Tax Capacity and Effort in Sub-Saharan Africa: A Panel Stochastic Tax Frontier Analysis of Efficiency

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Abstract: Taxation plays an important role in generating revenue for economic development and government expenditure finance in many developing countries. This study measures the efficiency of the tax system in Sub-Saharan Africa (SSA) through stochastic tax frontier analysis of tax capacity and tax effort based on Battese and Coelli's Maximum likelihood random effect time-varying inefficiency effects model. By using data from 2000 to 2020, the study finds that Value-Added Tax (VAT), Corporate Income Tax (CIT), Personal Income Tax (PIT) and International Trade Tax operate close to their frontiers. In addition, the efficiency of the tax system in terms of tax effort is adversely affected by institutional factors such as corruption and political violence, while Government effectiveness positively affects tax efficiency, especially international trade taxes. For specific country results, Cameroon has the highest tax effort and DR Congo has the lowest for VAT, while for CIT, Cameroon has the highest effort, while Zimbabwe has the lowest. Rwanda has the highest tax effort for PIT, while Zimbabwe has the lowest for international trade tax; Lesotho and Namibia have the highest effort, while Mauritius has the lowest. In respect of tax capacity, Namibia has the highest, while Ethiopia has the lowest. The study recommends that countries should improve their tax systems by broadening the base of their various tax handles and adopting digital technology to reduce human contact in tax collection.

1. Introduction

To achieve economic development and the ability to finance public infrastructure, education, health and national defence, among others, depend on efficient tax

revenue mobilisation. According to the World Bank, the tax revenue to GDP ratio in SSA averaged 16% in 2021, relative to an average of 34% in OECD countries (World Bank development database, 2023). In 2021, the OECD countries' tax-to-GDP ratio was on average 34%, while that of Asia-Pacific was 20%. However, the issue of domestic revenue mobilisation remains a problem for many governments in developing countries, especially in Sub-Saharan Africa. This has led to a call on African countries to improve their tax performance to generate more revenue by undertaking reforms to expand the tax bases and revise the existing tax rates, which feed into the tax capacity and tax effort of various countries (Besley et al., 2013; Gupta et al., 2008).

This study therefore attempts to examine the causes of low tax performance in the Sub-Saharan Africa region with focus on tax capacity and tax effort and how efficiently these influence tax revenue generation, particularly on selected tax handles such as, value added tax (VAT), corporate income tax (CIT), personal income tax (PIT) and international trade tax (ITT). In addition, the study estimates the baseline scores of selected countries in terms of their tax capacities and tax efforts to compare their revenue generation performances.

Conceptually, tax capacity of a country refers to the maximum level of revenue achievable, while tax effort is the ratio of the actual tax revenue generated to the tax capacity (Pessino & Fenochietto, 2010). For effective tax policy design, a good knowledge of a country's tax effort is required as it informs countries about the extent to which they can utilise their tax capacities to mobilise revenue leveraging on their social, demographic, economic and institutional factors (IMF, 2023; Tagem, 2021).

Since 2015, there has been a growing interest in taxation fueled by several factors, including debt sustainability issues occasioned by widening fiscal deficits, particularly in SSAs. Furthermore, the desire to achieve developmental goals has positioned taxation as an important catalyst for national development (Mawejje & Sebudde, 2019; Gupta, 2007).

In addition, the post-2010 tax reforms across sub-Saharan Africa saw a steady increase in tax revenues. For example, Ghana recorded an increase from 8.90% before 2010 to 11.54% after 2010, while Togo saw an increase from 9.64% before 2010 and 12.88% after 2010. Madagascar's tax revenue also increased from 8.90% to 9.30%. Despite these increases in the tax performance, it remains behind the global averages

due to the high levels of informalities associated with the region (Makochekanwa, 2020). This low tax revenue generation gives rise to low tax efforts, even though there is a huge tax potential in these countries. Therefore, understanding the factors that influence the capacity and tax effort of the overall tax system and the main tax handles in selected countries of SSA becomes imperative.

From a policy perspective, the growing interest of African countries to reach the fruition of the agreed Sustainable Development Goals (SDGs) by the United Nations member countries also plays a major part in the rationale for internal revenue mobilisation by the sub-Saharan Africa region. This led to further modernisation of tax systems, reformation of tax policies and improving the efficiency of tax systems in order to meet the optimum tax revenue collection while considering the deleterious impact taxes may have on taxpayers in countries (Amo-Yartey et al., 2019).

The main goal of this study is to determine the efficiency of tax systems in selected countries in SSA from 2000 to 2020 by applying the Stochastic Frontier Analysis to estimate the tax capacity and tax effort. To achieve the main objective, the study specifically seeks to examine the potential factors driving the tax capacity and effort of various tax handles in SSA and to estimate the taxable capacity and effort of tax handles for selected countries.

The rest of the study is organised as follows: the next section deals with the review of related literature and followed by section three, which covers the methodology and data while the section four presents the results and the discussion and the final section concludes the study with policy suggestions.

