	-1.499488
Sum squared resid	1.490961	Schwarz criterion	-1.452527
Log likelihood	90.46980	Hannan-Quinn criter.	-1.480421
F-statistic	116.2372	Durbin-Watson stat	2.000002
Prob(F-statistic)	0.000000		

Appendix 5: Unit root test, TAXES_ON_GOODS_AND_SERVICES (in Level)

ull Hypothesis: TAXES_ON_GOODS_AND_SERVICES has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.873408	0.3438
Test critical values:	1% level	-3.486064	
	5% level	-2.885863	
	10% level	-2.579818	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TAXES_ON_GOODS_AND_SERVICES)
Method: Least Squares
Date: 04/30/26 Time: 14:50

Sample (adjusted): 2015M03 2025M01
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TAXES_ON_GOODS_AND_SERVICES(-1)	-0.003431	0.001832	-1.873408	0.0635
D(TAXES_ON_GOODS_AND_SERVICES(-1))	0.935334	0.031977	29.24995	0.0000
C	0.154667	0.082714	1.869904	0.0640

R-squared	0.883170	Mean dependent var	-0.023667
Adjusted R-squared	0.881155	S.D. dependent var	0.129329
S.E. of regression	0.044585	Akaike info criterion	-3.357967
Sum squared resid	0.230584	Schwarz criterion	-3.287905
Log likelihood	202.7991	Hannan-Quinn criter.	-3.329517
F-statistic	438.4464	Durbin-Watson stat	1.982160
Prob(F-statistic)	0.000000		

Appendix 6: Unit root test, TAXES_ON_GOODS_AND_SERVICES (in First difference)
Null Hypothesis: D(TAXES_ON_GOODS_AND_SERVICES) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.836193	0.3615
Test critical values:	1% level	-3.486064	
	5% level	-2.885863	
	10% level	-2.579818	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TAXES_ON_GOODS_AND_SERVICES,2)
Method: Least Squares
Date: 04/30/26 Time: 14:51
Sample (adjusted): 2015M03 2025M01
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TAXES_ON_GOODS_AND_SERVICES(-1))	-0.059085	0.032178	-1.836193	0.0689
C	-9.33E-05	0.004209	-0.022168	0.9824

R-squared	0.028010	Mean dependent var	0.001387
Adjusted R-squared	0.019702	S.D. dependent var	0.045511
S.E. of regression	0.045060	Akaike info criterion	-3.344967
Sum squared resid	0.237560	Schwarz criterion	-3.298259
Log likelihood	201.0255	Hannan-Quinn criter.	-3.326001
F-statistic	3.371606	Durbin-Watson stat	1.941468
Prob(F-statistic)	0.068868		

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Appendix 7: Unit root test, TAXES_ON_GOODS_AND_SERVICES (in Second difference)

Null Hypothesis: D(TAXES_ON_GOODS_AND_SERVICES,2) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.78051	0.0000
Test critical values:	1% level	-3.486551	
	5% level	-2.886074	
	10% level	-2.579931	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TAXES_ON_GOODS_AND_SERVICES,3)
Method: Least Squares
Date: 04/30/26 Time: 14:53
Sample (adjusted): 2015M04 2025M01
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TAXES_ON_GOODS_AND_SERVICES(-1),2)	-1.000945	0.092848	-10.78051	0.0000
C	0.001400	0.004228	0.331177	0.7411

R-squared	0.500472	Mean dependent var	3.61E-16
Adjusted R-squared	0.496166	S.D. dependent var	0.064667
S.E. of regression	0.045901	Akaike info criterion	-3.307843
Sum squared resid	0.244404	Schwarz criterion	-3.260882
Log likelihood	197.1627	Hannan-Quinn criter.	-3.288775
F-statistic	116.2194	Durbin-Watson stat	2.000002
Prob(F-statistic)	0.000000		

Appendix 8 Results of the OLS model

Dependent Variable: DDCENTRAL_GOVERNMENT_DEBT
Method: Least Squares
Date: 04/30/26 Time: 14:58
Sample (adjusted): 2015M03 2025M01
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004743	0.009719	0.487972	0.6265
DDTAXES_ON_GOODS_AND_SERVICES	-0.851024	0.214360	-3.970072	0.0001

