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# Forest Tax Revenue, Fees, and GDP Growth in Tanzania: An Empirical Investigation of Their Relationship

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## Abstract

The forestry sector contributes to Tanzania's economy through employment creation, income generation, provision of forest products, and government revenue collection through taxes, royalties, and fees. However, despite the importance of forestry resources, limited empirical evidence exists on the long-run relationship between forest tax revenue and economic growth in Tanzania. This study examines the relationship between forest tax revenue and Gross Domestic Product (GDP) growth in Tanzania using quarterly data covering the period from 2012 to 2020. The study applies time-series econometric techniques, including Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, Johansen cointegration analysis, Granger causality testing, Vector Error Correction Model (VECM), and impulse response analysis to investigate both short-run dynamics and long-run relationships between forest tax revenue and GDP. The findings indicate that both forest tax revenue and GDP are non-stationary at levels but become stationary after first differencing, confirming that both variables are integrated of order one. The Johansen cointegration test provides evidence of a long-run equilibrium relationship between forest tax revenue and GDP, suggesting that the two variables move together over time despite short-run fluctuations. Granger causality results reveal a bidirectional relationship between forest tax revenue and GDP growth, indicating that forest tax revenue contains useful information for predicting GDP growth and that economic growth also influences future forest revenue generation. The impulse response analysis further demonstrates that shocks to forest tax revenue and GDP generate dynamic adjustments between the two variables. The study concludes that forest taxation represents an important fiscal linkage between Tanzania's forestry sector and macroeconomic performance. Although the current contribution of forestry revenue to national income remains relatively limited compared with other sectors, improving forest tax administration, strengthening formal forestry enterprises, and promoting sustainable forest utilization could enhance the sector's contribution to domestic revenue mobilization and economic growth. The findings provide policy insights for designing forest fiscal strategies that support both sustainable resource management and Tanzania's long-term economic development.

Keywords: Forest tax revenue; GDP growth; forestry sector; taxation; cointegration; Tanzania.

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## I. INTRODUCTION

Tanzania's forest sector plays an important role in supporting economic development, livelihoods, and environmental sustainability. The sector provides employment opportunities, generates income for local communities, contributes raw materials for industries, and supplies essential ecosystem services. Forest resources also remain a major source of energy, with wood fuel accounting for a significant proportion of household energy consumption in Tanzania (Ngaga, 2011). In addition to timber, forests provide a wide range of non-timber products, including honey, wild fruits, and other products that contribute to household income and rural livelihoods (Monela et al., 2000).

Despite its economic importance, Tanzania's forest resources are under increasing pressure due to population growth, rising demand for forest products, agricultural expansion, and increased energy needs. The National Forest Resources Monitoring and Assessment (NAFORMA) reported that Tanzania's annual wood consumption was approximately 62.3 million cubic metres, while sustainable supply capacity was estimated at 42.8 million cubic metres, resulting in an annual deficit of about 19.5 million cubic metres (MNRT, 2015). These challenges highlight the need for effective forest management systems that promote sustainable utilization while ensuring that forest resources contribute meaningfully to national economic development.

One of the mechanisms used by the government to regulate forest resource utilization and generate public revenue is forest taxation. Forest taxes and fees, including royalties, charges, and other payments collected from forest products and services, serve two important purposes: generating government revenue and influencing the sustainable management of forest resources. According to Heaps and Helliwell (1985), taxation can influence resource extraction decisions by affecting the profitability and level of forest utilization. Therefore, an effective forest taxation system can encourage sustainable harvesting practices while contributing to government revenue.

In Tanzania, revenue collected from forest-related taxes and fees forms part of public income and contributes to the broader taxation system. Since taxation is a component of Gross Domestic Product (GDP) under the income approach, changes in tax revenue may have implications for national economic performance (Laurent, 2025). GDP growth reflects the overall expansion of economic activities, and government revenues generated from productive sectors can support public investment, infrastructure development, and economic transformation. Therefore, understanding the contribution of forest tax revenue to GDP growth is important for evaluating the economic significance of the forest sector.

Although forest taxation has been discussed in relation to forest management and revenue collection, limited empirical evidence exists regarding the relationship between forest tax revenue and economic growth in Tanzania. Previous studies have mainly focused on identifying different types of forest taxes and fees, their administration, and challenges affecting the forestry sector (GAI, 2014; Ngaga, 2011). For example, the Forest and Beekeeping Division (FBD, 2011) noted that fixed royalty charges may increase market prices and profitability but may also create challenges for small-scale forest enterprises. However, these studies provide limited understanding of whether forest tax revenue has a measurable long-term contribution to Tanzania's GDP growth.

The absence of empirical evidence creates uncertainty regarding the economic importance of forest taxation and its role in national development. It is therefore necessary to examine whether forest tax revenue and GDP growth have a long-run relationship, whether changes in forest tax revenue influence economic growth, and whether economic growth affects forest tax revenue generation. Such analysis can provide evidence for designing effective forest fiscal policies that balance revenue generation, sustainable forest management, and economic development.

This study therefore aims to examine the relationship between forest tax revenue and GDP growth in Tanzania. Specifically, the study seeks to: (i) determine the long-run relationship between forest tax revenue and GDP growth; (ii) examine the direction of causality between forest tax revenue and GDP growth; and (iii) assess the contribution of forest tax revenue to Tanzania's economic performance over time. The findings are expected to provide useful insights for policymakers in developing taxation systems that enhance the contribution of the forest sector to Tanzania's economy.

## II. Conceptual Framework

The conceptual framework of this study is based on the principles of fiscal policy and macroeconomic growth theory (Hansen, 2009), which suggest that government revenue generated through taxation can influence economic performance by supporting public investment, infrastructure development, and productive activities. Therefore, an increase in forest tax revenue may contribute positively to GDP growth through enhanced government revenue and improved management of forest resources.

However, the relationship between forest tax revenue and GDP growth may not be one-directional. Economic growth can also influence forest tax revenue generation through increased investment, expansion of forestry enterprises, improved production capacity, and increased demand for forest products. Thus, higher GDP growth may stimulate the development of the forestry sector, resulting in increased forest production and higher tax and fee collections.