2.1. Theoretical Literature

Tax capacity is the maximum amount of tax revenue that could reasonably be realised by a country within a specified time, based on the prevailing characteristics of the country, while tax effort is expressed as the extent to which the actual tax revenues collected by a country reach its estimated tax capacity. (Langford & Ohlenburg, 2015). The effort is seen as a reflection of the policy choices and enforcement protocols implemented by governments to generate tax revenue. The tax effort of a country is thus considered as an "unused tax potential" characterised by enforcement issues (Alfirman, 2003).

The concept of tax capacity and effort has been studied under different methodological frameworks since its inception. However, the advent of stochastic

frontier analysis in efficiency studies changed the course of research into tax capacity and tax effort in the literature. The Stochastic Frontier Analysis was initiated by Aigner et al. (1977), Meeusen and Broeck, (1977), and Battese and Corra (1977) based on the Cobb-Douglas Production function, which assumes complete efficiency of firms and industries. However, a modified version of the production function that includes an inefficiency term is used to indicate the fact that there is a level of inefficiency associated with every production process, which tends to prevent firms from operating on their frontiers.

Following the introduction of stochastic frontier analysis, several efficiency models emerged based on the pioneering ones. These models include Pitt and Lee (1981) with a half-normal distribution model, Schmidt and Sickles (1984) with a fixed effects model, Kumbhakar (1990) with a maximum likelihood random-effects flexible time-varying efficiency model, Battese and Coelli (1995) with a maximum likelihood random-effects time-varying inefficiency model, and Green (2005) with true fixed effect and true random effect models. The majority of these models have been applied in the study of tax capacity and tax effort of countries. Dalamagas et al. (2019), however, criticised these standard econometric models on the grounds that the models are unable to trace how the optimal tax revenue is allocated to the fiscal objectives of countries, either in equity or efficiency.

Pessino and Fenochietto (2013) further opined that the stochastic tax frontier model and the production frontier models are similar, with two main differences. The first difference is that the latter's output is produced specifically by capital, land and labour explicitly, but it is not clear with the former, although GDP per capita and level of education have been identified as major determinants of revenue generation. Secondly, the difference lies in the interpretation of the results, with the production frontier, the gap between actual output produced and the frontier estimates represents the level of inefficiency by firms or countries. For the tax frontier model, the difference between actual tax revenue collected and estimates of tax capacity from the stochastic frontier tax revenue model reflects the technical inefficiencies attributable to policy inconsistencies, which could be modified by nations through tax codes, tax bases, tax rates and tax laws (Stewart, 2002).

2.2. Empirical Literature

Studies that have empirically tested the above models include Mawajje and Sebudde (2019), who conducted a study using the SFA on the ICTD dataset for total tax, direct

tax, indirect tax, income tax, corporate tax, goods and services tax, as well as trade tax. They found GDP per capita, trade openness, non-agricultural GDP, health expenditure, inflation, and corruption to be statistically significant for each of the tax handles. Also, to estimate the determinants of the tax-to-GDP ratio, Addison and Levin (2011) used the Generalised Method of Moments (GMM) technique and established that agriculture, openness, GDP per capita, population, aid, conflict, and a VAT dummy are statistically significant for the following taxes: total tax, trade tax, direct tax, and indirect tax. The study concluded that openness, agriculture, population and conflict are important considerations for tax revenue generation in the study countries.

Additionally, Brafu-Insaidoo and Obeng (2020) applied SFA on Ghana's dataset for direct and indirect taxes. The study found statistical significance for tax base, institutional reform index, foreign grant, foreign loans, government current and capital expenditure, inflation rates and urban population. They concluded that the reduction of inefficiencies in the Ghanaian tax system requires a robust political system, strong executive constraint and institutionalised democracy as these factors tend to enhance public goods provision, improved accountability and inclusivity.

It can be derived from the reviewed literature above that countries with higher tax revenue to GDP tend to have higher GDP per capita, liberalised trade (openness), and a low agricultural sector. Hence, these form the inputs to the tax frontier analysis, akin to the capital, land and labour inputs for the production frontier analysis. However, this study augments the tax frontier model with other factors such as institutions and demographic variables to ascertain their roles in countries' tax systems. In addition, the study uniquely estimates tax effort and tax capacity of various tax handles for sub-Saharan African countries.

3.1. Models and Data

3.1.1. Theoretical Model

The study adopts the theoretical stochastic frontier framework of Aigner et al. (1977) and Meeusen and Broeck (1977) in explaining tax capacity. It starts by assuming that in an ideal world, tax administration in a country collects tax revenues.

The stochastic frontier model of Aigner et al. (1977) has been identified as the standard econometric model for the analysis of tax effort. It relates to the production function approach, where the inputs of the function give the maximum level of output.

This is expressed as:

$$T_{it} = f(X_{it}; \beta) \tag{1}$$

Where T_{it} is the observed tax revenue as a percentage of GDP for a country i in period t, x_{it} is the vector that represents variables affecting tax revenue for the country i at the time t, and β is the vector of unknown parameters.

