Economic Insights – Trends and Challenges	Vol.XI(LXXIV) No. 4/2022	107 - 124

Simulating Tax Effects on Economic Activities in Sierra Leone: A DSGE Framework

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DOI: https://www.doi.org/10.51865/EITC.2022.04.07

Abstract

In order to analyse the macroeconomic effects of changes in the marginal tax rate on cyclical fluctuations in Sierra Leone, we created a DSGE model that evaluates the macroeconomic impact of three tax instruments (i.e., consumption, income, and capital). The model is calibrated with parameter values that reflect the peculiarities and representative tax structure of the Sierra Leone economy. We found that; a 5% increase in consumption tax rate causes a distortionary effect on output, consumption, and investment (in the short-run), while in the long-run output contract by 3.1%, with a permanent decline in consumption and investment. Whilst, fiscal revenues increase in the dynamic short run, 15%, higher than it previous steady-state value. On the other hand, a simulation of a 5% reduction in consumption tax, labour income tax, and capital income tax from the current rates shows a positive impact on consumption and investment as such output grows permanently by 8.45%, but fiscal revenues decrease marginally by 1.7%. The key point in the analysis is that in Sierra Leone tax changes have distortionary effects on the decisions of individuals and firms, affecting output, investment, consumption, and fiscal revenues. As such tax policy can alter economic behaviour in profound ways. We observed that fluctuations in tax rates produce large substitution effects that alter investment & consumption decisions and have distortionary effect on the behaviour of economic agents. The results suggest that the authorities should synchronize policies to manage the trade-off between the desire for more welfare gains, output growth, and the need for more fiscal revenue mobilization.

Keywords: *DSGE models; tax simulation; fiscal policy; optimal taxation; Sierra Leone.*

JEL Classification: *H30; H21; E62; D58.*

Introduction

Tax policies typically result in a number of policy objectives in Sierra Leone, just like in any other nation. Taxation is meant to provide money for public spending, which always involves redistribution of income, economic stabilization, overcoming externalities, influencing resource allocation, and supporting robust economic growth. To achieve the most ideal fiscal policy

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goals (such as allocation, redistribution, and stabilization), which are crucial for attaining economic growth and fiscal consolidation, a tax system must be efficiently structured. Economic theory holds that taxes, with the exception of lump sum taxes, lead to distortions that have a detrimental effect on economic growth. Given a straightforward production function, taxes can have an impact on growth through their effects on three different types of capital: human capital, physical capital, and total factor productivity (TFP).

In this context, this paper, therefore, focused on assessing the role of government in delivering an efficient tax system. In general, two types of taxes are worth mentioning here: Firstly, lump-sum taxes, which are non-distortionary and do not change households' and firms' decisions (ignored for this study). Secondly, distortionary taxes (e.g., income or consumption taxes) - affect the market prices of goods and production inputs, and hence change private agents' economic decisions. The focus therefore of this study is to pay attention to three types of taxes - labour income tax, consumption tax, and capital gains/income tax, which are said to affect households directly. In our pursuit to develop a DSGE model to account for the impact of tax on economic activities, the key focus is to introduce distortion/shocks that manifest their relative effects on the price of production factors and the final good. On that note, (economic) decisions of the private agents will change in response to the tax code. In this framework, we can study the effects of fiscal policies through public revenues. Therefore, in the DSGE model constructed, the government will be the deciding factor on tax policy, while consumers and firms will make their decisions accordingly by accepting tax rates set as given by the government. In other to simplify the theoretical framework, we assume public revenues are ploughed back into the economy in the form of an exogenous sequence of lump-sum transfers.

This study is intended to add value to knowledge and generate understanding of the tax system and policy in Sierra Leone, especially its importance in economic activities. This research seeks to construct a DSGE tax model for Sierra Leone that will provide answers to three questions: Firstly, computing steady-state values for indicators like output, consumption, investment, and fiscal revenues. Secondly, understanding the dynamic short-run effect of a permanent change in consumption tax on economic activity. Lastly, compute dynamic short-run effects of multiple tax decreases in consumption, labour income, and capital income tax, while at the same time observing the possibility of a substitution effect between investment and consumption.

To achieve the above objectives, the authors have affirmed their efforts to construct a DSGE model that accounts for the deterministic simulation of the impact of regime change or the introduction of a new tax system/rate. Moreover, a deterministic model assumes full information, perfect foresight, and no uncertainty around shocks. The solution to the chosen model does not require linearization - instead, it involves numerical simulation to determine the exact paths of the endogenous variables that satisfy the model's first-order conditions and shock structure. This approach can therefore be useful when the economy is far from achieving its steady-state condition (when linearization offers a poor approximation).

This paper differs from other studies in multiple ways. Based on the available literature, no study has employed the deterministic DSGE simulation approach to analyze the economic implications of tax systems in the context of Sierra Leone. More generally, this research will build on the framework from previous research endeavours – particularly the role of fluctuations in tax variables as a source of business cycle fluctuations. By extension, it will also assess how movements in effective tax rates amplify fluctuations in investment. It will also add value to the understanding of welfare decline and its association with fluctuations in distortionary taxes. The use of simulation for the constructed DSGE model will also help in supporting effective policy formulation by relevant Ministries, Departments, and Agencies (MDAs) – notably, the Ministry of Finance (MoF), National Revenue Authority (NRA), and the Bank of Sierra Leone (BSL), which are considered key players in the management of the supposed distortionary and inflationary effect of tax hikes and welfare losses.

The rest of the paper is therefore planned as follows: Section 2 provides a review of relevant literature, which is pertinent to understanding the tax system in Sierra Leone. Section 3 presents the methodology, model specification, and the calibration of parameter values. Section 4 presents the results and simulation of the response of key variables concerned with various tax changes under different scenarios. Finally, Section 5 concludes, with proffered policy recommendations.

Literature Review

Dynamic stochastic general equilibrium (DSGE) models are commonly used to analyse the effects of tax policies on macroeconomic outcomes. Barro and Sala-i-Martin (1992) introduced the concept of tax smoothing, which suggests that governments should adjust taxes gradually over time to minimize the impact of tax volatility on private consumption and investment decisions. They presented a DSGE model that incorporates stochastic interest rates to analyse the effects of tax volatility on macroeconomic outcomes. Clarida, Gali, and Gertler (2002) presented a DSGE model commonly used for analysing the effects of monetary policy on macroeconomic variables, such as output, inflation, and interest rates. They demonstrated how this framework can be extended to incorporate fiscal policies, including tax policies, and showed how changes in tax rates can affect aggregate demand, output, and inflation. Uhlig (2010) presented a DSGE model that includes both government spending and taxation as endogenous variables. He showed that changes in tax rates can have significant effects on aggregate demand, output, and employment.