The framework therefore assumes a bidirectional relationship between forest tax revenue and GDP growth. An increase in forest tax revenue can contribute to economic growth, while economic growth can enhance the capacity of the forestry sector to generate additional tax revenue. Over time, improved economic performance and effective forest sector management may promote sustainable forest utilization and ensure a reliable supply of forest products

## III. METHODOLOGY

### Study area

Tanzania possesses extensive forest resources that play a significant role in supporting economic development, environmental conservation, and rural livelihoods. The total area covered by forests and woodlands in Tanzania Mainland is estimated at 48.1 million hectares (ha), representing approximately 55% of the country's total land area (MNRT, 2015). These forest resources include natural forests, plantations, and woodlands that provide timber, fuelwood, non-timber forest products, and important ecosystem services. Forest resources contribute to household welfare, especially among rural communities that depend on forests for energy, food, income generation, and other livelihood needs (Monela et al., 2000; Ngaga, 2011).

The forestry sector is an important component of Tanzania's economy, contributing approximately 4% of national income (MNRT, 2018). The sector supports various economic activities, including timber production, wood processing, beekeeping, charcoal production, and trade in forest products. In addition to its direct contribution to national income, forestry provides employment and livelihood opportunities to a significant proportion of the population, particularly in rural areas where dependence on forest resources remains high (FAO, 2015). The contribution of forestry to employment and income generation demonstrates its importance not only as an environmental resource but also as an economic sector that supports national development.

Employment generated by the forestry sector occurs through both formal and informal activities along the forest value chain, including forest management, timber harvesting, forest industries, fuelwood collection, charcoal

production, and trade in non-timber forest products. According to FAO (2015), forest-related activities provide important livelihood support in many developing countries, particularly through informal employment and small-scale forest enterprises. However, estimating the exact number of people employed in Tanzania's forest sector remains challenging due to the significant contribution of informal activities that are not fully captured in official employment statistics. Differences in the definition and measurement of forest-sector employment also contribute to variations in reported estimates. Therefore, while employment demonstrates the socioeconomic importance of forestry, it is considered contextual evidence in this study rather than a direct analytical variable.

Beyond employment and livelihood support, the forestry sector contributes to Tanzania's economy through the generation of government revenue from forest taxes, royalties, and fees. Forest taxation serves both fiscal and regulatory purposes by generating public revenue while influencing the sustainable utilization of forest resources (Heaps & Helliwell, 1985). Forest tax revenue in Tanzania is mainly generated from commercial forestry activities, particularly large-scale forestry enterprises involved in timber production and processing. These enterprises contribute a substantial share of forest-related government revenue through payments such as Pay As You Earn (PAYE), corporation tax, royalties, and other forest charges (GAI, 2014; FBD, 2011). Therefore, forest taxation provides an important fiscal linkage between forest resource utilization and macroeconomic performance.

From a macroeconomic perspective, taxation contributes to economic growth by providing government revenue that can finance public investment, infrastructure development, and other productive activities. Under the income approach to GDP measurement, taxes represent an important component of national income accounting (TET, 2019). Consequently, increased forest tax revenue may contribute positively to GDP growth through enhanced fiscal capacity and improved management of forest resources. Conversely, economic growth may stimulate investment, expand forestry enterprises, increase demand for forest products, and improve revenue collection from forest-related activities. This indicates the possibility of a bidirectional relationship between forest tax revenue and GDP growth.

Despite Tanzania's extensive forest resources and the economic importance of forestry activities, limited empirical evidence exists regarding the relationship between forest tax revenue and GDP growth. Previous studies have mainly examined forest taxation systems, revenue collection mechanisms, and challenges associated with forest management (GAI, 2014; Ngaga, 2011). However, there is limited understanding of whether forest tax revenue contributes significantly to Tanzania's economic growth and whether changes in GDP influence forest revenue generation. Addressing this knowledge gap is important for developing effective forest fiscal policies that enhance revenue mobilization, promote sustainable forest utilization, and strengthen the contribution of the forestry sector to Tanzania's economic development.

**Data collection methods**

Data were obtained from two different sources. Tanzania's GDP data were sourced from quarterly financial reports published by the Bank of Tanzania (BOT). These data represent GDP at constant 2015 prices (adjusted for inflation), covering the period from the first quarter of 2012 to the fourth quarter of 2020.

Forestry tax revenue data were obtained from quarterly sectoral revenue reports published by the Tanzania Revenue Authority (TRA), also spanning from the first quarter of 2012 to the fourth quarter of 2020. However, there was a missing data point for the fourth quarter of 2018. This value was estimated using the Moving Average (MA) method for the purpose of analysis. In total, the GDP dataset consists of 36 quarterly observations, while

the forestry tax revenue dataset includes 35 observations. Both datasets form time series data frames suitable for analysis.

**Model specification**

This study employs cointegration techniques to examine the long-run relationship between Tanzania's gross domestic product (GDP) and forestry tax revenue (FORT). Cointegration analysis is suitable for identifying equilibrium relationships among non-stationary time series variables. Following the approach of Awe and Idumah (2017), the analysis proceeds through three main stages.

In the first stage, a conventional regression model is estimated to examine the effect of forestry tax revenue on economic growth, measured by GDP. This approach captures a unidirectional relationship from forestry tax revenue to GDP. The long-run relationship between the variables is specified as:

$$\ln GDP_t = \beta_0 + \beta_1 \ln FORT_t + \mu_t \quad \text{..... (1)}$$

Where $\ln GDP_t$ is the natural log of Tanzania GDP for a time period of 36 quarters from 2012 to 2020, $\beta_1$ is the intercept coefficient of the cointegration equation, $\beta_2$ is the co-integrating parameter, which is basically the rate of change of GDP based on the change in forestry revenue, $\ln FORT_t$ is the natural log of forestry tax revenue over a time period of 36 quarters from 2012 to 2020, and $\mu_t$ is the error term assumed to be serially uncorrelated, constant variance and zero mean.

**Unit root testing for stationarity**

Prior to cointegration analysis, the stationarity properties of the variables were examined to determine their order of integration. The Augmented Dickey–Fuller (ADF) unit root test was employed for this purpose. Both GDP and forestry tax revenue series were transformed into their natural logarithmic forms and tested in first differences.