R-squared	0.118720	Mean dependent var	0.003562
Adjusted R-squared	0.111188	S.D. dependent var	0.112407
S.E. of regression	0.105974	Akaike info criterion	-1.634582
Sum squared resid	1.313967	Schwarz criterion	-1.587874
Log likelihood	99.25765	Hannan-Quinn criter.	-1.615616
F-statistic	15.76147	Durbin-Watson stat	2.004074
Prob(F-statistic)	0.000124		

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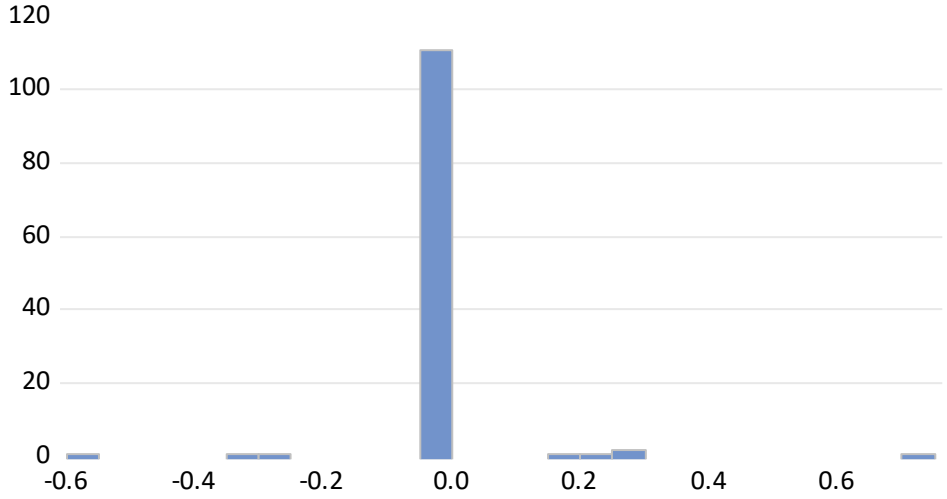
Appendix 9: Normality of Residuals



Series: Residuals	
Sample 2015M03 2025M01	
Observations 119	
Mean	4.15e-18
Median	-0.004743
Maximum	0.730968
Minimum	-0.591046
Std. Dev.	0.105524
Skewness	1.398547
Kurtosis	30.33092
Jarque-Bera	3742.563
Probability	0.000000

Appendix 10: Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	7.399447	Prob. F(1,117)	0.0075
Obs*R-squared	7.078281	Prob. Chi-Square(1)	0.0078
Scaled explained SS	100.3463	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 04/30/26 Time: 15:04
Sample: 2015M03 2025M01
Included observations: 119

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.010595	0.005364	1.975251	0.0506
DDTAXES_ON_GOODS_AND_SERVICES	0.321816	0.118306	2.720193	0.0075

R-squared	0.059481	Mean dependent var	0.011042
Adjusted R-squared	0.051443	S.D. dependent var	0.060053
S.E. of regression	0.058488	Akaike info criterion	-2.823337
Sum squared resid	0.400235	Schwarz criterion	-2.776629
Log likelihood	169.9886	Hannan-Quinn criter.	-2.804370
F-statistic	7.399447	Durbin-Watson stat	2.066474
Prob(F-statistic)	0.007520		

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Appendix 11: Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.000490	Prob. F(2,115)	0.9995
Obs*R-squared	0.001015	Prob. Chi-Square(2)	0.9995

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 04/30/26 Time: 15:05
Sample: 2015M03 2025M01
Included observations: 119
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.66E-07	0.009803	2.71E-05	1.0000
DDTAXES_ON_GOODS_AND_SERVICES	-1.34E-05	0.216215	-6.20E-05	1.0000
RESID(-1)	-0.002059	0.093251	-0.022075	0.9824
RESID(-2)	-0.002076	0.093252	-0.022259	0.9823

R-squared	0.000009	Mean dependent var	4.15E-18
Adjusted R-squared	-0.026078	S.D. dependent var	0.105524
S.E. of regression	0.106891	Akaike info criterion	-1.600978
Sum squared resid	1.313955	Schwarz criterion	-1.507562
Log likelihood	99.25816	Hannan-Quinn criter.	-1.563044
F-statistic	0.000327	Durbin-Watson stat	1.999974
Prob(F-statistic)	0.999992		