TAX ADMINISTRATION CAPABILITIES AND REVENUE EXTRACTION EFFICIENCY IN SUB-SAHARAN AFRICA: EVIDENCE FROM A PANEL STOCHASTIC FRONTIER MODEL

Cyril Chimilila[1]*, Vincent Leyaro*[2]

Abstract

Using panel data for 42 countries from 1991 to 2019, and applying a panel stochastic frontier model, this study examines the capabilities and efficiency of tax administrations in sub-Saharan Africa (SSA). The estimation results show that macroeconomic variables, aid dependence, and governance structures affect tax efforts. In addition, we find strong evidence that tax revenue extraction efficiency is influenced by the resourcing of tax administrations and the allocation of those resources to core tax administration functions, such as tax audits. Furthermore, technical efficiency is influenced by internal operational efficiency, which tends to reduce revenue collection costs. This implies that the resourcing of the tax administration, the quality of employment, the allocation of human and other resources, the application of technologies (such as mobile payment) in order to simplify tax administration and reduce costs, and staff motivation are equally important when attempting to maximise revenue administration capabilities and efficiency.

Keywords: Tax Effort, Tax Administration Capability, Technical Efficiency, Panel Stochastic Frontier Model.
JEL Classifications: H20, H24

1. INTRODUCTION

Generally, capable states are those able to garner enough tax revenues from the economy and ensure the effective implementation of policies through efficient public administration (Gaspar et al., 2016). An important question is, therefore, what influences the ability of the government to raise adequate revenue to fund public goods and services? This question has created renewed interest among scholars seeking to identify factors that influence states' tax revenue raising capacities. The question is particularly relevant for developing countries, like those found in sub-Saharan Africa (SSA), which are unable to raise adequate revenue to fund basic needs in both the public and social sectors (such as health care, basic education, and infrastructure). The observed high disparity between developed and developing countries in terms of their abilities to raise tax revenue, as measured as a percentage of tax revenue to gross domestic product (GDP), and the correlating observed differences in levels of development suggest that raising adequate revenue is a prerequisite for greater development. The capacity to collect taxes and to ensure the effective use of the taxes collected has given rise to "development clusters": groups of rich countries that have strong state capacities and groups of poor countries with weak state capacities (see, for example, Besley & Person, 2011).

The ability to raise tax revenue is influenced by, amongst other things, macroeconomic, structural, and institutional factors. According to Besley and Person (2011, 2014), the observed

[1] School of Economics, University of Dar es Salaam, Dar es Salaam, Tanzania. Email: cyrilchimilila@gmail.com
[2] School of Economics, University of Dar es Salaam, Dar es Salaam, Tanzania. Email: vleyaro@yahoo.com

cross-country differences in ability to raise revenue exist as a result of the interaction between tax capacity, legal capacity, and public administration capacity. While ability to raise revenue (tax effort) is key, efficiency (the ability to collect more for the given amount of resources) is equally important. Many studies in this area have concentrated on the determinants of tax effort, and most have taken a similar approach, examining the production functions of tax revenue (tax to GDP) and factors which influence a state's ability to raise taxes. While there is a broad literature on the antecedents of tax efforts, there has been a dearth of studies of efficiency.

The lack of empirical evidence with regard to the drivers of capability and efficiency in government-specific functions is common and this is also the case for tax administration. This has been noted in studies by Fukuyama (2012), Cingolani (2013), and Giosi et al. (2014).

The few studies that have focussed on factors that affect effectiveness in raising tax revenue include Taliercio Jr. (2004) and Das-Gupta et al. (2016). These studies use various indicators of tax administration and examine how these indicators influence revenue collection across tax jurisdictions and between periods. Our study tries to bridge this knowledge gap about factors affecting effectiveness and efficiency in tax revenue collection. In particular, we endeavour to contribute to the literature by examining the influence of tax administration characteristics and practices on governments' tax revenue raising capabilities and efficiency in countries in SSA.

Unlike the aforementioned studies, this study approaches the problem of tax revenue extraction from a technical efficiency point of view. We estimate inefficiency using a stochastic frontier approach and assess the effects of various tax administration capability indicators on the observed cross-country inefficiencies. We adopt key indicators of tax administration capability, as used in Crandall (2010), Rasul and Roggery, (2013), the International Growth Centre (2014), Das-Gupta et al. (2016), Mills (2017), Ricciuti, Savoia and Sen (2016), and Dom (2017). The data on tax administration capability indicators for this study was obtained from African Tax Administration Forum (ATAF, 2017, 2019).[3] One limitation to this study arises from the fact that, while the ATAF took the initiative to collect and publish these indicators, it only publishes a few of them, and the most recent data available only covers some countries—its African Tax Outlook (ATO) member countries—for a period of just ten years (from 2010 to 2019).

This study advances the discussions in literature by extending its analysis to include an estimation of technical inefficiencies and an assessment of how these indicators influence cross-country differences in tax revenue raising efficiency. To that end, we estimated the marginal effects of the determinants of technical inefficiencies, which revealed an interesting insight: the allocation of resources to core tax administration functions significantly reduces inefficiency. Organisational factors, as observed through the cost of revenue, increase inefficiency while arrears recovery reduces inefficiency. Likewise, the capacity of the tax administration, as observed through the number of taxpayers per member of staff, has a significant effect on inefficiency.

Section two presents a review of the literature. It starts by providing a theoretical underpinning of tax administration capability in relation to compliance enforcement, the determinants of tax administration capability, and a review of the analytical approaches taken to estimate tax effort. Section three presents the methodology of the study. It covers the data used and its descriptive

[3] Full data is available from the author upon request.

statistics, as well as the empirical model and the analytical approach. Section four presents the findings, while section five summarises the study and discusses its implications.