For **GDP**,

$$\Delta \ln GDP_t = c + \rho \ln GDP_{t-1} + \sum_{j=1}^{k-1} \gamma \Delta \ln GD\,P_{t-j} + \beta T + \varepsilon_t \quad \text{..... (2)}$$

For **FORT**,

$$\Delta \ln FORT_t = c + \rho \ln FORT_{t-1} + \sum_{j=1}^{k-1} \gamma \Delta \ln FOR\,T_{t-j} + \beta T + \varepsilon_t \quad \text{..... (3)}$$

Whereby hypothesis tested were

$H_0$: ρ = 0, the series is not stationary;

$H_1$: ρ ≠ 0, the series is stationary

**Johansen cointegration test**

After establishing that both variables are integrated of order one, I(1), the Johansen cointegration technique was applied to test for the existence of a long-run equilibrium relationship between GDP and forestry tax revenue. The Johansen approach is based on a Vector Autoregressive (VAR) model of the form:

$$\Delta \ln GDP_t = \Pi \ln GDP_{t-1} + \sum_{j=1}^{k-1} \gamma \Delta \ln FOR\,T_t + \omega_t \quad \text{..... (4)}$$

and

$$\Delta \ln FORT_t = \Pi \ln FORT_{t-1} + \sum_{j=1}^{k-1} \gamma \Delta \ln GD\,P_t + \omega_t \quad \text{..... (5)}$$

Where, $GDP_t$ and $FORT_t$ are vector columns of GDP and forest taxes revenue collected in the period of time, which are integrated of order I(1), the Π, γ, and Φ, forms the parameter matrix. And also, $\omega_t$ is a vector of random error follows Gaussian white noise process. The model tests the rank of matrix (Π), which contains long-run information of the variables. If rank Π = r = k, (where k is the number of endogenous variables) the variables in level are stationary meaning that no cointegration exists and if rank Π = r = 0, meaning that all the elements in the adjustment matrix have value zero, therefore, none of the linear combination is stationary (Alam, 2011).

The Granger representation theorem by Engle and Granger (1987) states that, when $0 < \text{rank}(\Pi = r) < k$, there are r cointegrating vectors. A rank of Π = r = 1, implies that there is a single cointegrating vector or one linear combination which is stationary and that the Π can be shown as Π = αβ' where, α is the adjustment vector

and β is the cointegrating vector and both $\beta' \ln GDP_{t-1}$and $\beta' \ln FORT_{t-1}$ are integrated at order I(0). The Johansen method was used to estimate the Π matrix from an unrestricted VAR model and to test whether the restriction implied by the reduced rank of Π can be rejected. The trace test for testing reduced rank (r) from coefficient matrix Π is as follows:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i^2) \quad \text{..... (6)}$$

Where $\hat{\lambda}_i$is the estimated values of the ordered eigenvalues obtained from the estimated matrix and T is the number of usable observations. The trace statistic tests the following hypotheses

$H_0$: the number of distinct cointegrating vectors (r) ≤ r

$H_1$: the number of distinct cointegrating vectors (r) > r

**Granger causality between GDP and forest taxes revenue**

The existence of cointegration between GDP and forestry tax revenue implies at least one direction of causality. To determine the direction of influence between the variables, Granger causality tests were conducted within a VECM framework. The bivariate error correction equations are specified as:

$$\begin{bmatrix} \Delta \ln GDP_t \\ \Delta \ln FORT_t \end{bmatrix} = \sum_{i=1}^{k-1} \begin{bmatrix} \gamma_{11,i} & \gamma_{12,i} \\ \gamma_{21,i} & \gamma_{22,i} \end{bmatrix} \begin{bmatrix} \Delta \ln GDP_{t-i} \\ \Delta \ln FORT_{t-i} \end{bmatrix} + \begin{bmatrix} \omega_{1t} \\ \omega_{2t} \end{bmatrix} + \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} \begin{bmatrix} \ln GDP_{t-k} \\ \ln FORT_{t-k} \end{bmatrix} \quad \text{..... (7)}$$

Where, $\Delta \ln GDP_t$ and $\Delta \ln FORT_t$ represent the first differences of GDP and forest taxes revenue over time respectively. Analysing equation (7), there are three possible cases associated with testing for long-run causality, (a) $\alpha_1 \neq 0,\ \alpha_2 \neq 0$, (b) $\alpha_1 = 0,\ \alpha_2 \neq 0$and (c) $\alpha_1 \neq 0,\ \alpha_2 = 0$. Case (a) implies bi-directional causality, while cases (b) and (c) imply unidirectional causality.

To test for short-run Granger causality, i.e., GDP does not Granger cause forest taxes revenue in the short run (or forest taxes revenue does not Granger cause GDP in the short run), the statistical significance of the lagged dynamic variable changes is examined by testing the null hypothesis using a standard Wald test.

$$H_0: \sum_{i=1}^{k} \gamma_i \, (\ln VAR) = 0,$$

where $VAR$ represents either GDP or FORT.

Failure to reject the null hypothesis ($H_0$) implies the variable tested does not Granger cause the other variable.

**Vector error correction model (VECM) specification**

The final category is the estimation of the VECM to explore the short-run dynamic relationships and the speed of adjustment for the long-run equilibrium between both forestry taxes revenue and GDP (Awe and Idumah, 2017; Streimikiene *et al*., 2018).

The following are the model specifications for the VECM.

$$\Delta \ln GDP_t = \alpha_1 ECT_{t-1} + \sum_{i=1}^{p-1} \gamma_i \, \Delta \ln GDP_{t-i} + \sum_{j=1}^{q-1} \psi_j \, \Delta \ln FORT_{t-j} + \omega_{1t} \quad \text{..... (8)}$$

$$\Delta \ln FORT_t = \alpha_2 ECT_{t-1} + \sum_{i=1}^{p-1} \gamma_i \Delta \ln FORT_{t-i} + \sum_{j=1}^{q-1} \psi_j \Delta \ln GDP_{t-j} + \omega_{2t} \quad \text{..... (9)}$$

Where the one period lagged error correction term $ECT_{t-1}$ is the lag of estimated residuals from the cointegrating regression and estimated from Johansen model specified in equations (8) and (9). The $p$and $q$are the number of lags which were chosen through Schwarz Criterion (SC), Hannan Quinn (HQ) and Final Prediction Error (FPE) lag selection criterion. The size and statistical significance of $\alpha_1$ and $\alpha_2$ parameters measure the rate of adjustment of the variables to the disturbance from the long-run equilibrium relationship.