Woodford (2003) presented a DSGE model that incorporates a common currency and fiscal policy coordination among member countries of a monetary union. The author showed how tax policies can be used to stabilize macroeconomic fluctuations and how the optimal tax policies may differ across countries depending on their relative economic conditions.

Finally, Romer and Romer (2010) presented an empirical approach to estimating the effects of tax policy changes on macroeconomic outcomes using a vector autoregression (VAR) model. They showed how changes in tax rates can affect consumption, investment, and employment and demonstrated the importance of considering the timing and size of tax policy changes in assessing their macroeconomic effects.

These works and others in the literature provide useful insights and theoretical foundations for studying the effects of tax policies in a DSGE framework for Sierra Leone. By using a DSGE model, researchers can simulate the effects of different tax policies and assess their impact on macroeconomic outcomes, which can inform policymakers and contribute to the development of effective tax policies.

Empirically, there is a plethora of published literature on taxation - notable highlights include studies on the effects of income tax under the homogeneous and heterogeneous preference hypothesis among individuals. It is a well-known truth that individual preferences vary in utility values, particularly with regard to the items and services they choose to purchase, as mentioned by Kaplow (2008). Additionally, people' physical and psychological inclinations—which are frequently restricted by aspects of the environment and resource distribution—give birth to varied preferences. When preferences are visible, income taxation optimality should be higher with higher utility values, according to Kaplow's (2008) conclusion on the topic of the heterogeneous preferences hypothesis. Contrary to unobservable preferences, homogenous preferences are thought to be identical to optimal income tax rates. Additionally, Cremer et al. (2001) and Saez (2002) demonstrate how commodity taxes can significantly influence the assumption of an optimal income tax incidence schedule. Golosov et al. (2013), however, disproved this finding by demonstrating that capital taxes actually produce modest welfare improvements when commodity taxes are considered to be a nonlinear function of consumption

and income. Moreover, Boadway et al. (2002) analysis of optimal tax schemes under heterogeneous and quasi-linear individual preferences for leisure arrived at the following: the utilitarian welfare (tax) function is fret with regressive redistribution due to the adoption of some tax intervals. In addition, studies by Tarkiainen and Tuomala (2007), Blomquist and Christiansen (2008), and Lockwood and Weinzierl (2015) also stressed the impact of heterogeneous preferences on tax design.

Plethoral of researchers are now resorting to the use of DSGE models in assessing the overall behaviour of economic agents by incorporating tax components. Notable examples include: (i) the RAMSES Swedish model produced by Adolfson et al. (2008), (ii) AINO Finish economic model presented by Kilponen and Ripatti (2006), and (iii) the FiMod model developed by Stähler and Thomas (2012), which is a joint venture between German and Spanish National Central Banks, also popularly utilized by the European Central Bank (ECB). The literature on specific tax themes, which addresses issues such the "effects of taxation on income, inequality and labour supply and investment, budget and government trajectory balances, and many more," is available in addition to the DSGE models that have already been published. Krusell and Smith's seminal study from 1998 demonstrated how variability in discounting behaviour alters the explanation of wealth inequality from a macroeconomic perspective with regard to the effects of taxation on income, wealth, and inequalities. Nishiyama and Smetters (2005) find that output and wealth levels increase in the presence of an uninsurable wage shock after examining the effects of replacing progressive taxation with flat consumption taxes in an overlapping-generation model with heterogeneous agents (considered as able working). This result is corroborated by the works of Coleman (2000) and Correia (2010) who found a positive connection between consumption taxes and welfare dynamics. In their 2011 study on inequality, Garca-Pealosa and Turnovsky highlighted that wealth and income distribution are significantly impacted by tax changes, which has some implications for tax redistribution. The beginning state of capital distribution, as well as how fiscal policy affects pre-tax income and welfare inequalities through the labor supply channel, are emphasized in earlier studies by Garca-Pealosa and Turnovsky (2007). Coleman (2000) discovered a favourable relationship between consumption taxation and welfare in support of his efforts to conduct an empirical study on taxation. According to the author, welfare increases are possible by completely replacing the income tax with a special consumption tax. The effects of a two-revenue neutral income tax reform for Germany are evaluated by Heer and Trede in 2003. Using a general equilibrium model framework and data from 1996, the authors explicitly look into the quantitative effects of consumption tax implementation and flat-rate income tax amendments. When compared to the German taxation system, the results show benefits in both efficiency and welfare from the application of these tax measures. Despite the authors' best efforts, the paper's scope is limited because they didn't try to calculate any potential welfare losses due to the changes in the tax system. Bouza and Turnovsky (2012) and Lim and McNelis (2014) conducted studies on the connection between economic openness and inequality, taking taxation into account in the final analysis.

Hanlon and Heitzman (2010) particularly cited examples of how taxes affect investments, analysing the effects of various taxes on business decisions. In spite of this, Hassett and Metcalf (1999) discussed issues with uncertainty in research on taxation and investment dynamics. Thus, research by Edmiston (2004) over a 28-year period finds a negative relationship between enterprises' taxation volatility and investment growth in 15 member states of the European Union, Japan, and the United States. In line with earlier findings, El-Shazly (2009) discovered that corporate tax reduction and transparency in tax policy promote capital accumulation. The study by Agliardi (2001) examines the constructive relationships between taxation and business investment choices.

Salgado (2011) constructed a DSGE model with heterogeneous enterprises to analyse the cyclicality of the distribution of investment rates among firms with growth dynamics. He finds

that the higher the corporate taxes are, the less concentration there is between the degree of investment rates across firms and the cyclical component of GDP. Last but not least, Afonso and Jalles (2015) discovered that taxation had an impact on both private and public investment decisions, contrary to Alesina et al quantitative evidence of how various taxes impact enterprises' earnings in 2002.

Finally, we highlight the research done by Romer and Romer (2010) and Jaimovich and Rebelo in relation to fiscal policy and its effects on economic performance through the taxation channel (2017). According to Fernandez-Villaverde (2010), tax cuts have a less effect on financial friction than increases in government spending intended to spur economic expansion.

Furthermore, Mertens and Ravn (2011) used a DSGE model to assess the influence of macroeconomic factors on unexpected and anticipated tax shocks and concluded that anticipated tax cuts have a adverse impact on GDP until they are implemented de facto. Under a New Keynesian DSGE model, Cloyne (2014) assesses the public expenditures of the Keynesian multiplier, taking into account how government expenditures are financed and how consumers behave when they expect future tax increases.