2. A REVIEW OF LITERATURE

A Theoretical Framework of Tax Administration Capability

The capability of a tax administration is observed through its effectiveness in enforcing taxpayer compliance (see Das-Gupta et al., 1995; Das-Gupta et al., 2016). A tax administration's capacity and its efficiency are therefore inseparable. A capable tax administration ought to be effective at collecting the maximum possible level of revenue (or, at least, a set revenue target) while ensuring that it allocates its resources optimally so as to achieve this objective at the lowest possible cost.

Following Das-Gupta et al.'s (1995) example (with some adjustment), we argue that the efficient tax administrations raise more revenue, as they are capable of influencing the size of the tax base, its concentration, and taxpayer compliance, while simultaneously adopting technologies and approaches that simplify tax administration, and reduce tax collection and administration costs.

We start by specifying that: tax revenue (R) depends on tax rate (τ), tax base (B), and level of compliance (C).

$$R = \tau BC \tag{1}$$

The size of the tax base is related to level of income (Y) and concentration of the tax base refers to the number of taxpayers (N), such that:

$$B = b_0 Y^{b_1} N^{b_2} \tag{2}$$

Higher concentration improves the efficiency of the tax administration. When taxpayers are few and scattered, it is ineffective and costly to enforce compliance.

Furthermore, taxpayer compliance (C) depends on taxpayer compliance attitudes (E) and tax administration effectiveness (T). Tax administration effectiveness is, however, reduced by the size of underground economy (γ), such that:

$$C = c_0 E^{c_1} T^{c_2} \gamma^{-c_3} \tag{3}$$

It follows that by substituting (2) and (3) into (1), and collecting the terms, we obtain

$$R = b_0 c_0 \tau Y^{b_1} N^{b_2} E^{c_1} T^{c_2} \gamma^{-c_3} \tag{4}$$

where b_0, b_1, b_2, c_0, c_1 and c_2 and c_3 are constants.

Lastly, we assume that taxpayer compliance attitudes (E) hold constant in the short-term, such that:

$$R = a_2 \tau Y^{b_1} N^{b_2} T^{c_2} \gamma^{-c_3} \tag{5}$$

where $a_2 = b_0 c_0 E^{c_1}$ (6)

The meaning of equation (6) is that tax administration capability affects a government's ability to raise tax revenue. The channel for this effect is effectiveness in widening the tax base and enforcing compliance. A capable tax administration is able to reduce the size of the informal economy by registering as many as taxpayers as possible (see Savić et al., 2015), which increases taxpayer concentration, reduces tax administration costs, and improves tax revenue extraction efficiency.

Determinants of Tax Capacity and Tax Effort

The literature on tax capacity and tax effort reveals stylised facts about the differences between developed and developing countries' tax revenue mobilisation efforts. In addition, developing countries collect very little tax as a share of GDP when compared to developed countries (see, for example, Besley & Persson, 2014). Even when tax effort is considered in the analysis, developing countries are still shown to collect much less revenue than they have the potential to collect (see, for example, Mawejje & Sebudde, 2019). Therefore, the issues of low tax capacity and low tax effort in developing countries boil down to compliance issues and tax administration capability, rather than their tax-generating potential.

We may conceptualise the factors which affect tax capacity as intrinsic and extrinsic to the tax administration. Extrinsic factors include: the structure of the economic activities; political factors (see, for example, Ricciuti, Savioa & Sen, 2016; Yogo & Ngo Njib, 2016); social factors (see, for example, Azulai, et al., 2014; Roll, 2011); and the social contract between the state and its citizens (see, for example, Bird & Wallace, 2003). While extrinsic factors relate to the environment within which the tax administration operates and which determines the tax capacity and effort, intrinsic factors relate to the actions and characteristics of the tax administration organisation that affect tax administration capability and efficiency.

The level and structure of economic activities are the primary determinants of the ability to tax revenue collection. The level of economic activities represents the size of the tax base. In terms of a state's capacity to tax and, in particular, to tax incomes, the issue of the structure of the economy is far more important than income levels (see Tanzi, 1992). Tanzi and Zee (2000) note that the typical structure of developing countries' economies features a significant agricultural sector (mostly for subsistence), extensive informal sector activities and occupations, and many small business establishments. The existence of a large informal sector makes it difficult to identify economic transactions and complicates taxation (Joshi et al., 2014; Tanzi & Zee, 2000).

Likewise, the prevalence of a large subsistence agriculture sector with very short value chains limits a state's ability to expand the tax base for certain modern taxes, such as personal income taxes and value added tax, and thus limits its ability to collect high amounts of tax. Furthermore, personal income levels in developing countries are very low. A large proportion of the population in a developing country earns just enough for subsistence. Conversely, raising taxes from the incomes of the poor has both political and social implications (see Ricciuti et al., 2016). As a result, low-income countries impose very low marginal income tax rates (see Sicat & Virmani, 1988). Other considerations that limit the taxation of the incomes of the poor include equity and cost-effectiveness (Bird & Zolt, 2005; Junquera-Varela et al., 2017).
Natural resource endowment is another factor which affects the tax effort. Resource-rich countries extract very little tax from non-resource sources, such as personal incomes. Crivelli

and Gupta (2014) analyse the impact of expanding resource revenues in 35 resource-rich countries on different types of non-resource domestic tax revenues, and find a statistically significant negative relationship between resource revenues and total non-resource domestic tax revenues. Thomas and Treviño (2013) provide more insights into what causes this tendency. According to them, low contribution of non-resource taxes in resource-rich countries is a result of the prevalence of high levels of corruption, incentives for tax evasion, large tax exemptions, and/or weaker enforcement (Thomas & Treviño, 2013). Many resource-rich countries have, however, experienced governance problems and internal conflicts, which have undermined their efforts to collect non-resource domestic revenue. In economics, this is known as "the resource curse" (Auty, 1993).