**Parameter estimation**

Since the tax revenue and GDP data are expressed in their logarithmic forms, the cointegration vector ($\beta$) estimated from the Johansen (VAR) model specified in equations (4 and 5) measures the long-run marginal rate of the forest tax revenue on the GDP and vice versa for each model. Short run marginal rates are estimated by the parameter ($\varphi$) in equations (8 and 9). Specifically, it represents percentage adjustment of the GDP or forest tax revenue following a period change in forest tax revenue and GDP respectively. Furthermore, the parameter vector ($\gamma$), is an autoregressive term, measuring the effect of each period change on the change of the current period of both variables depending on the direction of the relationship.

## IV. RESULTS AND DISCUSSION

### Trends of forest tax revenues and GDP

### Sectoral revenue collection by TRA

Study results indicate a predominantly upward trend in revenue collection by the Tanzania Revenue Authority (TRA) within the forestry sector. Most of this revenue is derived from receipts issued to large forest enterprises and value-added tax (VAT) on forestry products. The data presented in Figure 2 spans from the first quarter of 2012 to the fourth quarter of 2020. It reveals a general increase in forest tax revenue over time, although there is a data gap for the fourth quarter of 2018.

The series displays fluctuations characteristic of stochastic processes and seasonal patterns, which are expected given the quarterly nature of the data. Such variations are common in econometric time series and are often linked to different phases of the business cycle (Canova and Ghysels, 1994). Since the business cycle directly affects total output (GDP), it also influences tax revenue due to the ad valorem structure of many taxes (Mankiw, 2018). Additionally, the observed upward trend in revenue can be attributed to GDP growth and the strengthening of tax enforcement related to forestry products. Over the 36 fiscal quarters between 2012 and 2020, the highest revenue recorded was TZS 4.94 billion in the second quarter of 2019. This increase is mainly attributed to the relatively small number of registered forestry companies and limited VAT enforcement by the TRA (GAI, 2014; TRA, 2012). Notably, this amount represents a 38.3% increase compared to the maximum annual forestry tax revenue of TZS 3.6 billion reported by GAI (2014) in 2014.

When compared with the agriculture, livestock, and fisheries sectors, the forestry sector still contributes relatively less in terms of both GDP and tax revenue. Agriculture remains the dominant sector in Tanzania's economy, employing the majority of the population and consistently contributing about 26 to 30% to national GDP (URT, 2020). The livestock and fisheries sectors also have significant economic and social roles, particularly in food production, employment, and exports (FAO, 2019). These sectors enjoy broader participation, larger market systems, and relatively higher production levels.

In contrast, the forestry sector has historically been underutilized, with limited formalization, fewer industrial operations, and weaker enforcement of tax policies (MNRT, 2015). However, the observed increase in forest tax

revenue reflects progress in policy implementation and growing formal economic activity within the sector. This trend suggests that forestry has untapped potential to contribute more substantially to national revenue and economic diversification if further developed and regulated effectively.

From a macroeconomic perspective, the rising revenue from the forestry sector signifies a positive shift towards expanding the country's fiscal space. Broadening the tax base to include more contributions from natural resource sectors can enhance domestic revenue mobilization and reduce over-reliance on traditional sectors and external funding (World Bank, 2021). Furthermore, it implies the potential for job creation, industrial growth, and sustainable environmental management if the forestry sector is strategically integrated into national development plans. This could support Tanzania's goals of inclusive growth and transition to a semi-industrialized economy, as well as reinforce efforts toward long-term economic resilience and sustainability (URT, 2021)

**GDP growth in Tanzania from 2012 to 2020**

Quarterly GDP in Tanzania has grown steadily thereby establishing a general increasing trend. As depicted in Figure , the series is shown to have seasonal fluctuations which is normal for quarterly GDP data (Canova and Ghysels, 1994). Because the Tanzania economy is agriculture driven, it can be expected that the seasonal changes in GDP are corresponding to the agricultural seasons in the country (Laudien *et al.,* 2020).

**Relationship Between Forest Tax Revenue and GDP**

The graphical representation in Figure 4 illustrates a positive correlation between forest tax revenue and Gross Domestic Product (GDP), indicating that as GDP increases, forestry tax revenue also rises proportionally. This suggests that there is a potential economic relationship between forest tax revenue and GDP, where an increase in national economic activity may lead to higher tax revenues from the forestry sector.

However, to further explore and validate this relationship, more rigorous statistical analysis was carried out. The Johansen test for co-integration was employed to examine whether a long-run equilibrium relationship exists between the two variables. The Johansen test is a widely used method in econometrics to assess co-integration, which can confirm whether both variables share a stable, long-term connection, despite any short-term fluctuations that might occur.

The results of the Johansen test will provide more insight into the nature of the relationship and whether changes in GDP are likely to have a lasting effect on forest tax revenue over time. If a long-run co-integration relationship is found, it would suggest that forest tax revenue and GDP move together in the long term, reinforcing the economic importance of the forestry sector as the economy grows.

**Testing for stationarity of the forest tax revenue and GDP variables**

Before observing and analysing time series variables for a long run relationship, the time series variables should be checked for stationarity which implies that the variables will not have a unit root (Rath and Akram, 2021). Stationarity also refers that the mean and variance of the variables do not change specifically due to time. However, most time series econometric variables including GDP and tax revenue are non-stationary i.e., they contain a unit root, due to seasonality, cyclicality, and trends (Shrestha and Bhatta, 2018). This is reflected to the Tanzania GDP (GDP) and forestry sector tax revenue (FORT). By looking at their respective graphs in Figure , these variables show a strong presence of unit roots at level i.e., without differencing, due to the trend and fluctuations over time. Therefore, augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for

stationarity were conducted at level, logarithmic level form, and first differences of their logarithmic transformations with the following results in Table 1.

From the results in Table 1, of ADF for GDP at level indicates that absolute test statistics value of (-1.7443) is less than absolute critical value at 5% significance level. Also, the p-value (Z(t) = 0.6726) is not statistically significant than p-value of 0.05. Moreover, ADF for FORT at level indicates that absolute test statistics value of (-2.0754) is less than absolute critical value at 5% significance level. Also, the p-value (Z(t) = 0.5438) is not statistically significant than p-value of 0.05. This concludes that the null hypothesis that claims the presence of unit root cannot be rejected for both level and their level natural logarithmic transformations. Due to that the ADF test for both GDP and FORT series at level concludes the presence of a unit root which can lead to spurious correlation (meaningless correlation) if the analysis will be conducted without removing the unit root (Awe and Idumah, 2017; Revelian, 2016; Streimikiene *et al.*, 2018).

