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Efficiency of Tax Revenue Administration in Africa

Onesmo K. Mackenzie

Achieving stable domestic tax revenue allows countries to finance their essential spending needs. For most countries in Africa, enhancing tax revenue is critical for sustainable development. To build up fiscal capacity, country experiences suggest the importance of tax administration reforms that aim at improving the performance of these institutions. Despite its importance, empirical literature on tax administration is limited, especially in Africa. Lack of comparable tax administrative data explains the scant literature. However, the African Tax Administration Forum (ATAF) has compiled a dataset for African countries which makes empirical analysis possible. The paper makes use of this administrative dataset available for 28 African countries for the 2012 - 2017 period to investigate the efficiency of tax administration in Africa. It applies Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA) and Tobit regression to analyse efficiency scores, rank tax administrations and explore the factors that matter. Among the findings, the paper indicates minimal variation in efficiency across the African tax administrations and significant impact of the size of the informal sector, size of non-tax revenue, employee length of service and autonomy of the tax administration.

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1 INTRODUCTION

Building state capacity is a subject that has been under investigation for decades. Researchers have sought to unravel the process behind the development of effective states. Besley and Persson (2011, p. 3) describe an effective state as one with the ability to mobilize resources and provide investments in infrastructure and public services. A state requires political and administrative capacity to raise sufficient revenue to meet its need for development (Dincecco, 2015, p. 13). With a high capacity, states are able to facilitate economic activities, provide quality public services, promote social welfare, and institute public investments in infrastructure as well as in research and development (Dincecco & Katz, 2016, p. 5).

State capacity has been limited in Africa with countries not being able to mobilize resources sufficient to support legitimate demands for public services and higher levels of infrastructure. Herbst (2000, p. 115) stresses the limited ability to mobilize resources as one explanation for the narrow government fiscal capacity. For example, tax to GDP ratios are relatively low on the continent (Ndikumana & Abderrahim, 2010, p. 2). It is not surprising, therefore, that external aid and support have been significant sources of revenue. However, economic downturns such as the global financial crisis have made it increasingly difficult for African countries to receive sufficient aid and attract private capital flows (Fjeldstad, 2013, p. 3).

To build state capacity, African countries are in search of possible ways to create a sustainable revenue base. The focus is on expanding and exploiting domestic sources of revenue to be able to support public services and achieve development. Using taxation as a fiscal policy tool, African governments aim to optimize their resource mobilization efforts on the domestic front. Taxation features prominently as a viable tool because most countries in Africa generate their mainstream revenue through taxation (Mabugu & Simbanegavi, 2015, p. 2)[1]. Hence, among the different sources of revenue, taxation forms an essential and significant tool for building the state capacity of these countries[2].

The need to optimize revenue has exerted pressure on the institutions charged with the responsibility to administer taxes. Dincecco (2015, p. 13) states that tax administration has a huge bearing on a country's ability to mobilize resources. The effectiveness of tax administration determines the extent to which it exploits the existing tax base. According to

[1] Some countries such as Nigeria, rely primarily on non-tax revenue.

[2] Donor funds, borrowing, natural resource extraction, user charges and administrative fees constitute other sources of revenue.

Magumba (2019, p. 1), governments need effective, efficient and capable tax authorities to mobilize sufficient revenue. Improvement in tax administration, when accompanied by improvement in public service delivery, has the potential to build confidence in the fiscal system and increase revenue mobilization (Fossat & Bua, 2013, p. 14).

One of the pertinent issues in dealing with tax administration relates to the efficiency with which the administration implements the tax system. This is about the administration's ability to achieve maximum possible levels of tax revenue given the resources at its disposal and the exploitable tax base as defined by tax laws (Cullinane, Wang, Song, & Ji, 2006, p. 5). As stressed by Alm and Duncan (2014, p. 3), a country may not build a sustainable revenue base if its tax administration is inefficient or ineffective. In such cases, it becomes difficult for the country to effectively build state capacity. It is important, therefore, that the process of searching for ways to build sustainable revenue bases includes an investigation of how efficient the existing tax administrations are and the drivers of such efficiency.