Political systems also influence the development of a state's tax system. Weak and unaccountable states are unlikely to have strong motives to build fiscal capacity and their citizens are unlikely to develop strong compliance norms. The strengthening of institutions for taxation largely reflects a strong political will towards taxation (Bird et al., 2008). The level of development of the political system, therefore, is an important factor that helps with the establishment of strong institutions for taxation and the development of compliance norms. In the literature, it is widely acknowledged that democratic polities collect more taxes than non-democratic polities (see, for example, Ross, 2004, and Balamatsias, 2016). This is because of the support that they receive from their citizens through bestowed legitimacy. Democracy enables the development of strong institutions, and provides checks and balances in the system.

On the other hand, tax compliance is very low in states in which there is conflict and in fragile states. A lack of checks and balances, and weak accountability, has resulted in weak governance and rampant fiscal corruption existing in most developing countries (see CMI, 2016). Corruption lowers tax compliance and is negatively associated with overall tax revenue and most of its components. Corruption can also harm revenue potential through the introduction of tax exemptions or other tax loopholes in exchange for bribes (International Monetary Fund [IMF], 2019). In order to reduce corruption within a tax administration, it may be necessary to reduce the complexity of tax laws and procedures, reduce monopoly power, and reduce the degree of discretion that tax officials have (executive constraint).

Foreign aid also affects tax efforts, but in a more ambiguous way (see Clist & Morrissey, 2011). Most of the studies published in the past decade claim that aid discourages tax effort. Countries that receive more foreign assistance will collect less domestic tax revenue, as they have less incentive to pursue politically costly, local tax collection (see, for example, Gupta et al., 2004). However, other studies, such as Morrisey et al. (2014), highlight the positive effects that aid may have on taxation. When governments receive lower amounts of aid, it can have a significant effect, as this provides them with the resources to fund government initiatives that strengthen revenue collection. However, when they receive higher amounts of aid, governments may relax their domestic tax collection efforts.

Social and cultural norms also affect tax effort. Low-income countries have lower levels of taxation due to, among other reasons, the weaker taxpaying ethic that exists within them. As a result of a weaker compliance norm, any given statutory level of taxation will raise less revenue than would otherwise be expected. A norm is an intrinsic attribute that can be shaped by a number of factors, including culture. Taxpayer morale is diminished if they perceive that evasion is rampant, and that the state does not have the capacity to detect and punish noncompliance (Bénabou & Tirole, 2011). Tax morale can be linked to the fairness of the tax system. A high level of evasion makes that tax system unfair, as some taxpayers bear a higher

burden than others and, hence, become demotivated with regard to compliance. In a similar vein, studies have also found strong correlations between taxation and democratisation (Ross, 2004), public goods provision (Timmons, 2005), high quality services in exchange for taxes (Hanousek & Palda, 2004), and quality of governance (Moore, 2008).

Tax Administration Capability

Tax mobilisation also depends on institutional capacity, especially in situations where there are high levels of noncompliance. There is certainly no jurisdiction with full tax compliance. However, levels of tax noncompliance in developing countries, such as those in SSA, are relatively high when compared to those in developed countries. In a high noncompliance situation, the tax administration will have to play the role of policeman (see Savić et al., 2015). This would be typical for most of countries in SSA. However, due to resource limitations, tax administrations have to develop the capacities and capabilities to support voluntary compliance and enforce compliance where necessary. The capacity to enforce compliance involves the use of strategic interventions, such as risk-based audits, to detect noncompliance and penalise those who do not comply.

The review of literature discusses various aspects and features relating to tax administration capability. In summary, tax administration capability involves the ability to perform tax administration processes, utilising various inputs and interactions with various stakeholders in the most effective and efficient way, in order to mobilise high levels of tax revenue according to the potential of the economy. Thus, countries with low tax capabilities, as is the case in most developing countries, collect lower levels of tax revenue relative to economic activities (GDP) and their potential. A tax administration's capability is measured by various indicators of tax administration performance (see, for example, Crandall, 2010; Gallagher, 2004). These measures are indicative of how well, or how poorly, the tax administration is performing against its goals and objectives. The proper monitoring of these performance measures enables improvement in terms of management reforms, efficiency, cost awareness and overall effectiveness (OECD, 2011). The Tax Administration Diagnostic Assessment Tool (TADAT), which was developed under the auspices of the IMF and the World Bank, is an integrated monitoring framework that measures the performance of a country's tax administration in respect of essential tax administration aspects (ATAF, 2017, 2019; Crandall, 2010). The primary (and often considered to be the overall) indicator of a tax administration's capability and performance is its ability to raise taxes, which is measured as a ratio of tax revenue to GDP. More rigorous measures, such as the share of non-resources taxes to GDP or share of direct taxes to GDP, are also often used.

The overall performance of a tax administration depends on the implementation of tax administration functions. Tax administration capability and performance can be construed as an input-output framework, such that processes and inputs are the building blocks (indicators) for the achievement of the overall performance, i.e. tax collection capacity. Table 1, below, summarises the core functions of a tax administration and their corresponding capability indicators.

The recognition of the importance of the tax administration structure with regard to efficient tax revenue mobilisation has led to the transformation of tax administration functions including, notably, the creation of semi-autonomous tax administrations in most countries in SSA during the 1990s. When a tax administration is semi-autonomous, tax administration functions are freed, as the tax administration is no longer a department within the Ministry of

Finance. This results in improved revenue collection, reduced political interference, increased autonomy with regard to decision making (including recruitment) and resource allocation, enhanced utilisation of technologies (such as information and communications technology [ICT] for tax administration), and improved governance in tax administration (Crandall, 2010; Dom, 2017; Gallagher, 2004; Junquera-Varela et al., 2019).