The variables were in a stationary state by differencing their natural logs to the 1st order before further analysis. ADF test was redone at first difference of the natural logarithm of the variables, where the test statistics rejected the null hypothesis therefore concluding the elimination of the unit root in both series.

**Cointegration test results between forest taxes revenue and GDP**

The Johansen test for cointegration was conducted with the following test results. A VAR specification of three (3) lags was chosen based on Schwarz Criterion (SC), Hannan Quinn (HQ) and final prediction error (FPE) lag selection criterion. The trace statistics for cointegration are presented in Table 2 which indicate that the null hypothesis of no presence of a cointegration relationship is rejected at the 5% significance level for both the model without trend and model including the trend. Estimating two different models is suggested by Harris and Sollis (2003). Thus, the Johansen cointegration model confirms that the Tanzania GDP exhibit a long-run cointegrating relationship with the forest tax revenues (FORT).

**Granger causality test results**

The Granger causality test was conducted to examine whether past values of forest tax revenue and GDP contain useful information for predicting changes in each other. It is important to note that the Granger causality approach identifies predictive relationships rather than confirming true structural economic causality.

The results presented in Table 3 indicate a bidirectional Granger predictive relationship between GDP and forest tax revenue. This means that past values of GDP provide statistically significant information for predicting forest tax revenue, while past values of forest tax revenue also provide useful information for predicting GDP. Therefore, the two variables demonstrate dynamic interaction in the short run.

The observed predictive relationship is consistent with fiscal and macroeconomic theory. Increases in economic activity may expand the taxable base, improve forestry sector investment, and increase government revenue collected from forest-related activities. Similarly, higher forest tax revenue may strengthen government fiscal capacity and support economic activities through public expenditure and investment. However, the Granger causality results should not be interpreted as evidence of direct economic causation, since the test does not identify the underlying structural mechanisms through which one variable affects another.

The finding of bidirectional predictive interaction is consistent with previous studies that have identified feedback relationships between taxation and economic performance (Dzingirai & Tambudzai, 2014; Awe & Idumah, 2017). However, other studies have reported different results depending on country-specific economic conditions and

policy environments (Iriqat & Anabtawi, 2016). The differences highlight the importance of considering institutional and economic contexts when interpreting the relationship between tax revenue and economic growth.

**Vector error correction model (VECM)**

From the estimated Vector Error Correction Model (VECM), the long-run cointegrating equation was found to be: $\Delta \ln GDP = -0.049 \Delta \ln FORT$

This long-run relationship indicates that a 5% decrease in forest tax revenue (FORT) will result in a 1% increase in GDP in the long run. This may appear counterintuitive at first, but it underscores the complexity of economic relationships, particularly within developing economies like Tanzania's, where non-traditional sectors such as forestry can have multifaceted impacts on broader economic performance.

The estimated Vector Error Correction Model (VECM) was used to examine both the long-run relationship and the short-run adjustment dynamics between forest tax revenue and GDP. The estimated long-run cointegrating equation is presented in the manuscript, while the short-run parameter estimates are reported in Table 4.

The Error Correction Term (ECT) is negative and statistically significant, with an estimated coefficient of -2.08. The negative sign confirms that the long-run equilibrium relationship between forest tax revenue and GDP is stable and that deviations from equilibrium are corrected over time. Therefore, whenever short-run shocks cause the variables to move away from their long-run equilibrium, the adjustment mechanism acts to restore equilibrium.

However, the magnitude of the coefficient exceeds one in absolute value, indicating that the adjustment process is not gradual. Instead, it suggests an oscillatory adjustment, whereby deviations from the long-run equilibrium are initially over-corrected before converging through subsequent periods. This implies that GDP and forest tax revenue may temporarily move beyond their equilibrium levels following a shock before gradually stabilizing.

The estimated short-run coefficients further indicate that current GDP is significantly influenced by past changes in both GDP and forest tax revenue, confirming the existence of important short-run interactions between the two variables. Overall, the VECM results support the existence of both a stable long-run equilibrium relationship and dynamic short-run adjustments between forest tax revenue and GDP in Tanzania.

This phenomenon highlights the importance of fostering sustainable resource management policies in Tanzania. The forestry sector's potential for growth, particularly with increasing global attention on climate change and the importance of sustainable development, could make forest resources a more integral part of Tanzania's broader economic strategy. This, in turn, could lead to better tax revenue management and a more diversified economy, aligning with Tanzania's long-term growth aspirations.

**Generalized impulse response functions**

Impulse response functions (IRFs) were analyzed to examine the relationship between GDP and forest tax revenue. The primary purpose of these functions is to graphically illustrate the effect of one variable in response to a shock induced by another variable. The Generalized Impulse Response Function (GIRF) reveals that positive shocks to GDP initially cause forest tax revenue to drop below its mean for about two quarters before it begins to rise and stabilize. Conversely, positive shocks to forest tax revenue result in an increase in GDP, which then stabilizes around its mean. The GIRF for both GDP and forest tax revenue are illustrated in Figure 6.

These findings have several important implications for the Tanzanian economy. First, positive shocks to GDP initially lead to a decrease in forest tax revenue, suggesting that in the short term, economic growth might not

directly translate into higher forest-related tax income. This could be due to shifting economic priorities or a lag in the response of the tax system (Smith, 2018). However, as the economy stabilizes, forest tax revenue begins to recover and increase, indicating that sustained economic growth could eventually bolster the tax base over time (Johnson & Wang, 2020).

On the other hand, positive shocks to forest tax revenue have a beneficial impact on GDP, promoting economic growth that stabilizes around its mean. This highlights the potential role of forest-related revenues in supporting broader economic stability and development. The result suggests that increasing forest tax revenue could stimulate economic growth, potentially through reinvestment in sustainable projects or boosting government spending in critical sectors (Adams et al., 2019).

From a policy perspective, these results suggest that while short-term shocks to GDP might temporarily depress forest tax revenue, long-term policies focusing on both economic growth and sustainable forest management could be mutually reinforcing. Therefore, a balanced approach is required, where policies promoting GDP growth are complemented by strategies that ensure the stability and increase of forest tax revenues over time, contributing to both economic and environmental sustainability in Tanzania (Brown & Davis, 2017).