Despite the heightened need to understand the efficiency of tax administration, there has not been much research on the efficiency of revenue mobilization of African tax administrations. Lack of cross-country administrative data is one reason behind the scanty literature (Efobi, Beecroft, & Belmondo, 2019, p. 7). The administrative data encompasses information regarding the capital and operating costs that tax authorities incur, the structure and organization of tax administrations, the number of taxpayers and their characteristics, the number of employees and their characteristics among other factors. The absence of such data on a comparable basis, especially in Africa, has resulted in few attempts to estimate empirically the efficiency of institutions responsible for tax collection.

However, the African Tax Administration Forum (ATAF) has compiled a dataset for African countries that makes efficiency analysis possible. As an international organization for African tax administrations, ATAF provides a platform through which African tax authorities can improve their performance. The paper makes use of the ATAF compiled administrative dataset, available for 28 African countries for the 2012 - 2017 period, to answer the following research question: how (technically) efficient are African tax administrations in collecting tax revenue?[3] The specific objectives include:

- To estimate the technical efficiency of tax administration in Africa

[3] The paper also uses other sources of data like the World Bank apart from the ATAF dataset. This is discussed further in section 6.

- To explain the factors that drive the technical efficiency of tax administration in Africa
- To analyse the variation in technical efficiency of tax administration in Africa

To achieve the first objective, the paper applies two standard efficiency measurement techniques of Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). While SFA is a parametric technique that computes efficiency scores based on econometric analysis, DEA is a non-parametric technique that computes scores based on linear programming (Coelli, Rao, & Battese, 1998). To minimize chances of obtaining results that are entirely method driven, the paper applies both techniques in cognisance of their strengths and weaknesses.

To achieve the second objective, the paper uses a Tobit regression to establish factors that affect efficiency. It is applied on the censored (between one and zero) efficiency scores estimated from the DEA method. To achieve the third objective, the study analyses the efficiency scores of the SFA and DEA techniques to explain the variation of efficiency across the countries in the sample. This helps in establishing trends and similarities which can be useful in improving the administrative system.

The paper is organized as follows: the next section gives a general overview of African tax administrations. This is followed by the theoretical underpinnings of the notion of efficiency in Section Three. An outline of the methods is presented in Section Four while Section Five surveys the literature on efficiency studies. Section Six expounds on the data employed in the study and is followed by a discussion of the results in Section Seven. Section Eight provides the conclusion.