Table 1: Selected Indicators of Tax Administration Capability

Tax administration functions	**Capability indicators**	**Measurement**
Overall performance (revenue extraction)	- Tax to GDP ratio - Non-resource tax to GDP ratio	- A ratio of tax revenue (or non-resources tax) collected as a share of GDP
Registration and filing compliance	- Percentage of taxpayers filing on time	- A ratio of the number of registered taxpayers to the number of tax administration staff
Taxpayer services and education	- Compliance rate	- Percentage of registered taxpayers who file returns and comply with their tax obligations
Returns processing and payment	- Revenue per unit of operational cost	- A ratio of total tax revenue collected to total operational costs
Collection of arrears	- Percentage of arrears to total revenue	- A ratio of total arrears recovered to total tax revenue collected during the period
Audit and investigations	- Percentage of staff in audit functions	- A ratio of tax administration staff in tax audit to the total number of tax administration staff
	- Audit recovery rate	- A ratio of tax revenue recovered through tax audits to total declared taxes
Appeals	- Average length of appeals case	- Average time taken to complete appeals (i.e. issue an appeal decision)
Administration	- Ratio of total staff to staff in core functions	- A ratio of tax administration staff in core functions (registration, returns processing, audit, investigation, debt management) to the total number of tax administration staff
Budget allocation	- Budget in core functions against total budget	- A ratio of budget allocated to core function to total budget of the tax administration

Source: Author's compilation from Crandall (2010) and ATAF (2017, 2019).

Since the 1990s, when these major reforms took place, many countries in SSA have continued to make efforts to improve and modernise tax administration in order to enhance their capabilities for revenue mobilisation. However, more effort is required in order to improve

their capacities for higher tax revenue extraction. The primary area in which most tax administrations in SSA need to improve is resource allocation. A report published by ATAF in 2019 indicates that the resources allocated for tax administration are inadequate in most countries in SSA. For instance, the number of tax auditors to total tax administration staff among ATO member countries stood at an average of 12 percent in 2018 and ten percent in 2019, which is far lower than the recommended ratio of 30 percent (ATAF, 2020, p.135).

In addition to increasing resources, such as the number of staff in the tax administration, it is important to ensure that employees have the necessary qualities and capabilities in terms of skills and competencies. The business environment within which tax administrations operate has become more complex, particularly with the emergence of the telecommunications sector, the mining sector, financial institutions, multinational corporations, international transactions, digital transactions, and e-commerce. As a result, staff require specialised skills in order to ensure effective tax administration and to curb tax evasion. Thus, a tax administration's failure to develop the skills of its employees in order to keep up with the pace of changes in the operating environment is likely to affect its capability.

While increasing resources is key, there is much scope to enhance tax administration capability by investing in technologies like ICT. ICT utilisation improves a tax administration's capability to enforce compliance, lowers tax compliance costs, and makes paying taxes more convenient for taxpayers. For instance, the recent developments that have enabled money transfers to take place via mobile phones have seen their way into tax administration. Mobile phone money transfer is now one of the most convenient and cost-effective ways of making tax payments and collecting taxes in countries like Tanzania and Kenya. This has boosted taxation efficiency and capabilities across many developing countries that have adopted these person-to-government (or P2G) payment methods. The inadequate utilisation of ICT, such as the lack of a full automation system for domestic taxes, limits a tax administration's scope to promote greater transparency and integrity[4], and its ability to strengthen its compliance risk management which, in turn, affects its capability and efficiency.

Technical Efficiency in Tax Revenue Extraction

Tax potential represents the level of taxes that can be collected given the size of the tax base, the structure of the tax administration, and the level of compliance. The level of taxes actually collected relative to the tax potential is known as the tax effort. Empirical analyses suggest that tax potential and tax effort differ across countries, and even between those with similar economic characteristics. Therefore, something beyond tax potential explains what is actually collected on the ground: the effects of tax policies, tax laws, tax administration efficiency, and tax administration capability, as well as governance structures (Bird & Martinez-Vazquez, 2008).

Tax potential and extraction efficiency are inherently unobservable. However, they can be estimated empirically. Analysis of technical efficiency in tax administration follows a similar approach to that used in production and cost modelling (see, for example, Langford & Ohlenburg, 2016: Mawejje & Sebudde, 2019). Thus, studies investigating tax effort and efficiency often take a production frontier approach in order to estimate tax efforts and tax potential, and to derive cross-country efficiencies in tax revenue extraction. The frontiers are

[4] Unlike customs, where most of the processes are automated, domestic revenue operations still involve a high level of human intervention.

estimated from sample data using either parametric (econometric) methods or nonparametric (mathematical programming) methods, such as Data Envelopment Analysis (DEA). The classic DEA model assumes that input and output variables are deterministic. However, tax effort and tax revenue are stochastic in nature.

These parametric and nonparametric methods have been used and emphasised as standard techniques by which to explore the relative efficiency of agencies and institutions (see Alm & Duncan, 2014). However, these techniques take different approaches when estimating the efficient frontier. Parametric methods make use of econometric methods to estimate production frontiers when estimating technical efficiency (or inefficiency). The difference between parametric and nonparametric methods of estimating production frontiers is that parametric methods distinguish between deviations due to inefficiency and deviations due to random shocks, while nonparametric methods do not (McKenzie, 2021). Since tax effort and efficiency in revenue administration are affected by random (stochastic) shocks, we implement a parametric model—specifically a stochastic frontier analysis (SFA)—to account for these shocks.

Tax mobilisation efficiency is affected by tax policies, tax laws, and tax administration. While the effects of tax policies and tax laws ought to be static, the effects of tax administration capabilities and practices change over time. Technical change over time is possible, as tax revenue collection is subject to stochastic shocks due to changes to, for example, operational arrangements, technology utilisation, management, resource allocation, and recruitment policies. Therefore, as far as the technical efficiency of the tax administration is concerned, it is imperative to use models that account for time-varying technical inefficiency. This necessitates the choice of parametric methods (such as SFA) over nonparametric methods (such as DEA).