Given the above theoretical/empirical review, this study will make value addition to the existing body of literature on the effect of tax disturbances on real economic activity in Sierra Leone within a DSGE framework. The model intends to assess whether there exists a tax burden-induced GDP growth influence in Sierra Leone. By extension, it will analyse the impact of permanent tax changes on fiscal revenues, investment, consumption, and other key macroeconomic variables. The study also seeks to evidence the relative GDP growth influence of tax burden distribution across liable tax-paying groups in Sierra Leone. The study outcome is also expected to explore clues about possible indicative tax policy that will influence GDP growth, while at the same time archiving steady-state growth in tax revenues and output.

Background on the evolution of tax regime in Sierra Leone

The National Revenue Authority (NRA) manages taxes in Sierra Leone. Before 2000, tax administration was divided between the Income Tax Department and Customs and Excise Department, both under different ministries. Local governments administer local taxes while the NRA handles taxes owed to the government, including those from main sources of income. The NRA established the Domestic Taxes Department (DTD) to administer domestic taxes such as Capital Gains Tax, PAYE, Corporation Tax, Personal Income Tax, Rental Income Tax, Foreign Travel Ticket Tax, Goods and Services Tax, and Domestic Excise Tax. A brief summary of the tax structure and key taxes is provided below:

Income Tax: Both residents and non-residents of Sierra Leone are taxed on their total income annually. Residents pay taxes on all income regardless of source, but non-residents only pay taxes on domestic sources of income. Assessment of Sierra Leone's income source is based on actions completed there, regardless of contract location. All fringe benefits except leave allowances, calculated as one month's basic salary, are taxed under the Income Tax Act of 2000. Examples of taxed fringe benefits include a vehicle, lodging, food, chauffeur, and domestic help.

Since the first Income Tax Act was passed in 1943, there has been significant progress in the taxation of income in Sierra Leone. Several evaluations and adjustments have been made to the Act as the economy progressed, and the goals of successive administrations are redefined to achieve their political manifesto. The Consolidated Income Tax Act, which replaced the 2000 Income Tax Act, was passed in 2009 after being revised in April 2000. The Payroll Tax Act of 1972 mandates that all foreign workers in Sierra Leone must pay an annual lump sum tax, sometimes known as payroll tax. Employers are responsible for paying the payroll tax on behalf of any employee who is a foreign national. For ECOWAS citizens and non-ECOWAS citizens, the sums due are different. Every employer who hires non-citizens in Sierra Leone is required

by the Payroll Tax Act as amended to pay a tax by the 31st of January of each year. Regardless of the employee's start date in Sierra Leone, this tax is due.

Sierra Leone's Capital Gains Tax (CGT): are levied on profits or earnings from investments. Simply explained, CGT is the tax owed on extra purchases made beyond the sold asset's adjusted cost base.

According to the Finance Act of 2022, vendors must pay 25% Capital Gains Tax on their capital gain from selling a chargeable asset. Returns must be filed and paid within 30 days of sale or face a penalty. Foreign Travel Tax must be paid by travelers leaving Sierra Leone by air, sea or other means, collected by the ticket issuer and paid to the NRA within 15 days after the end of the ticket's month of issuance. Late payment incurs a 15% monthly penalty and repeated non-collection may result in license suspension or prosecution for tax evasion (punishable by a fine or 5-year imprisonment).

Withholding Tax: Deducted from income or payment for goods/services exceeding Le 500,000 per transaction, this tax type varies in rate based on recipient residency in Sierra Leone and the type of payment.

Corporation Tax: A tax on corporate entities like LLCs, trusts, and co-ops. Resident and non-resident companies with a Permanent Establishment are taxed at 30% of taxable income. Private and public companies with taxable profits must pay Corporate Income Tax in 4 equal instalments, due on the 15th of the 3rd, 6th, 9th, and 12th months of the assessment year.

Goods and Services Tax (GST): A modern sales tax on imported and local goods/services, collected as a percentage of their value when imported, sold, exchanged, or delivered. Most goods/services (including imports) in Sierra Leone are subject to a 15% GST rate. Only registered enterprises must collect GST from clients, excluding items like rice, petrol, and medical supplies. The GST system shifts the tax burden from producers to consumers and allows registered businesses to claim input GST, reducing operating costs and potentially passing savings onto clients. The net difference of output GST received and input GST paid is given to the authority after each month's transactions. Input GST exceeding output GST can be claimed for credits, subject to audit verification. Businesses rarely claim credits, except for exports and in loss situations, according to the GST Act 2009, which categorizes supplies into 4 categories and sets a general rate of 15%.

Methodology

The incorporation of tax components in the DSGE model requires the modification of the consumers' budget constraint and/or the profit function for the firms – this is dependent on the particular tax(es) to be considered. In reality, there exist a large variety of taxes as already described concerning Section 2: lump-sum taxes, income taxes, consumption taxes including excises and corporate profit taxes. In the Pay-As-You-Earn (PAYE) system of tax, contributions to social security are included in fiscal revenues and are therefore considered an additional tax.

Lump-sum taxes can be introduced in the following way:

$$C_t + S_t = Y_t - T_t \tag{1}$$

Where C_t is consumption, S_t is saving, Y_t is income and T_t is a fixed amount of tax, which is not related to any macroeconomic variable. An alternative is to consider the case of income tax. In this case, household budget constraint is therefore defined as:

$$C_t + S_t = (1 - \tau^y)Y_t \tag{2}$$

Where τ^y is the income tax rate. Consumption tax and Saving tax can also be considered as:

$$(1 + \tau^c)C_t + (1 + \tau^s)S_t = ((1 - \tau^c)Y_t \tag{3}$$

Where: τ^c is the consumption tax rate and τ^s is the saving tax rate.

Overall, we can distinguish between two types of taxes - direct and indirect taxes, the latter of the two is also referred to as income tax (e.g., labour income taxes, a capital income tax, or corporate tax). Consumption taxes are indirect taxes, which have a direct pass-through effect on the prices of goods and services (e.g., include Value Added Taxes (VAT), import and excise taxes). The introduction of tax elements in a DSGE model is rather a straightforward process as the main structure of the model does not change, except with the consideration of a new economic agent, which is typically the "Government". The analysis of what the government does with fiscal revenues is a complex process. In this model, we assume that revenues are returned to the economy as lump-sum transfers. Specifically, we consider the existence of three types of taxes for the household, and these are "consumption, labour income, and capital income taxes". In a competitive environment where households are the owners of the production inputs, there is no room for corporate tax as firms' profits are zero. Therefore, the consumer budget constraint can be written as:

$$(1 + \tau_t^c)\mathrm{C_t} + \mathrm{S_t} = (1 + \tau_t^1)\mathrm{W_t L_t} + \left(1 - \tau_t^k\right)\mathrm{R_t K_t} + \mathrm{G_t} \quad (4)$$

Where: τ_t^c is the tax rate on consumption, τ_t^k is the tax rate on capital income and τ_t^1 is the tax rate labour income, $\mathrm{W_t L_t}$ is the wages for labour, $\mathrm{R_t K_t}$ is the revenue from capital.