2 OVERVIEW OF AFRICAN TAX ADMINISTRATION

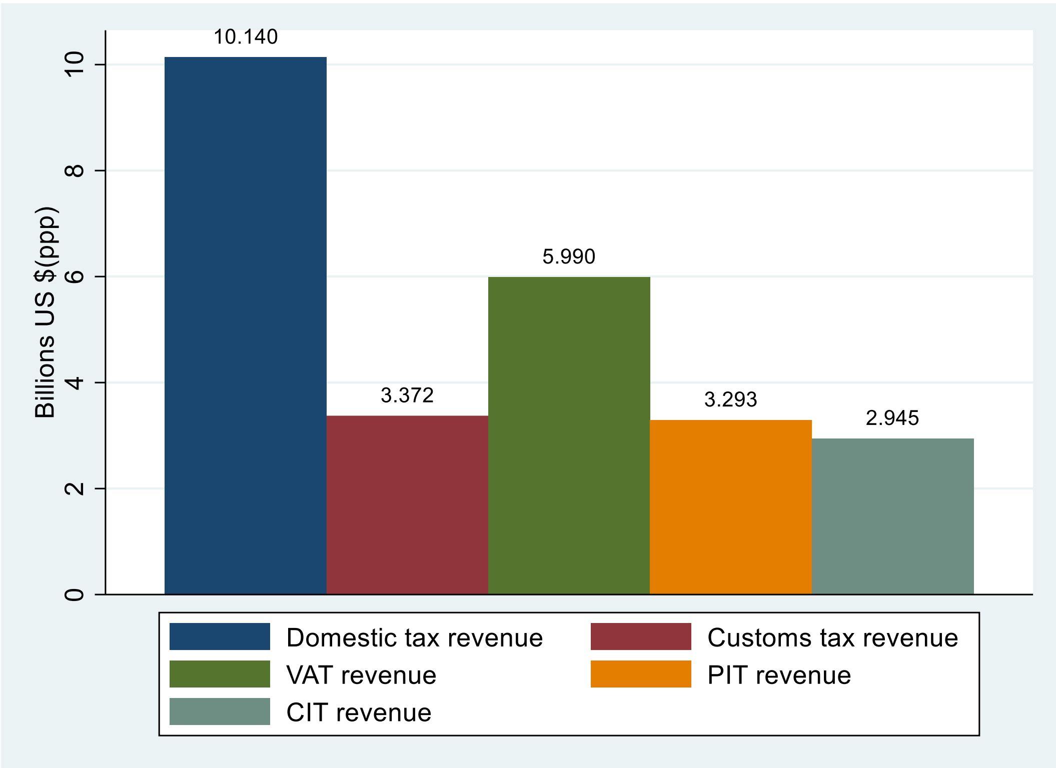
2.1 Introduction

There is increasing interest amongst policy makers and practitioners to gauge the performance of tax administrations, with the objective of improved and effective institutions to optimize revenue mobilization. This section begins with a discussion of the structures and the environment in which African tax administrations operate. It provides a context to tax administration in Africa by discussing tax base and tax instruments as well as the factors that influence these concepts. However, the section mainly focuses on the administrative structure of African tax agencies and the changes that have characterised these administrations in recent decades.

2.2 African tax structures and tax environment

African tax administrations operate in an environment characterised by challenges such as narrow tax bases, limited institutional capacity and large informal sectors. The tax base encompasses income, assets or consumption that tax authorities use as a basis for revenue collection. The size of a tax base largely depends on the taxpayers available in a country and the concentration of the base across different groups. For example, the Personal Income Tax (PIT) in South Africa does not have large numbers of taxpayers, because income is concentrated amongst the middle to higher income groups (Van Heerden, 2013, p. 20). A high number of taxpayers increases the size of the tax base and the concentration of the base across various taxpayer categories matters for revenue mobilization.

Figure 1: African countries' tax revenue by tax instrument (2012-2017)[4]



Notes: Author's own calculations using data from ATAF.

There are various tax instruments that African tax administrations use to collect revenue. The main instruments include Value Added Tax (VAT), Personal Income Tax (PIT), and Corporate

[4] The tax revenue is for a sample of 28 African countries. See the list in Appendix Table A.1.

Income Tax (CIT) and custom duties. The figure gives tax revenue shares disaggregated by the type of tax instrument for 28 African countries. Apart from VAT, PIT and CIT, domestic tax revenue includes excise tax, withholding tax, presumptive tax and other domestic taxes. Customs tax revenue includes VAT on imports, import duties, excises on imports and other custom duties. Figure 1 shows that countries in Africa collect more tax revenue domestically than they do from trade taxes. The small share of customs revenue is a possible indicator that African countries have migrated from trade taxes to rely more on consumption-based taxes. This trend reflects the trade liberalisation of recent decades and the longer-term shift from trade to income and consumption taxes accompanying economic development in all countries.

Aside from these, African countries generate revenue from other non-tax sources such as natural and mineral resources (oil, diamond, iron, coal, and uranium), fees, fines, penalties, licences, royalties and social security. Besides, most of the African countries still have a high dependence on external aid and support with the average inflows amounting to approximately 21 percent of GDP (Asongu & Leke, 2017, p. 19). However, as alluded to in the previous section, the economy has not been stable and global crises have fuelled the need for African countries to establish sustainable sources of revenue and build their state capacities.