The frontier model and the inefficiency can be implemented in a single-equation framework or a two-stage approach. In a two-stage approach, the frontier is estimated and estimates of technical inefficiency are derived. The technical inefficiencies are then regressed against the determinants of inefficiency in the second-stage analysis (see, for example, Mackenzie, 2021), using methods like a Tobit or ordinary least squares (OLS) model (Belmonte-Martin et al., 2021). However, this may lead to bias in the estimates of inefficiency, since the inefficiency variables can be correlated to other variables in the model (see Schmidt, 2011). As such, this study uses a single-equation framework, which involves simultaneous estimations of the frontier and inefficiency models in one equation. This approach has been used widely to study inefficiency in tax administration (Garg et al., 2014; Langford & Ohlenburg, 2016). Another strand of studies use a combination of parametric (SFA) and DEA models to estimate the frontier and inefficiencies (see, for example, Alm and Duncan, 2014). Alm and Duncan (2014) use a three-stage approach to estimate SFA and obtain coefficients that are used at a later stage to adjust the DEA. Mackenzie (2021) uses SFA and DEA to obtain inefficiencies, and later uses a Tobit regression to analyse the determinants of inefficiency.

3. METHODOLOGY

Analytical Strategy

The analytical strategy adopted in this study involves the estimation of a stochastic panel frontier model in a single-equation framework which includes the input variables for the frontier function and the variables that are postulated to account for technical inefficiency in tax administration. In order to distinguish countries' heterogeneity from inefficiency, we use both true fixed effect and true random effect specifications. A true effect stochastic frontier model captures the effects of time-invariant covariates that have nothing to do with inefficiency. At a later stage, we estimate the marginal effects of the determinants of inefficiency and plot these using scatter diagrams to provide a visualisation of their evolvement as the inefficiency variables change.

Data and Descriptive Statistics

The data used for this study covers 42 countries in SSA for a period of 29 years (1991 to 2019). It is mainly secondary data on tax revenue, macroeconomic variables, governance indicators, and tax administration. The panel data on tax revenue was compiled from UNU-WIDER's government revenue data set (UNU-WIDER, 2020).[5] Macroeconomic data, such as per capita GDP, openness (the sum of imports and exports as a share of GDP), capital formation, private credits, and official development assistance (ODA) was obtained from the World Development Indicators (WDI) dataset (The World Bank Group, 2022a). Regulatory quality data was extracted from World Governance Indicators (WGI) dataset (The World Bank Group, 2022b).[6] Executive constraint data represents the level of restraint on executive actions and was extracted from the World Bank database (The World Bank Group, 2022c). The size of the shadow economy data is adopted and compiled from the estimates produced by Schneider, Buehn and Montenegro (2010), and Medina and Schneider (2018). The data used for the determinants of inefficiency (i.e. administrative data relating to tax administration capability indicators) was obtained from the tax administration statistics compiled by the ATAF.[7] This administrative data provides meaningful and useful research into tax administration (see Mascagni, Monkam, & Nell, 2016; McCluskey & Isingoma, 2017). Summary statistics of the variables are provided in Table 2.

[5] This data set was previously compiled and published by the International Centre for Tax and Development.
[6] Regulatory quality reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
[7] The summaries of tax administration data compiled by the ATAF are published annually in its African Tax Outlook reports.

Table 2: Summary Statistics of the Key Variables

Variable	Source	Obs	Mean	Std. Dev.	Min	Max
Tax to GDP ratio	ICTD	1,218	13.4	7.7	0.6	53.9
Log. GDP per capita	WDI	1,218	6.7	1.1	4.2	10.0
Shadow economy (% of GDP)	WDI	1,214	39.4	9.1	19.2	69.1
ODA (% of GDP)	WDI	1,216	9.9	10.2	-0.3	94.9
Capital formation (% GDP)	WDI	1,198	22.0	10.1	-2.4	79.4
Openness (% of GDP)	WDI	1,179	70.3	44.0	20.4	531.7
Private credits (% of GDP)	WDI	1,210	18.0	22.4	0.4	160.1
Regulatory quality	WGI	1,138	-0.6	0.6	-2.3	1.1
Executive constraint	WGI	1,215	4.1	1.9	1.0	7.0
Staff in core functions to staff	ATAF	356	0.7	0.3	0.2	5.4
Cost to revenue	ATAF	338	2.6	0.8	1.0	4.6
Arrears recovered to revenue	ATAF	248	32.1	30.3	0.3	146.9
Taxpayers to tax staff	ATAF	299	354.5	436.9	1.2	1966

Analytical Models and Data Analysis

The analytical models used in the study are second-generation stochastic frontier models. These are panel data models estimated using the maximum likelihood method. The models assume that there is a change in technical inefficiency over time (see for example, Battese & Coelli, 1992; Greene, 2005; Kumbhakar, 1990; Kumbhakar, Lien & Hardaker, 2014; Kumbhakar & Wang, 2005; Lee & Schmidt, 1993).

The stochastic frontier model is expressed as:

$$Y_{it} = \alpha + f(X_{it}; \beta) + \varepsilon_{it} \quad (7)$$

The model that is examined can be written as

$$y_{it} = \beta_0 + x_{it}'\beta + v_{it} - u_{it} \quad (8)$$

$$y_{it} = \alpha_{it} + x_{it}'\beta + v_{it} \quad (8)$$

$$\alpha_{it} \equiv \beta_0 - u_{it} \quad (9)$$

where the term $-u_{it}$ represents time-varying inefficiency.

These error components are estimated simultaneously in a single-equation framework which also combines input variables for the frontier function and the inefficiency function.