The budget constraint indicates that final consumption, including excise and value-added taxes plus savings, cannot exceed the sum of net labour income and net capital rental income plus transfers received from the government, G_t. Note that transfers enter as a constant (a fixed amount, in the consumer budget constraint) so it will not have any influence on decisions at the margin. This does not happen with tax rates, as they normally affect consumption savings and labour leisure decisions. Finally, to simplify our analysis, we assume government budget constraint is satisfied from period to period. Therefore, transfers received by consumers G_t are exactly equal to tax revenue (Note that the corresponding part of the depreciation of physical is deducted from the tax on income generated by the capital. We will define later how we arrive to that expression).

$$G_t = \tau_t^c C_t + \tau_t^1 W_t L_t + \tau_t^k (R_t - \delta) K_t \quad (5)$$

Model specification

We construct a DSGE model that incorporates taxes and three economic agents: consumers, firms, and the government. The government's role is limited to affecting the consumer budget constraint via taxes on consumption goods, capital income, and labor income to fund a series of predetermined lump-sum transfers: $\{\mathrm{T_t}\}_{\mathrm{t=0}}^{\infty}$

Households

Consider a model economy where the decisions made by consumers are represented by a stand-in consumer whose preferences are represented by the following instantaneous utility function:

$$\cup\,(C_t, H_t\overline{H} - L_t)\;\gamma log C_t + (1 - \gamma) log(1 - L_t) \quad (6)$$

Private consumption is denoted by C_t. Leisure is defined by $1 - L_t$, which is simply the number of effective hours minus the number of hours worked, L_t,

Where: total availability of time is normalized to 1. The parameter $(1 < \gamma < 1)$ is the proportion of private consumption to total private income. The budget constraint is faced by the stand-in consumer, as defined above is:

$$(1 + \tau_t^c)C_t + S_t = (1 + \tau_t^1)W_t L_t + \left(1 - \tau_t^k\right)R_t K_t + G_t \quad (7)$$

Where: G_t is the transfer received by consumers from the government, K_t is the private capital stock, W_t is the compensation to employees, R_t is the rental rate and τ_t^c, τ_t^1, τ_t^k are the private consumption tax, the labour income tax, and the capital income tax rate respectively (Tax rates are constant and can be interpreted as average marginal tax rates. Jonsson and Klein (996) use an isoelastic specification of the tax schedule rather than a linear one in order to capture the progressivity of income taxation). The budget constraints indicate that total consumption and saving cannot exceed the sum of labour and capital rental income net of taxes and lump-sum transfers. Capital stock evolves according to:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{8}$$

Where: δ is the capital depreciation rate, which is modelled as tax-deductible, and I_t is the gross investment. The problem faced by the stand-in consumer is to maximize the value of their lifetime utility given by:

$$Max_{(C_t,L_t)} \infty_t \sum_{t=0}^{\infty} \beta^t [\gamma \, log \, C_t + (1-\gamma) \, log(1-L_t)] \tag{9}$$

Subject to the budget constraint, the assumption is that;

$$S_t = I_t \, (1+\tau_t^c)C_t + K_t - K_{t-1} = (1-\tau_t^1)W_t L_t + \left(1-\tau_t^k\right)(R_t - \delta_{k-1}) + G_t \tag{10}$$

Givenτ_t^c, τ_t^1, τ_t^k and K_0 and where $\beta\epsilon(0,1)$ is the consumer discount factor. The Langrangian problem to be solved for the households is to chooseC_t, L_t, and K_t to maximize:

$$Max_{(C_t,I_{t,}L_t)} \; L = \sum_{t=0}^{\infty} \beta^t \{[\gamma \, log \, C_t + (1-\gamma) \, log(1-L_t)] - \lambda_t \big[(1+\tau_t^c)C_t + K_{t+1} - (1-\tau_t^1)W_t L_t - \left(1-\tau_t^k\right)(R_t - \delta)K_t - K_t - G_t]\} \tag{11}$$

First-order conditions for the household maximization problem are:

$$\frac{dL}{dC_t}: \gamma \frac{1}{C_t} - \lambda_t(1+\tau_t^c = 0 \tag{12}$$

$$\frac{dL}{dI_t}: -(1-\gamma)\frac{1}{1-L_t} + \lambda_t\left(1-\tau_t^l\right)W_t = 0 \tag{13}$$

$$\frac{dL}{dK_t}: \beta^t \lambda_t [\, (1-\tau_t^k)(R_t - \delta) + 1] - \lambda_{t-1}\beta^{t-1} = 0 \tag{14}$$

Where: $\beta^t \lambda_t$ is the Langrangian multiplier assigned to the budget constraint at time t. combining equations (12) and (14), we obtain the condition that equates the marginal rates of substitution between consumption and leisure to the opportunity cost of one additional unit of leisure:

$$\frac{1}{1-L_t} = \frac{\gamma}{(1-\gamma)} \frac{(1-\tau_t^1)}{(1+\tau_t^c)} \frac{W_t}{C_t} \tag{15}$$

Combining expression (12) with (13) we find the inter-temporal equilibrium condition that equates the marginal rate of consumption with the rate of return on investment:

$$\frac{(1+\tau_t^c)C_t}{(1+\tau_{t-1}^c)C_{t-1}} = \beta[\, (1-\tau_t^k)(R_t - \delta) + 1] \tag{16}$$

This represents the consumption optimal path. Notice that if we assume that the consumption tax is fixed over time, this particular tax will not affect the households' consumption-saving decisions.

The firms

The firm's problem is to find the best values for labour and capital utilization. The final output Y necessitates the services of labour L and K. Taking the factoring process as given, the firms rent capital and employ labour to maximize profit at period t. The technology is given by a constant return to scale Cobb-Douglas production function:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{17}$$

Where A_t is the measure of total-factor, sector-neutral, productivity and where $0 \leq \alpha \leq 1$.

The static maximization problem for the firm is:

$$max_{K_t L_t} \prod_t = A_t K_t^{\alpha} L_t^{1-\alpha} - R_t K_t - W_t L_t \tag{18}$$

The first-order conditions for the firms' profit maximization are given by:

$$\frac{d \prod_{t\cdot}}{dK_t} : R_t - \alpha A_t K_t^{\alpha-1} L_t^{1-\alpha} = 0 \tag{19}$$

$$\frac{d \prod_{t\cdot}}{dK_t} : W_t - (1-\alpha) A_t K_t^{\alpha} L_t^{-\alpha} = 0 \tag{20}$$

From these FOCs we obtain the price for the production inputs:

$$R_t = \alpha \mathrm{A}_t K_t^{\alpha-1} L_t^{1-\alpha} \tag{21}$$

$$W_t = (1-\alpha) A_t K_t^{\alpha} L_t^{-\alpha} \tag{22}$$

The government

Finally, we consider the role of the government as a tax-levying entity. It is assumed that the government uses tax revenues to finance lump-sum transfers, which are paid out to the consumers. We assume the government balances its budget period by returning revenues from distortionary taxes to agents via lump-sum transfers T_t.