The presence of a large informal sector is one of the challenges that limits domestic tax revenue mobilization. The informal economy has a significant share of economic activities across the continent especially in agriculture, manufacturing and mining sectors. It contributes an average of 27 percent to Gross Domestic Product of African countries (Charmes, 2015, p. 4). Informal activities present peculiar challenges to tax administration as they are difficult for tax authorities to record and monitor without incurring large administrative costs. The actual size of the informal sector varies across countries and methodologies. For instance, South Africa has approximately 22 percent of the labour force engaging in informal activities while Zimbabwe experienced an increase in the size of the informal economy labour force from 10 percent in 1982 to 84 percent in 2011 (Dube & Casale, 2019, p. 4; Essop & Yu, 2008, p. 4).

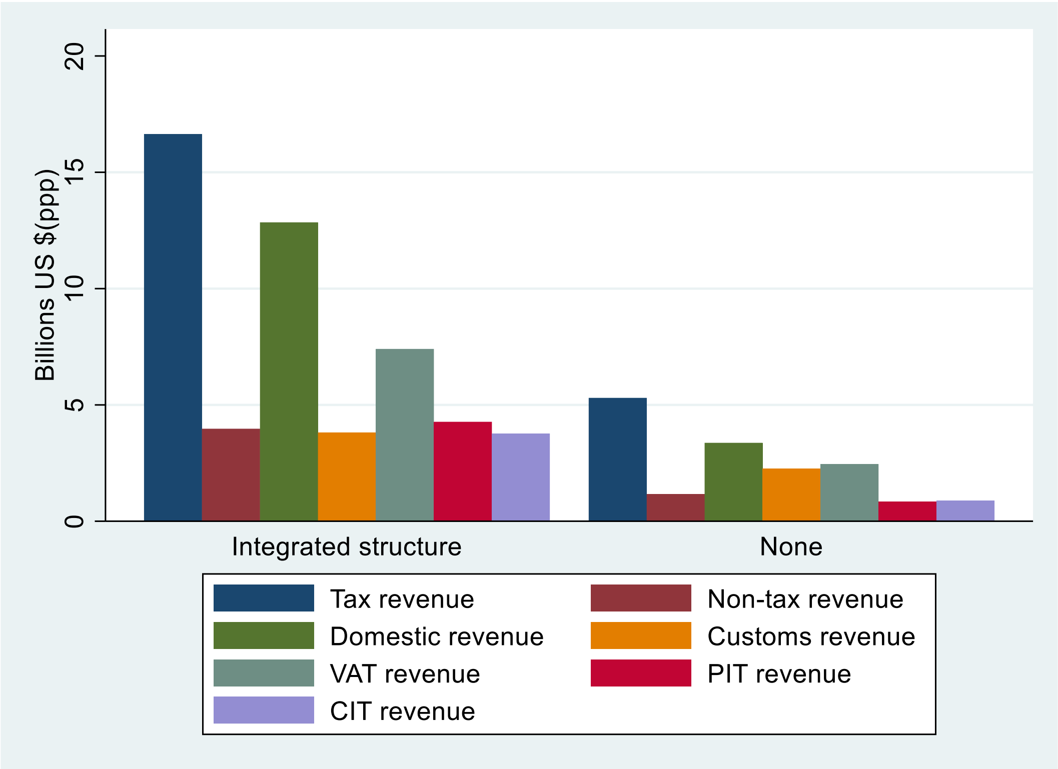
Over the years, tax administrations in Africa have implemented various strategies with the aim to address, among other challenges, the informal nature of economic activities. These strategies and the changes that tax authorities have undergone to optimize revenue mobilization are expounded in the next sub-section.

2.3 Administrative structure and strategies

The structure of tax administration aligns with its mandate of collecting tax revenue on behalf of government. The design of African tax administrations has evolved over time to reflect the various strategies that have been implemented as part of the efforts to improve service delivery and optimize revenue collection. These strategies relate to modernizing revenue collection by leveraging on information technology, minimizing the cost of collection, building staff capacity, encouraging voluntary compliance through taxpayer sensitization campaigns and maintaining integrity through independent audit services among other revenue collection aspects.