After combining the frontier and inefficiency models in a single equation framework, we extend the analysis to examine the marginal effects of the determinants of inefficiency. This is operationalised as follows:

Consider a stochastic production frontier model:

$$y_i = \beta' x_i + v_i - u_i \quad (13)$$

$$u_i \sim N^+(\mu_i, \sigma^2{}_{u_i}) \quad (14)$$

$$v_i \sim N(0, \sigma^2{}_{v_i}) \quad (15)$$

$$\mu_i = c_0 + \delta' z_i \quad (16)$$

$$\sigma_{u_i} = \exp(c_1 + \gamma' z_i) \quad (17)$$

$$\sigma_{u_i} = \exp(c_2 + \rho' z_i) \quad (18)$$

As per Jondrow et al. (1982), it can be shown that the conditional distribution of u_i given the composed error term $\varepsilon_i = v_i - u_i$, is the normal distribution truncated at zero, with mean $\tilde{\mu} = (\mu_i \sigma^2{}_{v_i} - \varepsilon_i \sigma^2{}_{u_i})/\sigma^2{}_i$ and standard deviation $\sigma_{*i} = \sigma_{u_i}\sigma_{v_i}/\sigma_i$, where $\sigma^2{}_i = \sigma^2{}_{u_i} + \sigma^2{}_{v_i}$. Thus, the point estimator of u_i is given by the conditional mean, i.e.:

$$E(u_i/\varepsilon_i) = \tilde{\mu}_i + \sigma_{*i} \frac{\phi(\tilde{\mu}_i/\sigma_{*i})}{\Phi(\tilde{\mu}_i/\sigma_{*i})} \quad (19)$$

where ϕ and Φ denote the standard normal density and distribution functions respectively. Lastly, the marginal effects of the inefficiency variables are computed from $\frac{\partial E(u_i/u_i>0)}{\partial z_{li}}$, where z_{li} is the l-th element of the inefficiency variables (z_i).

4. FINDINGS AND DISCUSSION

Stochastic Frontier Estimation

The results of the stochastic frontier estimation are presented in Table 3, which includes the results of the frontier function, and the inefficiency and error components. The results of the frontier function estimation show that the level of per capita income has a significant and positive effect on the tax effort (tax to GDP). The level of income constitutes a key variable (the tax base), from which the tax administration extracts taxes. Likewise, the level of capital formation and openness have positive and significant effects on tax effort under different model specifications. Capital formation and openness also relate to the tax base.

Shadow economy size was found to have a negative and significant effect in different model specifications. These results support the results of previous studies (e.g., Gupta, 2007; Kodila-Tedika & Mutascu, 2013) that find that the size of shadow economy reduces tax effort. This is particularly the case because it is difficult to enforce compliance in an environment where rampant informality exists. Informality is high in developing countries, where a sizable number of economic agents undertake transactions in the underground economy (unregistered by any authority), cash transactions are made in cash, and business entities are very small and scattered (which makes them difficult to reach and tax). Thus, efforts to reduce informality are likely to boost revenue mobilisation efforts in countries in SSA. This may require a number of interventions to take place, such as the identification and registration of taxpayers, the provision of support for growth, and fostering full tax compliance among taxpayers. In the same vein,

tax administrations may need to enhance their use of ICT and implement measures to reduce the number of cash transactions taking place (see, for example, Awasthi & Engelschalk, 2018).

The provision of credits to the private sector has a positive and significant effect on tax effort. Credits play an important role in the stimulation of economic activities and, hence, expanding the tax base. The provision of credits to the private sector is also associated with a reduction in informality, especially when these credits are provided by a formal registered financial agent. From this, it can be deduced that different forms of support for business growth, such as the provision of infrastructure for small informal businesses, are likely to improve the tax effort in countries in SSA.

ODA has a negative and significant effect under different model specifications, which conforms to the results of some previous studies that found that high levels of ODA are associated with a reduction in tax efforts; countries which receive high levels of ODA tend to relax their efforts to mobilise domestic revenue. However, there is a strand of studies that show that certain levels of ODA have a positive effect on tax effort, which is channelled through the provision of aid for the improvement of economic structures and tax administration modernisation in developing countries.

The implementation of governance practices, such as executive constraint, has a positive and significant effect on tax effort. Executive constraint, for example, limits corruption amongst public officials. Regulatory quality has a positive and significant effect on tax effort. This is because regulation improves business formalisation and compliance with various regulations, including the tax codes.

Determinants of Technical Inefficiency

The results of the determinants of technical inefficiency are also presented in Table 3 (above). They indicate that an increase in the proportion of staff employed in core tax administration functions, such as tax audit, has a negative and significant effect on the reduction of technical inefficiency. It is interesting that a report by the ATAF (2019) indicates that, in many ATO member countries, tax auditors account for less than 15 per cent of total tax, while the international benchmark is 30 per cent. Low tax recovery rates from tax audits are an indicator of tax administration inefficiency in tax collection.

In addition, organisational inefficiencies, as depicted by the cost of tax revenue collection, increases technical inefficiency. The cost of tax collection may be affected by organisational arrangements, technology utilisation, and staff efficiency. For instance, when a large proportion of a tax administration's staff are inexperienced, it is likely to drive up the cost to revenue ratio. Low utilisation of ICT limits a tax administration's scope for reaching and detecting transactions for the purposes of taxation, while ineffective internal organisation, such as the existence of a poor organisational structure, may hinder some core functions and, therefore, increase inefficiencies.

Furthermore, the results indicate that an increase in the number of taxpayers relative to tax administration staff is associated with an increase in technical inefficiency. Conversely, an increase in number of staff relative to the number of taxpayers reduces technical inefficiency. An increase in the number of staff working for the tax administration is likely to increase efficiency due to the fact that most tax administrations have limited human resources with which to administer a large population of taxpayers who have low compliance attitude. In the

same vein, tax administrations need to capacity-build, i.e. train staff to handle complex tax issues in order to curb tax evasion. In addition to staff numbers, tax administrations also face issues in terms of staff retention, recruitment quality, and staff motivation and progression. When these challenges are dealt with effectively, it can have a positive effect on organisational efficiency.