The government obtains resources from the economy by taxing consumption and income from labour and capital, whose effective taxes are $\tau_t^c, \ \ \tau_t^1, \ \ \tau_t^k$ respectively. The government budget in each period is given as shown in Eq. 23.

$$\tau_t^c C_t + \tau_t^1 W_t L_t + \tau_t^k (R_t - \delta_k) K_t = G_t \tag{23}$$

The government keeps a fiscal balance in each period. This assumption is made to highlight the distortionary effect of taxes, mainly on capital accumulation (The assumption has been used by Barro(1990), Glomm and Ravikumar(1994), Cassou and Lansing(1998), among others. They argue that this setup may represent a closer approximation to actual constraints than one which allows the government to borrow or lend large amounts).

Equilibrium of the model

By combining the equilibrium conditions for both households and firms, we find that:

$$\frac{(1+\tau_t^c) C_t}{(1+\tau_{t-1}^c) C_{t-1}} = \beta [\, (1-\tau_t^k)(\alpha A_t K_t^{\alpha-1} L_t^{1-\alpha} \ \ - \delta) + 1] \tag{24}$$

$$\frac{C_t}{1-L_t} = \frac{\gamma}{(1-\gamma)} \frac{(1-\tau_t^1)}{(1+\tau_t^c)} \, (1-\alpha) A_t K_t^{\alpha} L_t^{-\alpha} \tag{25}$$

Finally, the feasibility condition of the economy must hold:

$$C_t + I_t = Y_t \tag{26}$$

A competitive equilibrium for our constructed economy is a sequence of consumption, leisure, and private investment$\{C_t, 1-L_t, I_t\}_{\cdot t=0}^{\infty}$ and for the consumers, a sequence of capital and labour utilization for the firm $\{K_t, L_t\}_{\cdot t=0}^{\infty}$ and a sequence of government transfers $\{G_t\}_{\cdot t=0}^{\infty}$, such that given a sequence of prices, $\{W_t, R_t\}_{\cdot t=0}^{\infty}$ and sequence of taxes, $\{\tau_t^c, \ \ \tau_t^1, \ \ \tau_t^k\}_{\cdot t=0}^{\infty}$:

From the above, the optimization of the consumer is satisfied. Given prices for capital and labour, and given a sequence of public inputs, the first-order conditions of the firm are satisfied concerning capital and labour. Given a sequence of taxes, the sequence of public transfers is

such that the government constraint is satisfied. Finally, the feasibility constraint of the economy is satisfied. Notice that according to the definition of equilibrium for our model economy, the government enters completely parametrized, and fiscal policy is made consistent with the model and the data. In other words, in our model, the private sector reacts optimally to policy changes, and these policy changes are given exogenously.

Calibrations and model equations

Calibration means that most of the values of the model's parameters are chosen from ''findings from the empirical outcome in a similar applied economic environment... '' (Kydland and Prescott 1996). The few remaining parameters are chosen to ''yield, as close as possible, a correspondence between the moments predicted by the model and those in the sample data'' (Plosser 1989). Moment-matching (the more crucial of the two steps) is an informal judgment of the proximity of the second moments implied by the calibrated model to the analogous sample moments. No formal probability-based metric is used in this evaluation.

The equilibrium of our model economy is very similar to the standard models, as the total number of endogenous variables and thus, the number of equations does not change the differences in the existence of three new exogenous variables, which are treated as constant. The competitive equilibrium of the model economy is defined by a set of eight equations, representing the dynamics of the endogenous variables, $Y_t, C_t, I_t, K_t, L_t, R_t, W_t$ and total factor productivity A_t and where three additional exogenous variables are included: $\tau_t^c,\ \tau_t^1,\ \tau_t^k$. The set of equations is as follows:

$$\frac{1}{1-L_t} = \frac{\gamma}{(1-\gamma)} \frac{(1-\tau_t^1)}{(1+\tau_t^c)} \frac{W_t}{C_t}$$

(Intertemporal equilibrium for consumption & rate of return on investment) (27)

$$\frac{(1+\tau_t^c)C_t}{(1+\tau_{t-1}^c)C_{t-1}} = \beta[\ (1-\tau_t^k)(\alpha A_t K_t^{\alpha-1} L_t^{1-\alpha}\ \ -\delta) + 1]$$

(Equilibrium -Households and firms) (28)

$I_t = Y_t - C_t$ (Resource Constraint) (29)

$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$ (Production Function) (30)

$K_{t+1} = (1-\delta)K_t + I_t$ (Capital stock equation) (31)

$R_t = \alpha A_t K_t^{\alpha-1} L_t^{1-\alpha}$ (Marginal Capital rate equation/ROC) (32)

$W_t = (1-\alpha) A_t K_t^{\alpha} L_t^{-\alpha}$ (Marginal Wage rate equation/ROL) (33)

$lnA_t = (1-\rho A)\ ln\bar{A} + lnA_{t-1} + \varepsilon_t^A$ (Total Factor Productivity) (34)

To calibrate this model economy, we only need additional information about tax rates, which are assumed to be constants. The model parameters to be calibrated are: $\Omega = \{\alpha, \beta, \gamma, \delta, \rho A, \sigma A, \tau_t^c,\ \tau_t^1,\ \tau_t^k\}$

The model's calibrated parameters, which are displayed below, were taken into account and rationalized by taking into account the unique characteristics of the Sierra Leonean economy. The tax rates are the effective average tax rates for the Sierra Leone economy estimated by taking into account the prevailing tax rates in the economy as of 2022. Computational macroeconomic models of fiscal policy crucially depend on realistic measures of tax rates. Agents' decisions depend on marginal tax and therefore, effective marginal taxes should be used in the calibration. However, estimating marginal tax rates is a difficult task and, as pointed out by Mendoza, et al (1994), it is often impractical at the international level given the limitations, which is due to data limitations and difficulties in dealing with the complexity of tax systems.

Mendoza et al. (1994) proposed a method to estimate effective average taxes and show that these are within the range of marginal tax rates estimated in other works and display very similar trends. On the other hand, these authors argued that their definition of effective average tax rates can be interpreted as an estimation of specific tax rates that a representative agent, in a general equilibrium context, takes into account. Average effective tax rates involve the use of conservative values (smaller implied behavioural responses) relative to marginal taxes. Utilizing the strategy suggested by Mendoza et al (1994). We calibrate the model using effective average tax rates. Table 1 shows the estimated average tax rates for the three tax rates considered.