One of the administrative changes that African tax authorities have introduced involves the implementation of an integrated tax system. In earlier periods, revenue authorities had separate organizations that dealt with taxes relating to imports and exports (customs sections) and another segment that focused on domestic taxes. An integrated tax system locates the domestic and customs sections under a single tax administration. This ensures proper and simplified taxpayer management and compliance monitoring (ATAF, 2018).

Figure 2: Revenue shares versus an integrated structure (2012-2017)

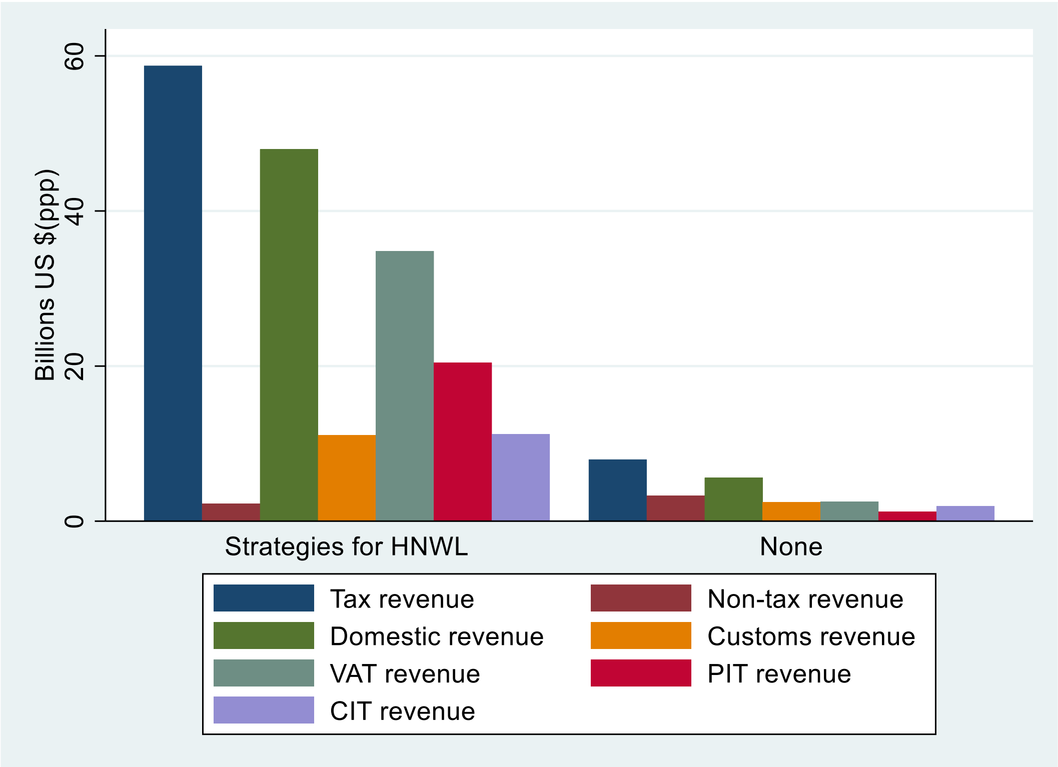


Notes: Author's own calculations using data from ATAF.

Figure 2 shows that tax administrations that use an integrated tax system collect more revenue than those that do not. Also, domestic revenue is larger than customs revenue with the difference being greater for administrations that use an integrated system than for those that do not. This is a possible indication that an integrated system enhances the effectiveness of tax authorities in mobilizing resources on the domestic front.