Table 3: Results of the Stochastic Frontier Estimation

Variables	True Fixed Effect		True Random Effect	
	TFE 1	TFE 2	TRE 3	TRE 4
Frontier function				
Log. GDP per capita	0.34388**	4.215595***	0.190289	3.98576***
	(0.1781)	(0.002476)	(0.154182)	(0.340895)
Shadow economy	-0.14006***	-0.07966***	-0.16826***	-0.0273019
	(0.02191)	(0.000561)	(0.023918)	(0.047605)
ODA	-0.03133**	-0.01644***	-0.04005***	0.0017294
	(0.011396)	(0.000282)	(0.011586)	(0.017922)
Capital formation	0.038718***	0.07962***	0.034401***	0.061887**
	(0.011324)	(0.000341)	(0.010971)	(0.022058)
Openness	0.019334***	0.059896***	0.023254***	0.101861***
	(0.004991)	(0.000145)	(0.004852)	(0.008565)
Private credit	0.060966***	0.000779***	0.054142***	0.0418412**
	(0.011286)	(0.000177)	(0.010032)	(0.016906)
Regulatory quality	0.045148	-3.4597***	0.487465*	
	(0.319254)	(0.010003)	(0.284431)	
Executive constraint	0.308756***	0.136535***	0.399306***	
	(0.074062)	(0.002382)	(0.068931)	
Constant			20.70305***	-16.54205***
			(1.636077)	(3.321857)
Inefficiency				
Staff in core		-0.63199**		-0.7072678**
functions		(0.292031)		(0.344812)
Cost to revenue		0.565196***		0.3494928**
		(0.207552)		(0.153842)
Taxpayers to tax staff		0.002272***		0.002772***
		(0.000421)		(0.000471)
Arrears to revenue		-0.01001*		-0.0010467
		(0.006164)		(0.007288)
Constant		0.243157		
		(0.568928)		
U_σ	1.558383***		1.518309***	
V_σ	0.734687***	-25.11938	0.935871***	-0.391242
σ_u	2.179709***		2.136469***	
σ_v	1.443894***	0.000004	1.596695***	0.8223235***
$\lambda = \sigma_u / \sigma_v$	1.509605***		1.338058***	
θ			6.776677***	4.899666***
Wald Chi2	439.40***	9.66e+08***	699.71***	693.15***
Log-likelihood	-2476.93	-375.32	-2637.52	-475.26
Mean Efficiency (%)	79.6%	74.4%	81.6%	77%
Observations	1073	209	1073	211
Countries	42	23	42	23

*** p<0.01, ** p<0.05, * p<0.1

Arrears recovery has a negative effect, implying that it reduces technical inefficiency. Effectiveness in respect of the actual collection of the assessed taxes is crucially important. A tax administration that has a large log of uncollected arrears is inefficient and ineffective. As the results in Table 3 suggest, tax administrations that are more capable of collecting arrears have higher technical efficiencies. However, it is important to note that, in some cases, arrears data is not well reported as, in practice, these figures are usually included within those for the taxes collected during the period.

Technical Inefficiency Estimates

The true fixed effect and true random effect models produce, more or less, the same results. Most of the parameter estimates for both models conform to the variable specifications, as suggested by economic theory, and are in line with the findings of previous studies. The basic models, which only fit the frontier (i.e. model TFE1 and TRE3), have inefficient estimates that are highly correlated with a Spearman's correlation of 0.9349. Likewise, the two models which include the inefficiency determinants (i.e. model TFE2 and TRE4) have estimates of technical inefficiencies which are highly correlated, with the Spearman´s rank correlation coefficient being 0.7450. In both cases, the correlation coefficients were statistically significant.

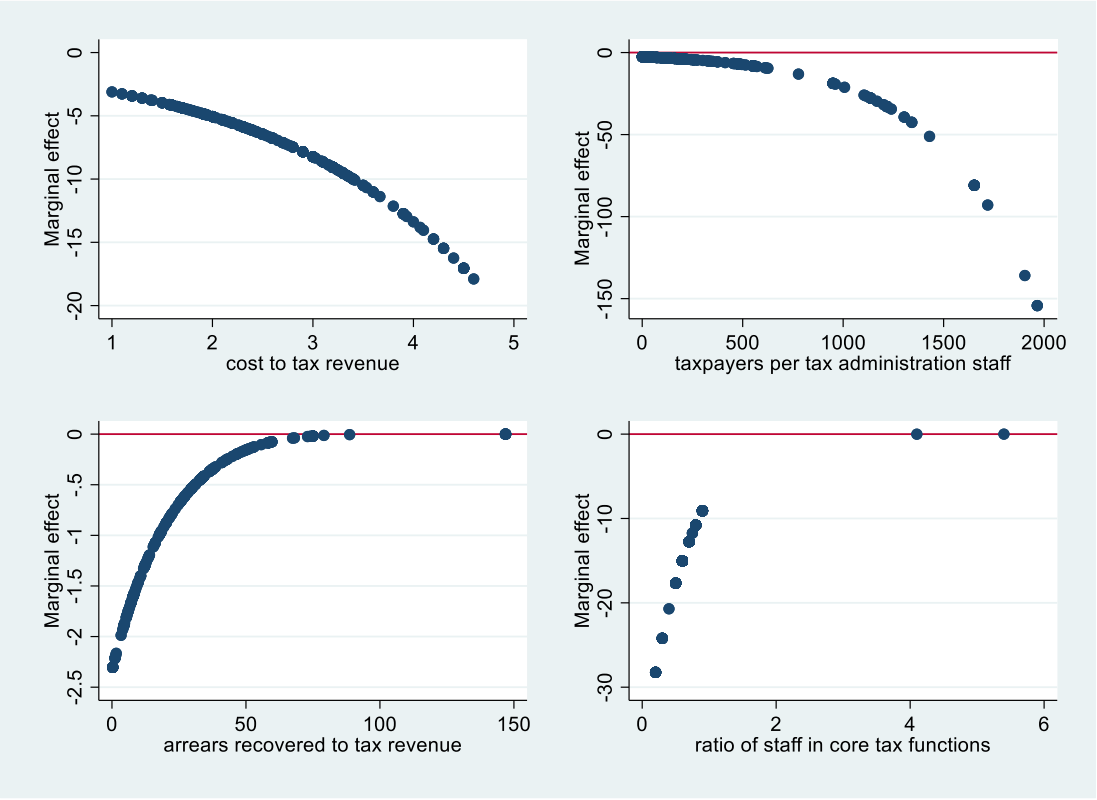
The estimates of average technical inefficiencies are included as an appendix. They show that technical inefficiency varies considerably between the 42 countries in SSA that were studied. The five most technically inefficient countries have average technical inefficiencies of at least 27 per cent, while the least technical inefficient have average technical inefficiencies of, at most, 17.6 per cent. The almost ten percentage points difference in average technical inefficiencies observed between the most and the least inefficient countries are explained by differences in terms of resource allocation, and operational efficiency and effectiveness across countries; these are explored using a marginal effect analysis.