While the production model assumes technical efficiency with no shocks in existence, the stochastic frontier model argues that tax collection faces some level of inefficiency, and hence the revenue generated from taxes falls below par, in that case. ψ_{it} defined as the level of inefficiency multiplied by the Tax revenue function and yields:

$$T_{it} = f(X_{it}; \beta) \, (\psi_{it}) \tag{2}$$

Where ψ_{it} is the level of inefficiency bounded at (0, 1)

If $\psi_{it} = 1$ then, the optimum amount of tax revenue is collected by the tax authorities given the available inputs X_{it} (specific institutional, economic, and demographic characteristics) that define the tax base of a given country. When $\psi_{it} < 1$, this indicates the inefficiencies that prevent the tax authorities from exacting maximum taxes. It further assumes that tax collection and technical inefficiencies are strictly positive, thus, $T_{it} > 0$ and $\psi_{it} > 0$. Also, the overall tax collection function is subject to stochastic shocks such that:

$$T_{it} = f(X_{it}; \beta) . \, \psi_{it}. \, e^{v_{it}} \tag{3}$$

The expectation that the deviation from expected production is a result of;

(a)   a random error process defined by $e^{v_{it}}$ and

(b)   inefficiency denoted by ψ_{it}

The standard econometric representation of a production stochastic frontier is derived by taking natural logarithms of the production function above. The results of the application of the natural logarithm are obtained by following Aigner et al. (1977) and defining the new denominations as:

$$y_{it} = \ln(T_{it}); \; x_{it} = \ln(X_{it}); \; v_{it} = \ln(V_{it}); \; u_{it} = -\ln(\psi_{it})$$

Now provided below is a panel representation of the stochastic frontier function we would estimate in this study.

$$\Rightarrow y_{it} = \alpha + \beta' x_{it} + v_{it} + u_{it}$$
$$but \; u_{it} = -\ln(\psi it) \tag{4}$$

Hence, the final model specified is given as:

$$y_{it} = \alpha + \beta' x_{it} + v_{it} - u_{it} \tag{5}$$

The model requires that u_{it} (as inefficiency) be subtracted from the function, and hence the minus sign of the u_{it} in the final function.

Where:

y_{it} represents the natural logarithm of tax revenue as a percentage of the GDP of the country i at time t, x_{it} denotes the vector of the log of variables affecting the tax revenue, β represents a vector of the unknown coefficients to be estimated in the model, v_{it} is the random statistical noise which represents the independent variables that explain the dependent variable but are not explicitly taken into account. It also represents measurement error and the case of incorrect functional form. It can be positive or negative, and so on the deterministic part of the stochastic frontier model, the output varies and u_{it} denotes the inefficiency associated with country-specific factors which contribute to the country i inability to attain its tax capacity at a time t, and also the inefficiency associated with extracting the maximum level of tax revenue.

While $u_{it} > 0$, v_{it} may take any value.

It is, however, also assumed that,

$$- v_{it} \sim iid \ N(0, \sigma^2_v)$$

In other words, v_{it} has a symmetric distribution, such as the normal distribution.

$$- u_i \sim iid \ N^+(0, \sigma^2_u)$$

where v_i and u_i are statistically independent of each other

Furthermore, the main aim of this analysis is to estimate the technical efficiency effects, and in doing so, we compute technical efficiency following the definition of tax effort which is defined as the ratio of the actual taxes collected to the estimated tax capacity (that is, the corresponding stochastic frontier tax revenue). This measure yields a value between 0 and 1.

The mathematical formula for estimating the Technical Efficiency (TE) is expressed as:

$$TE_{it} = \frac{T_{it}}{e^{(\alpha + \beta' x_{it} + v_{it})}} = \frac{e^{(\alpha + \beta' x_{it} + v_{it} - u_{it})}}{e^{(\alpha + \beta' x_{it} + v_{it})}} = e^{(-u_{it})} \tag{6}$$

Where, TE_{it} is the Technical Efficiency, T_{it} is the observed tax revenue without inefficiency, and the denominator is the tax capacity (the maximum attainable level of tax or the maximum potentiality of tax revenue achievable). There is a fraction as a result of deducting the inefficiency term from the numerator. Hence, unlike in the Ordinary Least Squares Regression, where Tax effort values may be greater than 1, which may require further assumptions to explain the results. This one ranges between 0 and 1, and with no difficulty in explanation.

More so, it is captured in Kumbhakar and Lovell (2000) that the technical efficiency of a country *i* at time *t* is the ratio of the actual output (T_{it}) to maximum or potential output (that is, tax capacity), hence 1 minus the technical efficiency would yield technical inefficiency since technical efficiency is less than one. Pessino and Fenochietto (2010) also defined it as the ratio of the actual tax revenues to the stochastic frontier estimate (that is, the maximum output).

3.1.2. Empirical Framework

This study employs panel stochastic frontier analysis by controlling for country-specific demographic, economic, and institutional characteristics that may change over time within the selected sub-Saharan African countries.