Tax administrations have also segmented their taxpayers into different categories to offer customized services and to increase administrative effectiveness. One prominent segmentation involves the introduction of a separate section to handle High Net Worth Individuals (HNWI). Using this section, tax authorities offer better services and establish reliable relationships through improved communication which simplifies revenue collection. Ligomeka (2019) explored the effectiveness of a HNWI section in the Malawi Revenue Authority (MRA). He observed that Malawi has low scores on standard performance measures even though its tax to GDP ratios are higher than most Sub-Saharan African countries.

Figure 3: Revenue shares versus Large Taxpayer Units (2012-2017)

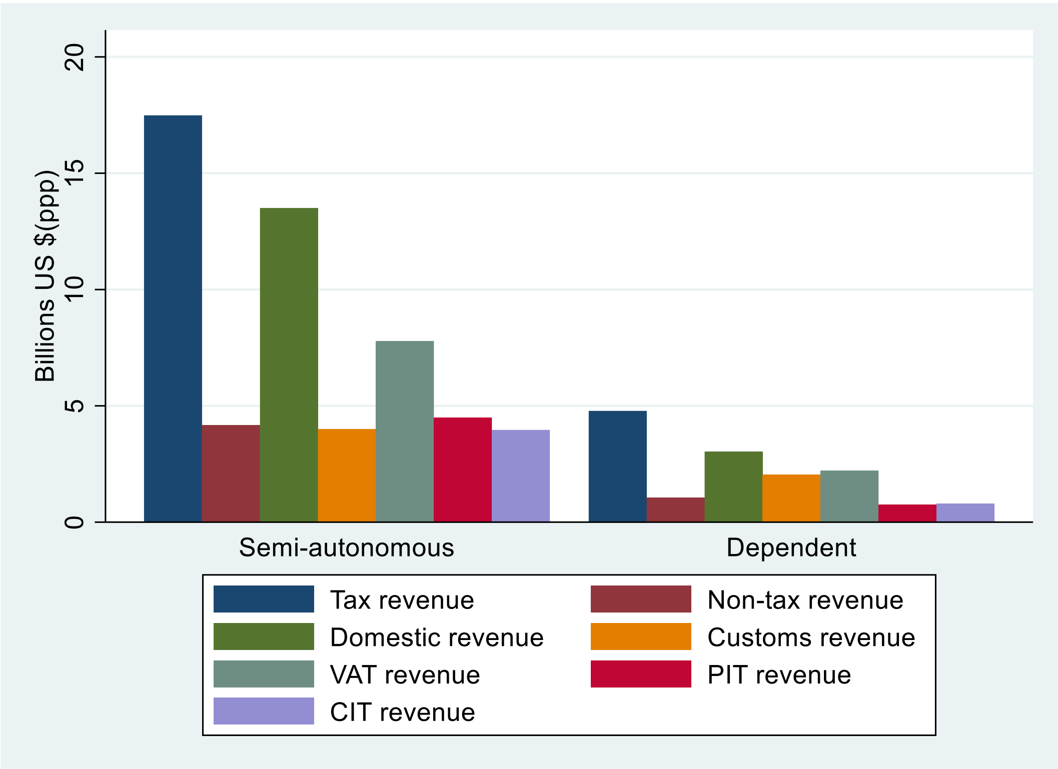


Notes: Author's own calculations using data from ATAF.

He established that the high revenue collection is a result of the effectiveness in the high net worth section of the Malawi Revenue Authority, which accounts for 70% of Malawi's tax revenue (Ligomeka, 2019, p. 22). Similarly, Mascagni et al (2018) report that special sections to deal with different taxpayers such as large taxpayer units or high net worth individuals have led to increases in revenue collections in Rwanda[5]. Figure 3 shows larger revenue shares for tax administrations that employ special strategies to deal with high net worth individuals than for those that do not.

The use of semi-autonomous revenue authorities (SARAs) is another prominent reform characterizing African tax administrations. SARAs is about granting partial authority to tax administrations[6]. Apart from reducing political interference, SARAs gives a degree of autonomy which allows tax administrations to exercise financial independence and freedom in management. Some studies show that tax authorities under semi-autonomous revenue authorities perform better in terms of revenue collection (Devas, Delay, & Hubbard, 2001; Dom, 2017; Taliercio, 2004). Figure 4 shows a similar trend with semi-autonomous revenue authorities having the larger share in revenue.