## V. Conclusion and policy implications

The forest tax revenues have demonstrated both short-run and long-run relationships with Tanzania's GDP, highlighting a complex interaction between the two variables. While the error correction term (ECT) coefficient, which measures long-run dynamics, was found to be negative, this suggests that the series are diverging from their equilibrium over time. This observation indicates that adjustments are not efficiently taking place in the long run, potentially signaling a need for policy intervention to correct this imbalance.

Further insights from the Generalized Impulse Response Function (GIRF) reveal intriguing patterns in response to economic shocks. Positive shocks to the GDP initially cause a decline in forest tax revenue rates below their mean for about two quarters before stabilizing and gradually rising again. Conversely, positive shocks to forest tax revenue tend to boost the GDP, leading to a sustained increase and eventual stabilization around its mean. This bi-directional relationship illustrates the interconnected nature of both sectors, where fluctuations in one can influence the trajectory of the other.

In light of these findings, it is recommended that policymakers leverage the interdependence between forest tax revenue and GDP to inform future economic strategies. Given the reciprocal influence between these variables, the implementation of well-designed forest tax programs could effectively optimize both sustainable economic growth and the long-term development of the forestry sector. By aligning fiscal policies with the dynamics identified in this study, Tanzania can better navigate the complexities of its natural resource management and economic progress, ensuring that both forest conservation and economic expansion are mutually reinforced

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## Tables

### Table 1: ADF tests results for stationarity of variables

| Variable | Transformation | DF test statistic | p-value | Decision |
|---|---|---|---|---|
| GDP | Level | -1.7443 | 0.6726 | Not stationary |
| | Log | -1.6486 | 0.7099 | Not stationary |
| | 1st Log difference | -29.187 | <0.01*** | Stationary |
| FORT | Level | -2.0754 | 0.5438 | Not stationary |
| | Log | -2.3696 | 0.4293 | Not stationary |
| | 1st Log difference | -29.187 | <0.01*** | Stationary |

***Statistically significant at 1% significant level

### Table 2: Multivariate cointegration rank test

| | | No linear trend | | | Linear trend | | |
|---|---|---|---|---|---|---|---|
| Test and $H_0$: rank(Π)=r | | Test statistics | Critical Values ($\lambda_{0.95}$) | Decision | Test statistics | Critical Values ($\lambda_{0.95}$) | Decision |
| Trace statistic ($\lambda_{trace}$) | r ≤ 1 | 37.4 | 7.52 | Rejected | 36.68 | 12.25 | Rejected |
| | r = 0 | 145.08 | 17.85 | Rejected | 144.98 | 25.32 | Rejected |

### Table 3: Wald test results for short-run directional causality

| Variables | | Causality test (likelihood ratio) Hypotheses | F-test | p-value | Causality decision |
|---|---|---|---|---|---|
| Dependent Variables | ΔlnGDP | $H_0: \sum_{i=1}^{k} \gamma_{i(lnGDP)} = 0$ | 1.1386 | 0.344 | Bi-directional causality |
| | | $H_1: \sum_{i=1}^{k} \gamma_{i(lnGDP)} \neq 0$ | | | |
| | ΔlnFORT | $H_0: \sum_{i=1}^{k} \gamma_{i(lnFORT)} = 0$ | 0.75009 | 0.5282 | |
| | | $H_1: \sum_{i=1}^{k} \gamma_{i(lnFORT)} \neq 0$ | | | |

### Table 4: Results of the vector error correction model (VECM)

| | $\Delta \ln GDP_t$ | | $\Delta \ln FORT_t$ | |
|---|---|---|---|---|
| | Parameter estimates | S. E | Parameter estimates | S. E |
| $ECT_{t-1}$ | -2.0875* | 0.8085 | 8.8738 | 13.0244 |
| Intercept | 0.0305* | 0.0122 | -0.1329 | 0.1970 |
| $\Delta \ln GDP_{t-1}$ | 0.5251 | 0.6114 | -8.5521 | 9.8498 |
| $\Delta \ln FORT_{t-1}$ | -0.0540* | 0.0220 | -0.5643 | 0.3548 |
| $\Delta \ln GDP_{t-2}$ | 0.0806 | 0.4191 | -3.8666 | 6.7511 |
| $\Delta \ln FORT_{t-2}$ | -0.0283 | 0.0154. | -0.4643 | 0.2477. |

| | | | | |
|---|---|---|---|---|
| $\Delta \ln GDP_{t-3}$ | -0.4493* | 0.2080 | -1.6825 | 3.3513 |
| $\Delta \ln FORT_{t-3}$ | -0.0044 | 0.0087 | -0.1423 | 0.1408 |

*Statistically significant at 10% significance level, S.E is the standard error of the coefficients

## Figures

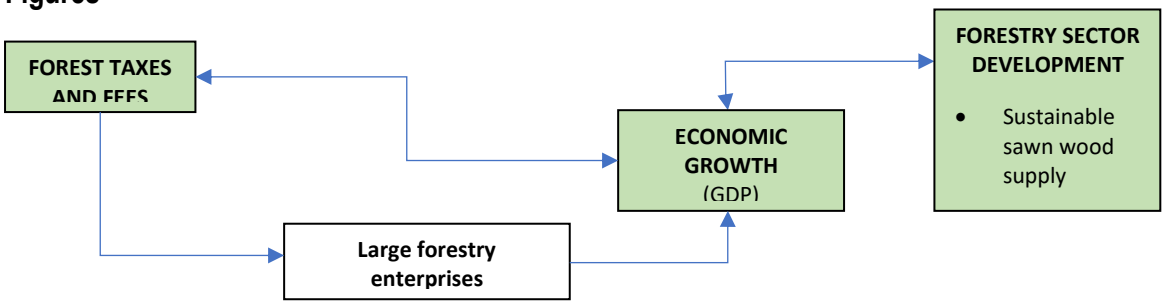


**Figure 1:** Conceptual framework on the implications of forest taxes and fees on the forestry sector and economic development.