Table 1. Tax rates calibrated values for Sierra Leone

Tax Group	Type	Tax Rate	General Tax Rate	Representative Tax Rate	Calibrated Value
Consumption Tax (τ_t^c)	Goods and Services Tax (GST	15%	15%	15%	0.150
Labour Income Tax (τ_t^1)	Pay-as-you-Earn (PAYE)	0% - 30%	30%	14%	0.140
	Payroll Tax	Le1.5M & Le5M	F		
	Payment to resident Contractors	5.5%	5.5%		
	Payment to non-resident Contractors	10.5%	10.5%		
	Management Fees	10%	10%		
Capital Income Tax (τ_t^k)	Corporate Income Tax (CIT)	25%	25%	17%	0.170
	Capital Gains Tax (CGT)	25%	25%		
	Interest Payment	15%	15%		
	Dividends	10%	10%		
	Rent	10%	10%		

Source: Authors calibration using existing tax structure

Note that these average Tax Rates are unweighted as it represents the mean value for the above tax brackets. As part of the calculation, the higher tax bracket is used, as it represents the top marginal rate. Also, the payroll tax was ignored as part of the average tax rate for Labour Income Tax as it is a fixed amount and its contribution to the total labour income tax is very small. The parameters of the model are restricted so that it matches key features of the current peculiarities of the Sierra Leone economy. Using data from the National Revenue Authority, we determine the effective tax rates as of 2022. Whilst the rest of the calibrated parameter values are shown in Table 2 below.

Table 2. Model parameter calibrated values

Parameter Definition	Values
Technological Parameter (α)	0.350
Discount Factor (β)	0.970
Preferences Parameter (γ)	0.450
Capital Depreciation Rate (δ)	0.060
TFP Autoregressive Parameter (ρA)	0.950
TFP Standard Deviation (σA)	0.010

Source: Authors calibration using existing literature, and knowledge of the Sierra Leone economy

In the output equation, the parameter α is a production parameter that, according to the literature, typically ranges from 0 to 1, and is primarily at the lower end of the range for small underdeveloped countries with very low national productivity. We utilize an Alpha density distribution with parameters based on this assumed theoretical foundation (0.3, 0.4). The variables agree with the previous mean of 0.35. The beta distributions' parameters were selected to base their weight on theoretically sound numbers. In the equation for consumption, the parameter β is a discount factor. It must fall within the range of 0 and 1, and is probably closer to the higher end. A prior beta distribution with parameters is used (0.90, 0.99). These variables agree with a previous mean of 0.95. The Preferences Parameter (γ) or tax preference, means an exemption, exclusion, deduction, credit, deferral, or preferential rate, for a tax administered by the tax authorities. We calibrate it to be 0.450 for the Capital Depreciation Parameter (δ) in the capital accumulation equation. It commonly lies between 0 and 1, mostly in the lower end of this distribution. Economic theory indicates that this will be negative. Because maintenance seems to be low and wear and tear is severe, capital depreciation is high in tiny developing economies. As a result, it is calibrated at 0.060 to reflect its impact on the economy of Sierra Leone.

The parameter ρA is a persistence parameter in the productivity equation for the autoregressive parameter. It often falls at the higher end of this density distribution, between 0 and 1.Therefore, we use a Rho distribution, with parameters (0.66, 0.99). This is also consistent with the prior mean of 0.8. The literature is used to determine the standard deviation of TFP, which is often stated as 0.010. With the use of technological shocks, the model is calibrated. However, given these disturbances signify technological development, it is possible to infer that there may be some relationship between current technical advancement and tax receipts.

It should be noted that ρA is a parameter characterizing the stochastic process for an investment-specific technology shock and that it is equivalent to the process for a neutral shock. The theoretical factors described above and our understanding of the economy of Sierra Leone, which includes the current tax structure, have guided our earlier decisions for all criteria. A distribution is selected for all priors since all parameters may be rationally constrained to the unit interval. To support the weight of preceding mass on ideally adequate values, the distribution's parameters were selected.

Results and Discussion

This section presents the simulation results of the DSGE tax Model constructed with parameter values calibrated for the Sierra Leone economy. The section is presented in the following order: firstly, the simulation result of the impulse response function of the various tax changes under different scenarios. This was done to observe the short-term and steady-state impact of tax changes: output, consumption, investment, and fiscal revenues. Furthermore, the analysis went on to assess the impact of an increase in consumption tax, while keeping labour income and capital income tax at the current rate. Finally, a simulation was done that accounted for simultaneous multiple tax decreases in consumption tax, labour income tax, and capital income tax. This was done to see the direction of movement of the key macroeconomic variables and observe any substitution effect by economic agents.

Tax model simulation results

Table 3's computed eigenvalues demonstrate that the model is stable, which is a requirement for the uniqueness of a stable equilibrium in the vicinity of the steady-state. This implies that there must be as many eigenvalues larger than one in modulus as there are system-wide variables with a forward-looking component. The stability of the model suggests that the Blanchard-Kahn criteria is satisfied, this establishes the local conditions (which are particularly simple to verify

in terms of eigenvalues calculated at the model's steady state) and must be met for the existence and uniqueness of a solution. Furthermore, as shown by the model simulation results below, the model found the perfect foresight solution because the errors after each iteration of the Newton solver used to estimate the solution to our model are decreasing with each iteration. This indicates that the model does not have a convergence issue.

Table 3. Model Simulation results and post estimation diagnostics

Steady-State Results of the Prevailing Tax Rate:		
Y (Output)	0.53488	
C (Consumption)	0.432351	
I (Investment)	0.102528	
F (Fiscal Revenues)	0.127922	
Steady-State Results After An Increase In Consumption Tax (τ_t^c)):		
Y (Output)	0.51878	
C (Consumption)	0.419337	
I (Investment)	0.099443	
F (Fiscal Revenues)	0.145038	
Steady-State Results After Decreases In Consumption(τ_t^c), Labour Income(τ_t^l) And Capital Income(τ_t^k):		
Y (Output)	0.580081	
C (Consumption)	0.459507	
I (Investment)	0.120574	
F (Fiscal Revenues)	0.110754	
EIGENVALUES:		
Modulus	**Real**	**Imaginary**
0.8791	0.8791	0
1.21	1.21	0
inf	Inf	0
There are 2 eigenvalue(s) larger than 1 in modulus for 2 forward-looking variable(s) The rank condition is verified.		
MODEL SIMULATION:		
Iter: 1,	err. = 0.0483368,	time = 0.108879
Iter: 2,	err. = 6.8352e-05	time = 0.105728
Iter: 3,	err. = 1.49278e-08,	time = 0.106316

Source: Matlab with Dynare interface.