Marginal Effects of the Determinants of Technical Inefficiency

The analysis of the determinants of technical inefficiency is extended to include their marginal effects. When the marginal effect is negative, it implies that an increase in a particular factor is associated with a decrease in technical inefficiency, while a positive marginal effect implies the opposite. The marginal effects of the inefficiency variables were estimated from the stochastic panel frontier and were summarised in scatter plots in four panels (one for each variable) to aid visualisation (Figure 1). The scatter plots show the marginal effects of each inefficiency variable against itself, holding all other variables constant.

The top left and top right panels in Figure 1 reveal that, for higher ratios of cost to revenue and higher numbers of taxpayers per members of tax administration staff, the marginal effects move towards higher negative values. This implies that the size of technical inefficiency is larger when these variables increase. The bottom left and bottom right panels reveal that the marginal effects of arrears recovery and staff in core functions tend towards zero at the higher levels of these variables. This implies that technical inefficiency fades as these variables increase.

Figure 1: Marginal Effects of Inefficiency Variables



5. SUMMARY AND IMPLICATIONS

This study examines the capabilities of tax administrations in SSA countries in relation to technical efficiency in tax revenue extraction. We set out to assess their capabilities and inefficiency in order to address the observed, persistent problem of low tax revenue extraction in these countries. We contribute to the literature by extending the analysis so as to examine how various capability measures affect these tax administrations' technical inefficiencies. We postulate that a tax administration's capabilities play an important role in a country's ability to extract adequate tax revenue. These capabilities include the resourcing of the tax administration, the allocation of resources to core tax administration functions, the utilisation of technologies, the internal organisation of revenue administration functions, internal efficiency, and the level of autonomy. However, due to data limitations, only some of these capabilities are examined.

We take a rigorous approach, involving the estimation of a panel stochastic production frontier and technical inefficiencies, and later derive the marginal effects of the technical inefficiency variables.

We obtain strong evidence that tax administration capabilities affect tax revenue extraction efficiency. The allocation of resources to core tax administration functions reduces technical inefficiency. Likewise, the overall resourcing of the tax administration, as measured by the number of taxpayers to each member of tax staff, reduces technical inefficiency. Internal efficiency, as measured by the cost of revenue collection, reduces technical inefficiencies. Inefficient tax administrations incur high revenue collection costs and are low on technical efficiency. Effective arrears recovery reduces technical inefficiency.

Some measures that could be used to reduce technical inefficiency in tax administrations in order to boost revenue extraction capabilities and achieve higher levels of revenue are suggested. The first is the resourcing of the tax administration, both in terms of human resources and the allocation of these resources to the core functions. The issue of quality of staff is equally important. While we address the issue of employee numbers, it is important to note that greater efficiency can be achieved by recruiting high-calibre staff. These aspects, at some point, require the tax administration to have a reasonable level of autonomy. However, some tax administrations lack this.

In the same vein, it is imperative that the internal efficiency of tax administrations is improved in order to reduce revenue extraction costs and to achieve higher levels of technical efficiency in respect of revenue extraction. This may require the enhanced utilisation of technologies, such as self-service applications, that can enhance taxpayer compliance. This is also likely to impact aspects such as audit effectiveness, integrity of staff, and the convenience of paying taxes which, in turn, will promote greater compliance and reduce technical inefficiency.

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APPENDIX

Average Technical Inefficiencies

S/N	Country	Mean	Std. Dev	S/N	Country	Mean	Std. Dev
1	Rwanda	0.27298	0.06983	22	Tanzania	0.25669	0.12980
2	Cent. Afr. Rep.	0.27166	0.08053	23	Gambia	0.25580	0.13678
3	Ivory Coast	0.27062	0.08094	24	Togo	0.25445	0.14017
4	South Africa	0.27062	0.08430	25	Sierra Leone	0.24968	0.15012
5	Senegal	0.27040	0.08348	26	Burundi	0.24403	0.16220
6	Burkina Faso	0.26775	0.09846	27	Congo*	0.24370	0.16435
7	Ethiopia	0.26551	0.11049	28	Guinea	0.23989	0.17111
8	Comoros	0.26487	0.10839	29	DRC**	0.23763	0.17748
9	Cameroon	0.26370	0.11446	30	Mauritius	0.23714	0.15949
10	Uganda	0.26351	0.11683	31	Namibia	0.23343	0.18204
11	Madagascar	0.26220	0.12163	32	Botswana	0.23122	0.18020
12	Liberia	0.26201	0.12248	33	Malawi	0.21649	0.20918
13	Niger	0.26120	0.11680	34	Gabon	0.21562	0.21476
14	Ghana	0.26071	0.12064	35	Nigeria	0.20880	0.19648
15	Mali	0.26036	0.12344	36	Eq. Guinea***	0.19715	0.22784
16	Zambia	0.25928	0.13102	37	Swaziland	0.19369	0.23952
17	Mauritania	0.25880	0.12894	38	Mozambique	0.17634	0.24057
18	Cape Verde	0.25844	0.12992	39	Angola	0.17566	0.24247
19	Kenya	0.25791	0.12191	40	Chad	0.16772	0.24855
20	Guinea-Bissau	0.25714	0.13789	41	Lesotho	0.15010	0.24883
21	Benin	0.25681	0.13064	42	Zimbabwe	0.14575	0.19688

*The Republic of the Congo. **The Democratic Republic of the Congo.** The Republic of Equatorial Guinea.