The stochastic tax frontier analysis is expected to provide a better analysis of efficiency than the methods of estimation that dominate the literature. In fact, a single cross-sectional analysis would be viable provided the data in use does not exhibit time-varying qualities because the structured panel data would be irrelevant. This can happen when u_{it} and v_{it} are independent over time and across countries as well. So, the strength of the cross-sectional overpowers the panel data and cross-sectional frontier models, such as the normal-half model of (Aigner et al., 1977) is applied to the pooled data set, which is obtained through maximum likelihood estimations or the gamma models by Greene (1990). Kumbhakar (1990) and Greene (2005) captured the log-likelihood function of the above frontier models.

This study determines the factors that influence various tax handles' revenue capacity and efforts by using the Battese and Coelli (1995) procedure for estimating time-varying inefficiency for panel data. The model is estimated in a *random effects framework* using the method of *Maximum Likelihood Estimation (MLE)*. The reason for considering this model over other models is that the result separates the determinants of inefficiency from the overall determinants of the tax capacity

frontier. Institutional variables are usually considered in determining inefficiencies in tax systems of countries, which indicates that the inefficiencies in tax systems are mostly through the institutional variables such as control of corruption, political stability and no violence, government effectiveness, among others. Furthermore, the Battese and Coelli (1988) approach helps to obtain predictions for technical efficiency and estimation of tax capacity, which measures the maximum amount of tax revenue that a country could potentially collect if it operates on the frontier, given a set of inputs.

The stochastic frontier analysis improves the identification of tax effort and also produces potential determinants that could manifest higher tax capacity and tax effort scores for countries. The empirical model for the estimation of the stochastic tax frontier analysis is given as:

$$\ln(T_{it}) = \beta_0 + \sum_{j=1}^{k} \beta_i \ \ln(X_{it}) + v_{it} - u_{it}$$

(7)

T_{it} represents the dependent variable, which could be any of the tax handles under study as a percentage of GDP. X_{it} represents a matrix of explanatory variables including economic, demographic and institutional variables, v_{it} denotes the noise component, u_{it} denotes the technical inefficiency associated with the frontier model. The specific explanatory variables include GDP per capita, trade openness, agriculture value added, population (15-65 years), grants, final consumption expenditure, consumer price index, political stability, government effectiveness, and corruption perception index.

3.1.3. The estimation model

The estimation model for the individual tax handles is presented below:

$\ln(thandle_{it}) = \ \beta_0 + \beta_1 \ln(gdppc) + \beta_2 \ln(tradeop) + \beta_3 \ln(agricva) + \beta_4 \ln(pop15up64)$
$+ \ \beta_5 \ln(conspi) + \beta_6 \ln(grant) + \beta_7 \ln(consexped) + \beta_8 \ i.lowincdummy$
$+ \ v_{it} - emean \ (\beta_1 \ln(goveff) + \beta_2 \ln(corrpi) + \beta_3 \ln(polstab))$

where;

'*thandle*' denotes the tax handle under consideration (that is, VAT, CIT, PIT or INT Trade Tax), '*gdppc*' denotes GDP per capita, '*tradeop*' represents trade openness, '*agricva*' represents agricultural value-added, '*pop15up64*' denotes population of 15 to 64 years of age, '*conspi*' denotes consumer price index, '*grant*' denotes grants (foreign), '*consexped*' represents final consumption expenditure (general

government), '*goveff*' denotes government effectiveness, '*corrpi*' denotes corruption perception index, and '*polstab*' represents political stability.

3.1.4. Sources of Data and Variables

Table 1: Data sources and variable description

	Variables	*Description*	*Source, Date*
1	Value-Added Tax revenue (% of GDP)	Tax levied on the consumables for every value added to the product along the supply chain.	(GRD, 2021)
2	Gross Domestic Product per capita	Gross domestic product divided by midyear population	(WDI, 2023)
3	Trade Openness	Measures the sum of exports and imports of goods and services.	(WDI, 2023)
4	Agriculture Value-Added	Value added to the net output of the agricultural sector.	(WDI, 2023)
5	Population (Age: 15-64 years) (% of Total Population)	Population between the ages of 15 to 64 as a percentage of the total population.	(WDI, 2023)
6	Government Effectiveness	The perception of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, policy and implementation.	(WGI, 2021)
7	Corruption Perception Index	It reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption.	(WGI, 2021)
8	Political Stability & No Violence	Measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	(WGI, 2021)
9	Grant (% of GDP)	This refers to the donations of multinational organisations, and other developed countries.	(IFS, 2022)
10	Final Consumption Expenditure (% of GDP)	The sum of household final consumption expenditure and general government final consumption expenditure.	(IFS, 2022)
11	Consumer Price Index	Changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.	(IFS, 2022)
12	Corporate Income Tax Revenue (% of GDP)	Tax levied by federal states or governments on the profit of businesses in a fiscal year	(GRD, 2021)
13	Personal Income Tax Revenue (% of GDP)	Tax levied on the earnings of individuals either on investment returns or employment	(GRD, 2021)
14	International Trade Tax Revenue (% of GDP)	Combined tax revenue from export and import taxes levied in countries	(GRD, 2021)