Impulse response functions

From Figure 1 below, in the simulation of an increase in consumption tax, the tax rates increased from the current consumption tax of 15% to 20%, which is an increase of 5 percentage points. Figure 1 below shows the effect of a tax increase on output, consumption, investment, and fiscal revenues.

Output reduces sharply followed by a slow decline to the new lower steady-state, which is equivalent to 3.1% less than it pre-shock value. Similar behaviour is observed for consumption, which declined by 3.01% in the long run. In the case of investment, we also observe a contraction of 3.01% as a result of the increase in the consumption tax rate, which will eventually feed into the decline in output. The impact on the household sector suggests that an increase in the consumption tax rate would push consumer prices up. The consequent fall in real incomes depresses real consumer spending and real GDP. Tax policy directly affects the economy by altering the demand for goods and services. This “Keynesian” effect, however, is supposed to be temporary and should last a few years at most, after which the economy will return to its underlying sustainable level. However, the distortionary effect appears permanent over the simulated horizon.

Fiscal revenues increase almost instantaneously in the short-run and to their new steady-state value, which is 15% higher than the pre-shock fiscal revenue levels. This observation pertains to the disruptions resulting from the distortionary impacts of consumption tax rates. This effect is manifested through the inter-temporal effect, where individuals make trade-offs between consumption and leisure, leading to changes in investment decisions. It can be observed that adjustment of the economy to the new steady-state is relatively fast for output and fiscal revenues but slower for consumption and investment. Note that this model does not account for the income and wealth effect caused by a change in taxes as it assumed that tax revenues return to consumers as lump-sum transfers.

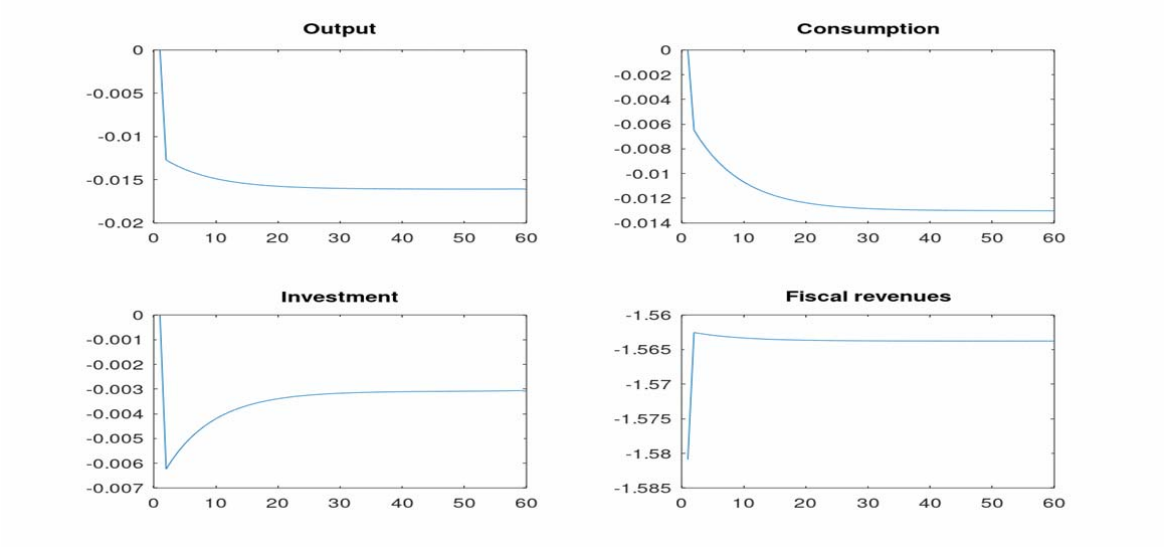

Fig.1. Short Run Reactions After a Consumption Tax Increase

Source: Matlab with Dynare interface.

From Figure 2 below, the simulation of a tax decrease by 5% on consumption tax, labour income tax, and capital income tax from the current rates indicates a positive impact on output, consumption, and investment.

Output increase by 8.45% in the long run. Tax reduction increase income after taxes. Most of the time, people spend part of their extra cash, which increases the demand for products and services. Businesses expand production in response to the rising demand. As a result, the demand for investment items may fluctuate, as may the cash flow of businesses or their motivations to invest. The direct effects of tax policy on demand can be complemented or countered by indirect effects. For instance, greater spending by those who receive tax breaks results in money for other people, who then boost their own spending. Similar to this, when businesses increase their personnel to accommodate rising demand, the newly hired employees may further increase demand and hence increase output. Tax reductions geared toward the low-income population have a disproportionately substantial impact on demand since they often spend the majority or all of their tax refunds. Contrarily, the effect of tax cuts aimed toward higher-income persons on demand would be relatively smaller because they may save a large percentage of a tax cut, especially if the cut is transitory.

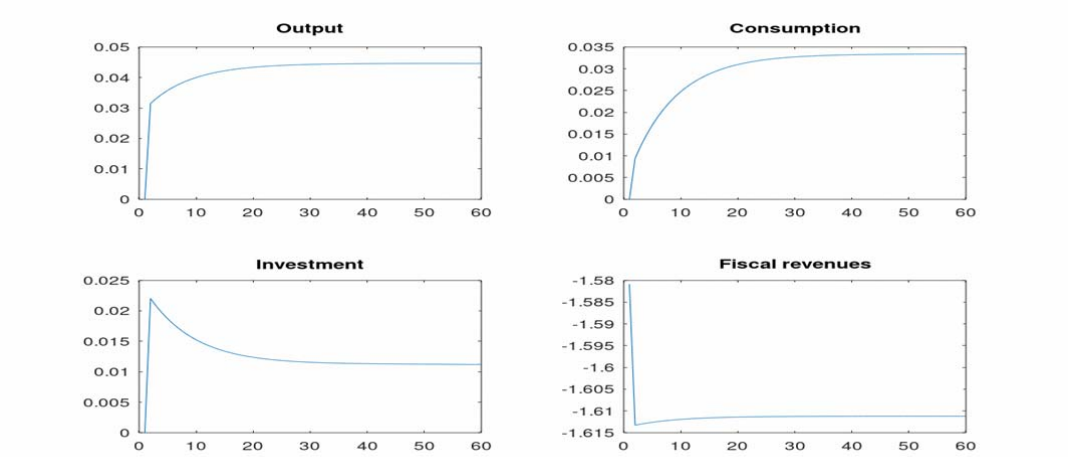

Fig. 2. Short Run Reactions after Consumption, Labour, And Capital Tax Decreases

Source: Matlab with Dynare interface.