Figure 4: Revenue shares versus Semi-autonomous revenue authorities (2012-2017)



Notes: Author's own calculations using data from ATAF.

[5] In this study, Mascagni, Monkam and Nell (2018) explore the potential of African administrative data and apply the data by studying tax compliance and progressivity in Rwanda.
[6] About 70% of the 28 sampled countries in this study have semi-autonomous revenue authorities

In addition, Taliercio (2004, p. 13) argues that politicians use SARAs as a tool to signal to citizens that tax administration will be competent, effective and fair without political interference. This creates an atmosphere of trust between taxpayers and the institution. In South Africa, adoption of SARA model brought the freedom to use more attractive pay scales, upgrade technology and introduce management practices that would most likely have not worked with civil service regulations.

Tax authorities implement other strategies to enhance taxpayers' voluntary compliance with tax regulations. A credible tax administration enhances the effectiveness of the tax system by executing its duties within the legal mandate. When taxpayers have trust in the tax system, voluntary compliance is enhanced. For example, Santoro and Mdluli (2019) explored the issue of tax compliance in Eswatini while focusing on nil returns filing. Nil-filers (taxpayers that indicate zero taxable income) represent underutilized taxable capacity which can be exploited if voluntary compliance is enhanced. Such strategies include building a wide taxpayers' database and deploying skilled staff to monitor nil-filers. (Santoro & Mdluli, 2019, p. 22).

African tax administrations have also focused on modernizing revenue collection through the digitization of tax processes. An electronic system simplifies taxpayer registration, tax filing and documentation. Efobi et al (2019, p. 7) report that electronic filing has been introduced in over 32% of developing countries and it has had significant effects on tax revenue collection. For example, Maisiba and Atambo (2016) found a substantial improvement in tax registration, payment and filing as a result of an electronic system introduced in the Kenyan Revenue Authority. They also found that revenue collection activities had significantly improved despite some taxpayers finding it difficult to use the system due to computer illiteracy and challenges with internet access (Maisiba & Atambo, 2016, p. 11). Similarly, the Rwandan Revenue Authority experienced a 21.8 percent increase in the number of registered taxpayers after introducing an electronic billing machine (Rwandan Revenue Authority, 2018).

Other strategies relate to building staff capacity and increasing staff retention. African tax administrations have adjusted remuneration schemes and introduced staff engagement activities to reduce staff turnover. The administrations have faced challenges retaining some of their experienced and competent staff due to relatively weak reward system. For example, the Mauritius Revenue Authority had 1.04 percent turnover while Lesotho had 2.2 percent turnover. The authorities are working on finding ways to attract and retain skilled workers.

2.4 Conclusion

The section has given an overview of tax administration in Africa. It has provided the context and environment in which African tax authorities operate with a discussion of tax structures and instruments. It has also discussed the administrative structure of African tax agencies and the changes that have characterised these administrations as a result of various strategies introduced to improve tax revenue mobilization. A tax administration experiences improvements in its effectiveness when it becomes integrated and semi-autonomous, institutes strategies to deal with the informal sector and sets up specific sections to handle high net-worth individuals (HNWI). As such, most tax administrations are restructuring their operations to take advantage of institutional innovations. However, it remains important to assess the efficiency of these institutions as part of the process of ensuring operational effectiveness. This requires an understanding of the theoretical underpinnings of efficiency and its application to organizations such as tax administrations. This is discussed in the next section which presents the theoretical grounding of the concept of efficiency.