4.1. Results and Discussions

4.1.2. The Summary Statistics of Study Variables

Table 2: Results of Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Minimum	Maximum
Tax Revenue (% of GDP)	462	14.4730	8.4429	0.5733	60.9464
GDP *per capita*	462	1729.837	1928.27	255.10	10959.34
Agric Value Added	462	19.1133	11.4043	1.9268	45.8827
Economically active population	462	55.2731	5.2638	47.2866	71.2144
Consumer Price Index (2010 base year)	462	109.774	130.1077	6.7987	2725.313
Grant (In GDP)	462	2.3088	3.0875	-7.1897	35.6335
Consumption expenditure (% of GDP)	462	87.2538	16.870	35.0726	177.884
Government Effectiveness	462	-0.5879	0.5989	-1.8414	1.1609
Control of Corruption	462	-0.4847	0.6198	-1.5747	1.1272
Political Stability	462	-0.4857	0.839	-2.4742	1.2236
VAT (in GDP)	462	4.1007	2.0232	0	9.9866
Corporate Income Tax	462	2.0795	1.1942	0.1191	7.1762
Personal Income Tax (PIT)	462	2.5107	2.3617	0.0002	13.3803
International Trade Tax	462	2.7745	2.4029	0.0299	13.4361
Excise Tax	462	1.5774	1.6422	0.0006	12.0098
Low-income country Dummy	462	0.4091	0.4922	0	1

Source: Authors' Calculations

Table 2 shows the descriptive statistics of the variables used for the study. The means and Standard deviations for the various tax handles, VAT, CIT, PIT, and international trade tax, indicate the variation of low tax levels in the sub-Saharan Africa region. There is a total of 462 observations for the selected 22 sub-Saharan African countries between the years 2000 to 2020. The selection of countries is based on data availability for the study years under consideration.

4.1.2. Determinants of tax capacity and tax effort for disaggregated tax handles

Table 3 presents the results of the determinants of the tax handles under study from the Stochastic Frontier Analysis (SFA) estimations.

Table 3: Frontier estimates of determinants of disaggregated tax handles

Variables	Value Added Tax	Corporate Income Tax	Personal Income Tax	Int. Trade Tax
GDP *per capita*	0.0627**	0.478***	0.249**	0.580***
	(0.0340)	(0.0552)	(0.100)	(0.0858)
Trade Openness	0.243***	-0.0896*	-0.111	0.549***
	(0.0410)	(0.0479)	(0.0904)	(0.106)
Agric. V. added	-0.115***	-0.300***	-0.593***	0.370***
	(0.0372)	(0.0402)	(0.0711)	(0.0814)
Population	-0.578**	-3.376***	-2.734***	-0.179
	(0.287)	(0.428)	(0.730)	(0.680)
Grant	0.0427	-0.0627	0.319**	0.376***
	(0.0515)	(0.0833)	(0.144)	(0.122)
Consumer price index	0.119***	0.221***	0.241***	-0.284***
	(0.0444)	(0.0424)	(0.0787)	(0.0671)
Consumption expenditure	0.275***	0.793***	1.103***	1.301***
	(0.0889)	(0.106)	(0.182)	(0.139)
Low Income Country Dummy	0.0207	0.160**	-0.561***	-0.0595
	(0.0456)	(0.0660)	(0.114)	(0.124)
Constant	1.100	7.894***	5.679**	-10.78***
	(1.028)	(1.546)	(2.661)	(2.337)
Determinants of Tax Effort/Efficiency (Mu)				
Government Effectiveness	0.172		249.5	14.78**
	(1.827)		(269.2)	(20.75)
Corruption Perception Index	-5.330**	-6.038**	-280.5	-15.26**
	(2.438)	(3.552)	(275.8)	(13.51)
Political Stability	-3.678***	-0.117	-81.10	-3.491
	(1.287)	(0.698)	(100.5)	(3.952)
Constant	11.60***	8.047**	73.40	-19.88**
	(3.362)	(4.217)	(111.2)	(14.97)
Variance of Tax Effort and the random error term				
σ^2_u_cons	-0.0179	-0.327	3.775***	1.101**
	(0.366)	(0.520)	(1.012)	(0.569)
σ^2_v_cons	-4.415***	-3.033***	-1.381***	-1.799***
	(0.211)	(0.369)	(0.117)	(0.125)
σ^2_u	0.991***	0.849***	6.603**	1.734***
	(0.181)	(0.221)	3.343	0.494
σ^2_v	0.110***	0.219***	0.501***	0.407***
	(0.012)	(0.040)	0.029	0.025
Lambda (λ)	9.012***	3.868***	13.169***	4.263***
	(0.181)	(0.204)	3.342	0.493

Source: Authors' Computation

The result in Table 3 indicates that the coefficient estimates of GDP *per capita* for all the tax handles under study are significant at either 5% or 1%. Specifically, the estimates suggest that a 1% increase in GDP *per capita* is expected to increase VAT revenue by 0.06%, corporate income tax revenue by 0.48%, personal income tax revenue by 0.25% and international trade tax revenue by 0.58%, other things being equal. This finding corroborates the study by Mawejje and Sebudde (2019) and Amo-Yartey et al. (2019) which concludes that the overall economic growth in a country will positively impact goods and services tax revenues accruing to governments.