Fiscal revenues in Figure 2, decline in both the dynamic short-run and steady-state long-run by 1.7%. These results suggest that the authorities should synchronize policy to manage the trade-off between welfare gains, output growth, with the need for more fiscal revenue mobilization. Tax policy has an impact on the government's budget deficit, which has an impact on the economy as well. The deficit grows as tax receipts decline (all else equal). Increased government borrowing caused by a higher deficit lowers the amount of money available for private investment since savings that would have gone to private investment are instead used to pay for the debt. Without adequate policy measures, a temporary rise in the deficit can quickly spiral out of control as the level of public debt increases. Interest rates rise as a result of rising debt as the government vies with the private sector for limited resources. The cost of debt service for the government rises as a result of rising interest rates and increased debt, thereby increasing the deficit and debt. The benefits of the tax cut to the economy eventually tend to be overshadowed by the deficit impacts. Tax cuts need not negatively affect the budget, and consequently the macro-economy. An increase in the motivation to labour to save would raise investment and the output level, as would a tax reform that decreased marginal rates while maintaining average rates. Even with the same average rates, the higher output would suggest higher taxable incomes, increasing revenue.

However, history indicates that the macroeconomic effects on revenue are not likely to be significant. Conventional predictions of tax plans that were later approved (i.e., those that disregard macroeconomic implications) don't seem to deviate significantly from actual results. That is to say, contrary to what one might predict if tax changes had significant macroeconomic consequences, conventional evaluations of tax changes have not consistently exaggerated either the revenue gains from tax hikes or the revenue losses from tax cuts. Large tax increases are likely to have a variety of diverse and frequently countervailing effects on the economy, which could be one reason why.

Output in the dynamic short run from Figure 2 below, increases instantaneously followed by a steady and persistent upward trend. Similar behaviour is observed for consumption which increases rapidly as lower consumption tax tends to induce more consumption by economic agents. In the case of investment, we observe an instantaneous jump in the short-run but eventually it declines to a value higher than the pre-shock situation. The observed decline in investment after an initial rapid increase could be explained by the fact that the determinant of investment in Sierra Leone is not just tax rate, but other considerations that are outside the remit of tax policy (for example, electricity, stable exchange rate, human capital, regulatory environment, etc.).

The findings in our study are consistent with several empirical studies on the impact of tax changes in an economy. For example, Alesina and Ardagna (2010) found that fiscal adjustments based on spending cuts are less harmful on an economy than those based on tax increases, which is consistent with the observed decline in output and investment in our tax increase simulation. One potential explanation for this finding is that spending cuts may be less harmful to private sector confidence and expectations than tax increases. Tax increases can be viewed as a negative signal about the state of the economy, which may lead to reduced confidence and investment by households and businesses. In contrast, spending cuts may be viewed as a positive signal about the government's commitment to fiscal responsibility and may lead to increased confidence and investment.

Moreover, Hines Jr. (2010) found that consumption taxes can have positive effects on savings and investment, but can also lead to distortions and reduced consumer welfare, which aligns with the observed decrease in aggregate consumption as consumer taxes rises and by logical extension the fall in real incomes in Sierra Leone. This suggests that while consumption taxes may have some benefits in terms of encouraging savings and investment, they can also have negative consequences for consumer welfare and the overall economy if not implemented carefully.

Furthermore, Cloyne et al. (2022) found that temporary tax cuts can provide short-term stimulus effects while also generating positive long-term growth effects. Specifically, the authors find that a temporary tax cut leads to an increase in output and employment in the short run and can have positive spill-overs on long-term growth through channels such as increased research and development and capital accumulation. Which can be implicitly deduced from our findings.

Likewise, Martinez (2022) analysed the macroeconomic effects of tax changes in the United States using a DSGE model, concluding that tax changes have significant implications for the overall economy, including consumption, investment, and employment. For example, the study found that a reduction in tax rates can stimulate consumption and investment, leading to an increase in employment in the short run. However, in the long run, the effects of tax changes can be more complex and depend on a range of factors, such as the level of government debt and the overall state of the economy. Which entirely agrees with our findings.

By using a DSGE model, we have provided a more nuanced understanding of the complex relationship between taxes and the broader economy in Sierra Leone, highlighting the need for careful analysis and modelling when making decisions about tax policy. While tax increases may generate much-needed revenue for the government, they can also have negative effects on economic output, consumption, and investment. Careful consideration of the distributional effects and the optimal tax policy is necessary to ensure sustainable economic growth.

Conclusion

In this paper, we have developed a DSGE model that is typical of Torres' (2013), with the introduction of tax as a component. In practice, it implies the introduction of a third economic agent (the government) in addition to households and firms, and its calibration to reflect the peculiarities of the Sierra Leone economy. In particular, we considered the existence of three different taxes - consumption, labour income tax, and capital income taxes. In standard fiscal systems, there are other types of taxes – typically corporate profit, lump sum, and PAYE schemes. Contributions to Social Security can also be considered as an additional tax.

In this simple framework, the only role assigned to the government is to achieve a certain level of fiscal revenues by taxing inputs, income, and consumption, and then return fiscal revenues to consumers as lump-sum transfers with the additional assumption that government budget constraints are fulfilled period to period. The key point in the analysis is, that those taxes have distortionary effects on the decisions of individuals and firms. We found that taxes are indeed

distortionary to output, investment, consumption, and fiscal revenues and could alter economic behaviour in profound ways.

By altering the incentives to work, save, and invest, tax policy has the potential to change the economy's long-term sustainable output. These consequences are partially determined by marginal tax rates or the tax rate on increased income in Leones. Policymakers and the general public should take into account the macroeconomic impacts of tax legislation while evaluating tax proposal. Economic growth is one of the objectives of tax law, and this objective might be particularly important during recessions. But the significance of the macroeconomic effects of tax policies is frequently underestimated. Generally speaking, Sierra Leone has a poorly functioning economy with constrained labour markets, underdeveloped capital markets, and a lax application of the law. Given this weak base, changes in tax policy on the scale of those that have been simulated in for this study will tend to affect the economy rather more fundamentally.

Moreover, our paper also highlights the importance of considering the timing, direction and magnitude of tax changes. In summary, our findings demonstrate the usefulness of DSGE models in analysing the macroeconomic effects of tax changes and provide useful insights for policymakers on the potential implications of various tax changes on the economy.

Acknowledgements

We wish to express appreciation to colleagues at the Bank of Sierra Leone for their time spent discussing outcomes and reviewing the final (Dr. Robert R. Korsu and Mr. Emerson A. Jackson). We also express our sincere gratitude to the Director of Research at the National Revenue Authority, Dr Philip Kargbo for his tremendous contributions.

Disclaimer

This paper is a product of the authors. Therefore, the views expressed in this are those of the authors and do not represent that of the institutions with which they are associated.

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