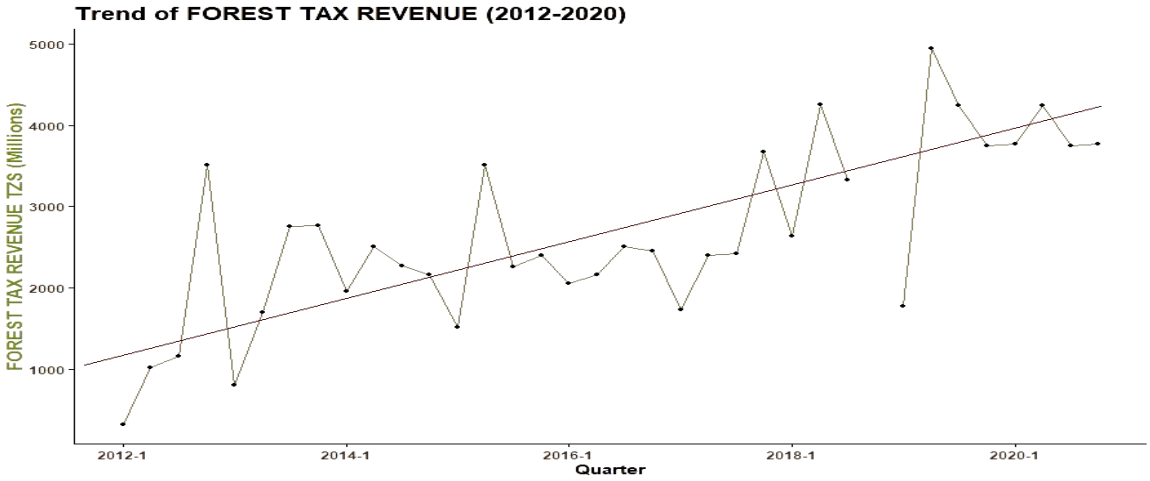


**Figure 2:** The trend of quarterly forestry sector tax revenue from 2012 to 2020.
Source of data (TRA, 2021)

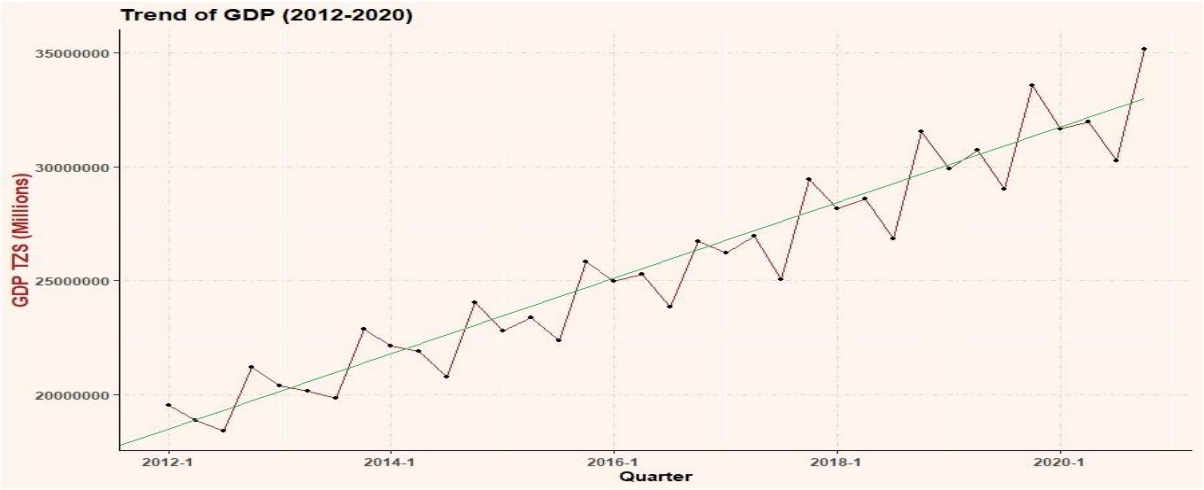


**Figure 3:** The trend of quarterly Gross Domestic Product (GDP) from 2012 to 2020.
Source of data (BOT, 2021)

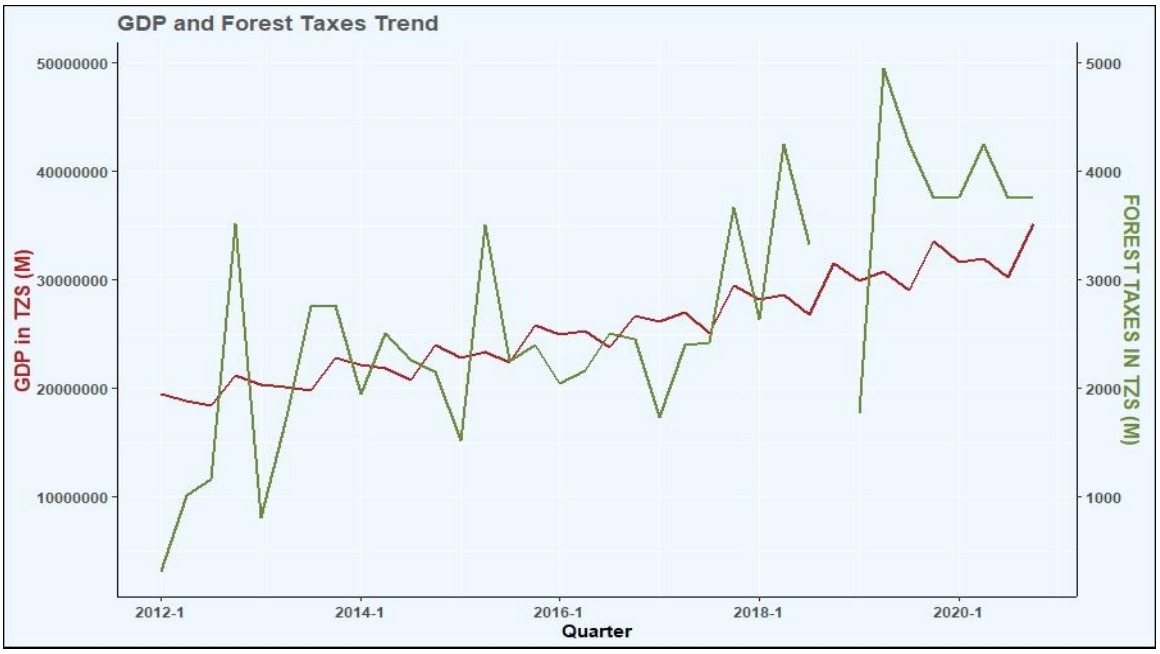