The results further indicate that coefficient estimates of trade openness with respect to the various taxes under study are also significant at either 5% or 1%. Given the coefficient estimates, the results imply that a 1% increase in trade openness is expected to increase VAT revenue by 0.24%, decrease corporate income tax revenue by 0.09%, and increase international trade tax revenue by 0.55%, other things being equal. This finding is also akin to the study by Mawejje and Sebudde (2019), which finds positive significance of trade openness with the various tax handles. It also conforms with the findings of Amo-Yartey et al. (2019).

On the Agriculture value-added variable, the coefficient estimates are negative and significant at 1% for all the tax handles except the international trade tax revenue, which is positive (0.370) and also significant at 1%. The result means that a 1 % increase in value-added agriculture is expected to decrease value-added tax revenue by 0.12 %, decrease corporate income tax revenue by 0.30 %, decrease personal income tax revenue by 0.60 % and increase international trade tax revenue by 0.37 %, other things being equal. This finding is similar to the study by Pessino and Fenochietto (2013), which found the coefficient estimate of the agriculture value-added to be negative in relation to total tax revenue, as their study did not consider the various tax handles. Also, the findings by Amo-Yartey et al. (2019) conformed to the negative significance of income tax revenue.

On population aged 15 - 64, the coefficient estimates are negative and statistically significant at 5 % for VAT and also negative and statistically significant at 1% for corporate income tax and personal income tax. This result implies that a 1% rise in the economically active population is expected to decrease VAT revenue by 0.58%, decrease corporate income tax revenue by 3.38% and decrease personal income tax revenue by 2.74%, other things being equal. This finding is similar to that of

Mawejje and Sebudde (2019), where they found the coefficient estimate of rural population to be negative and significant. In addition, Le Moreno-Dodson et al. (2012) pointed out that rapid population growth tends to increase inefficiencies in the tax systems of countries, hence low revenue. However, Amo-Yartey et al., (2019) found a positive significance and argued for the urban population's importance.

For foreign grants, the coefficient estimate is positive and statistically significant at 5% for personal income tax and 1% for international trade tax. This finding suggests that a 1% increase in grants is expected to increase personal income tax revenue by 0.32% and international trade tax revenue by 0.38%, other things being equal. This result is consistent with the study by Mawejje and Sebudde (2019), which found positive and significant coefficient estimates for grants and concluded that grants support efficiency-enhancing reforms that promote higher tax efforts. Mascagni (2016) also found a positive and significant coefficient estimate for foreign aid on tax revenue in Ethiopia.

The coefficient estimates for the consumer price index are positive and statistically significant at the 1% level for VAT, corporate income tax, and personal income tax, but negative and statistically significant at 1% for international trade tax. These suggest that a 1% increase in consumer price index is expected to increase VAT revenue by 0.12%, increase corporate income tax revenue by 0.22% and increase personal income tax revenue by 0.24%, but reduce international trade tax revenue by 0.58%, holding other things constant. This result is consistent with the findings by Pessino and Fenochietto (2013) as well as Chigome and Robinson (2021) which revealed that tax efforts tend to increase in higher inflation regimes.

Additionally, the coefficient estimates of government final consumption expenditure in respect of VAT, corporate income tax, personal income tax and international trade tax are all positive and significant at the 1% level. These findings imply that an increase in government final consumption expenditure by 1% is expected to increase VAT revenue by 0.28%, increase corporate income tax revenue by 0.80%, increase personal income tax revenue by 1.10% and decrease international trade tax revenue by 1.30%, other things being equal. This result agrees with that of Brafu-Insaidoo and Obeng (2020), who found a positive and statistically significant coefficient estimate for government current and capital expenditure on both the total tax and the disaggregated tax revenues. Also, this finding confirms the positive significance of the study by Amo-Yartey et al. (2019).

On the low-income country dummy, the coefficient estimate is positive and statistically significant for CIT but negative and statistically significant for personal income tax. This suggests that low-income countries, relative to middle-income countries in sub-Saharan Africa, are expected to increase their corporate income tax revenue by 0.16%. In addition, the personal income tax revenue of low-income countries decreases by 0.56% in reference to the middle-income countries in sub-Saharan Africa. This result is unique to this study, as no other study has considered the income status of countries in their analysis. The inclusion of this dummy variable in the model is to assess whether there is any difference in revenue mobilisation between middle-income and low-income countries in sub-Saharan Africa.

4.1.3. Determinants of Tax Effort/Efficiency for the Decomposed Tax Handles

The second stage of the results in Table 3 shows the determinants of tax effort/efficiency for the disaggregated tax handles. The coefficient estimate of government effectiveness reports a 14.78% increase in international trade tax revenue, which is statistically significant at a 5% level. This suggests that a 1% increase in government effectiveness is expected to increase international trade tax revenue by 14.78%, other things being equal. This finding suggests that improvement in the effectiveness of governments in administration and policy implementation has the tendency to increase tax revenues from international trade. A study by Chigome and Robinson (2021), however, found an insignificant coefficient for the variable.

In terms of the corruption perception index, the coefficient estimates indicate a negative coefficient, which is significant at 5% for VAT, corporate income tax and international trade tax. The result suggests that a 1% increase in the corruption perception index is expected to decrease the efficiency of VAT revenue by 5.33%, corporate income tax revenue by 6.04% and international trade tax revenue by 15.26%, other things being equal. The results of this study are in line with Bird et al. (2008), Pessino and Fenochietto (2013) and Mawejje and Sebudde (2019) all of which concluded that corruption, governance indicators and quality of institutions are important predictors of countries' tax effort or efficiency.

Furthermore, the coefficient estimate of the political stability index variable is 3.678 for international trade tax revenue and is significant at the 1% level. This implies that a 1% increase in political stability is expected to reduce the efficiency of VAT

revenue by 3.68%, other things being equal. This suggests that politically induced violence, such as *coup d'états*, electoral violence, civil wars, bandit activities, and terrorism, among others, is rampant within the sub-Saharan Africa region and results in the distortion of smooth governance in the sampled countries, leading to a marked decline in the growth of the economies. Other studies, such as Le et al. (2012) and Langford and Ohlenburg (2015), however, used other variables such as bureaucratic quality, institutionalised democracy, and democratic accountability as indicators for political systems in countries and found similar results. For instance, Langford and Ohlenburg (2015) estimated the tax potential and effort of countries and concluded that democratic accountability partly captures the willingness of citizens to pay taxes.

4.1.4. Tax Effort and Tax Capacity of Disaggregated tax handles for the sampled countries

Table 4: Estimates of Tax Effort and Tax Capacity of Disaggregated Tax Handles

(Based on year: 2020).

Countries	VAT Revenue	VAT Tax Effort	VAT Tax capacity	CIT Revenue	CIT Tax effort	CIT Tax capacity	PIT Revenue	PIT Tax Effort	PIT Tax capacity	Int. trade Tax Revenue	Int. Trade Tax effort	Int. trade Tax Capacity
Burkina Faso	4.86	0.84	5.80	2.26	0.86	2.64	1.82	0.82	2.23	1.82	0.79	2.30
Cameroon	7.54	0.95	7.94	2.94	0.90	3.26	3.52	0.81	4.33	4.09	0.83	4.95
Cabo Verde	5.01	0.90	5.56	2.33	0.75	3.09	1.01	0.44	2.31	1.49	0.68	2.19
Congo, DR.	1.37	0.24	5.77	2.38	0.83	2.86	1.25	0.75	1.66	0.77	0.73	1.05
Congo, Rep.	2.59	0.39	6.67	1.39	0.54	2.60	1.74	0.68	2.57	1.71	0.73	2.33
Cote d'Ivoire	2.92	0.57	5.16	1.82	0.67	2.72	1.00	0.56	1.79	3.83	0.82	4.70
Ethiopia	2.02	0.42	4.76	1.37	0.63	2.17	0.40	0.48	0.83	1.59	0.84	1.90
Ghana	2.40	0.44	5.44	2.98	0.87	3.42	2.06	0.74	2.78	1.44	0.69	2.07
Kenya	3.57	0.72	4.94	2.86	0.86	3.32	3.71	0.79	4.70	1.41	0.62	2.26
Lesotho	7.97	0.89	8.95	2.41	0.81	2.98	6.70	0.82	8.14	5.54	0.88	6.28
Madagascar	4.40	0.80	5.53	1.58	0.81	1.95	1.15	0.77	1.50	1.46	0.79	1.85
Mali	3.61	0.62	5.87	3.33	0.90	3.70	1.29	0.77	1.67	1.74	0.69	2.53
Mauritius	1.05	0.14	7.41	2.99	0.70	4.26	1.92	0.49	3.95	0.29	0.05	5.70
Namibia	4.76	0.68	7.05	4.87	0.88	5.54	7.88	0.85	9.30	12.73	0.88	14.40
Niger	3.74	0.74	5.03	1.80	0.75	2.39	0.92	0.67	1.37	1.50	0.69	2.18
Rwanda	4.97	0.87	5.73	1.43	0.76	1.88	5.03	0.90	5.62	1.20	0.50	2.42
Senegal	5.68	0.91	6.26	2.65	0.87	3.05	2.55	0.76	3.37	2.38	0.69	3.46
South Africa	6.00	0.84	7.17	4.16	0.76	5.44	8.85	0.79	11.23	0.84	0.37	2.29
Togo	5.42	0.92	5.92	1.76	0.83	2.13	0.97	0.74	1.31	2.83	0.85	3.32
Uganda	3.35	0.63	5.33	1.90	0.65	2.93	2.20	0.80	2.75	0.86	0.55	1.56
Zambia	4.37	0.60	7.30	2.86	0.79	3.62	5.84	0.79	7.39	1.06	0.84	1.26
Zimbabwe	3.69	0.41	9.02	2.85	0.46	6.16	2.40	0.41	5.84	1.23	0.85	1.44