**Figure 4:** Trends of forest tax revenue and GDP

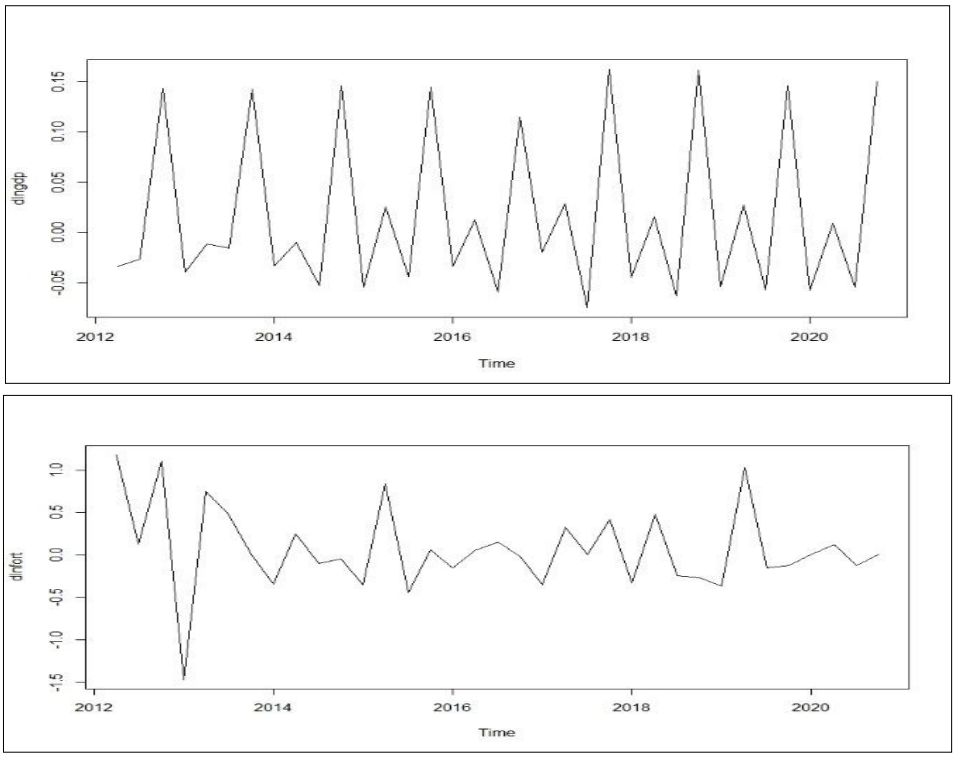


**Figure 5:** Plots of first differences of lnGDP and lnFORT showing elimination of trends

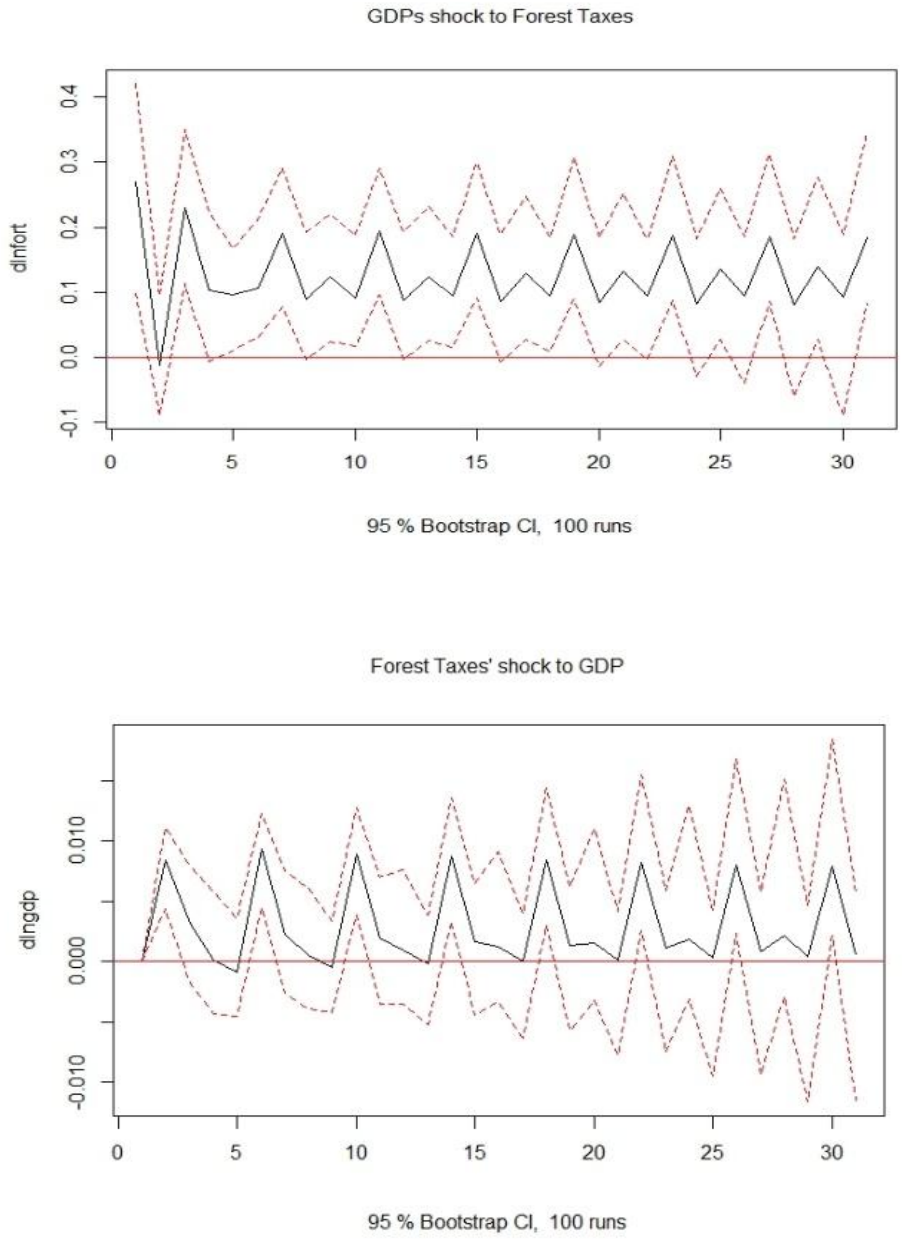


**Figure 6:** Generalized impulse response functions (GIRF) between GDP and forest tax revenue to a one standard deviation (S.D) shock