Source: Author's Computation

Table 4 presents the tax effort and the tax capacity estimates for the various tax handles under study using the Battese and Coelli (1988) formula for efficiency predictions across the 22 sampled sub-Saharan African countries. The results show the lowest tax effort score for VAT, corporate income tax, personal income tax and international trade tax revenues in Mauritius (0.14), Zimbabwe (0.46), Zimbabwe (0.41) and Mauritius (0.05), respectively. The result indicates the efforts that each country is making to close the gap in attaining the maximum revenue for the disaggregated taxes. For example, Ghana puts in a 44% effort at raising the maximum attainable VAT revenue (tax capacity) of 5.44% of GDP, thereby realising an actual VAT revenue collection of 2.40% of GDP in the base year of 2020.

On the other hand, the high tax effort countries for VAT, corporate income tax, personal income tax, and international trade tax revenues are Cameroon (0.95) for VAT, Cameroon and Mali (0.90) for corporate income tax, Rwanda (0.90) for personal income tax and international trade tax for Lesotho and Namibia (0.88). The meaning of this result is that the amount of effort each of these countries puts into their tax systems to close the gap between the maximum attainable revenue for the disaggregated taxes and the actual revenue realised in the base year of 2020. For example, Rwanda puts in 90% effort at achieving the maximum personal income tax revenue (tax capacity) of 5.62% of GDP to raise actual tax revenue of 5.03% of GDP. The rationale for disaggregating the total tax into various handles is to explore how much tax revenue countries are raising through these specific tax handles in order to inform countries about their respective tax systems and where to focus most to raise revenue from the tax systems.

5.1. Conclusion and Policy Suggestion

This paper aims to determine the efficiency of tax systems in sub-Saharan African countries by applying the Stochastic Tax Frontier Analysis to estimate the tax capacity and tax effort of various tax handles. In particular, the study determines the potential factors that influence the individual tax handles' capacity and effort and subsequently estimates the taxable capacity and effort of individual tax handles for the selected 22 countries. The findings indicate that the determinants of tax capacity and tax effort for the various tax handles include GDP *per capita*, trade openness, Grants, Government consumption expenditure, consumer price index and country dummy. Other institutional factors include government effectiveness,

corruption perception index and political stability. Specifically, the study finds that GDP *per capita* has positive significant effect on VAT, CIT, PIT and ITT revenues while trade openness also has positive significant effect on VAT and ITT revenues and negative significant effect on CIT. Agriculture value-added has negative significant effect on VAT, CIT, and PIT revenues, but positive significant effect on ITT revenue. Furthermore, Grant has a positive and significant effect on PIT and ITT revenues. Moreover, the consumer price index has a positive significant effect on VAT, CIT, and PIT revenues but a negative significant effect on ITT revenue. However, government consumption expenditure is positively significant on VAT, CIT, PIT, and ITT revenues, while the country dummy indicates that low-income countries tend to generate more revenue from CIT compared to middle-income countries, but low-income countries generate less revenue from PIT compared to middle-income countries. For the institutional factors, government effectiveness has a positive and significant effect on ITT revenue, while corruption perception index has a negative and significant effect on VAT, CIT and ITT. Additionally, the political stability index has a positive and significant effect on international trade tax revenue.

On the tax effort scores of the various tax handles for the countries under study, most of the sampled countries have low tax efforts, such as Mauritius for VAT and International trade tax, and Zimbabwe for personal income tax. Countries that have high tax efforts include Cameroon for VAT, Rwanda for personal income tax, Lesotho and Namibia for international trade tax and Cameroon and Mali for corporate income tax.

For policy purposes, the study suggests steps to be employed by SSA countries to enhance the tax systems in order to achieve the maximum tax revenue potential. First and foremost, countries should bolster their tax systems by revising tax rates, widening the tax net to cover the informal sector and eliminating unproductive tax handles which tend to increase the burden of tax on the citizens. On the tax efficiency grounds, countries are urged to reduce the level of corruption by targeting and issuing out stiffer punishments, such as jail terms with hard labour to culpable individuals or organisations to serve as a deterrent for others.

Furthermore, the bureaucracies surrounding tax filing processes in most countries in SSA should be eased by providing a one-stop shop and a robust online application system to taxpayers. The application of technology facilitates

tax collection and ensures fast assessment and reduces human interference, which fosters transparency in the tax system, hence, SSA countries should invest in technology for enhanced tax systems.

The study finds that value-added tax (VAT) has a wider tax net and is able to reach the largely untaxed sector of the economies, so countries such as Mauritius, Congo DR, Congo Rep., Zimbabwe, Ghana, and Ethiopia that have efforts below 50% of their VAT revenue capacities should consider revising the VAT rates upwards for more revenue or adopt a flat VAT Rate for a broader tax base in order to generate more revenue.

Lastly, there should be improvement in the institutional factors such as government effectiveness, political stability and no violence, which tend to adversely affect tax revenue of the various tax handles, so countries are urged to strengthen their political and governance systems in order to prevent political and civil unrest through sincere and accountable leadership with integrity.

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