3 THEORY AND EFFICIENCY CONCEPTS

3.1 Introduction

Building state capacity through increased resource mobilization requires an established administrative infrastructure with the capacity to achieve desired levels of resource extraction. African tax authorities provide the administrative apparatus for tax revenue collection. To assess the efficient performance of these institutions, it is imperative to provide a relevant theoretical framework for the empirical analysis in subsequent sections. In production economics, efficiency measures a firm's ability to apply input (s) into a production process to produce maximum output (s) (Varian, 2010, p. 332). This basic idea has been expanded to make it possible to measure the performance of organizations such as tax authorities as they share the common goal of maximizing the amount of tax revenue collected (output) using the various resources as inputs subject to relevant tax base as defined by tax laws.

This section begins with a theoretical discussion of the concept of efficiency using a basic short-run production process. It involves explaining the concepts of isoquants and the production possibility frontier in the input and output oriented production processes. It then distinguishes the different types of efficiency (technical, allocative, scale and x-efficiency) and motivates why the study focuses on technical efficiency.

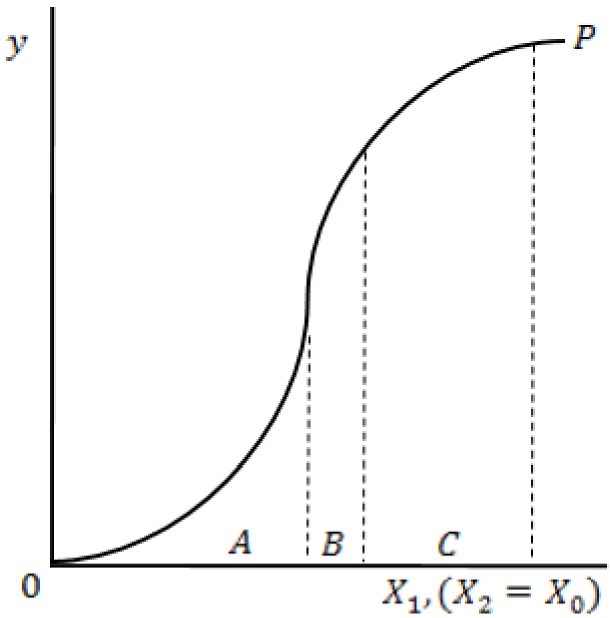
3.2 Basic production function

A production process involves the use of resources (inputs) to produce goods (output). The set of all combinations of inputs and outputs that can be produced given the state of technology forms a production set (Varian, 2010, p. 333). A mapping of the maximum level of output that a firm can produce at any level of inputs given its state of technology is what forms a production function. Equation 1 is a production function in which inputs X_1 and X_2 are used to produce output y with $f(.)$ capturing the state of technology.[7]

$$y = f(X_1|X_2 = X_0) \text{ .... (1)}$$

Varian (2010, p. 340) emphasizes that the basic production function has at least one factor of production fixed in the short run. Equation 1 assumes that X_1 represents a variable input (for example labour) and X_2 a fixed input (for example capital) which is fixed at X_0.

Figure 5: Production possibility set



Source: Author's own depiction, *adapted from Coelli et al (1998, p. 4)*

Graphically, equation 1 is depicted in Figure 5 with y (output) on the vertical axis and X_1 (input) on the horizontal axis (with X_2 fixed at X_0). The line P represents the production function which maps out the maximum output y that can be produced at different levels of

[7] This is a very simplified production process and it is used here to help discuss the basic textbook explanations of production functions using simplifying assumptions to avoid overcomplicating the discussion.

input X_1 when X_2 is fixed at X_0. All points below line P are feasible but points above line P are deemed unattainable (outside the production set) at the prevailing level of technology.

The shape of the production function as represented by line P displays the law of diminishing marginal returns. The marginal product of X_1 is the additional output y that comes as a result of a unit increase in X_1 (holding X_2 constant). The law of diminishing marginal returns states that when one input is increased while all other inputs are held constant, the marginal product of the increased input must eventually decline due to congestion in the use of the input (Varian, 2010, p. 342). This law makes it possible to divide the production function into three stages as given in Figure 5. In Stage A, the output produced by each additional unit of X_1 (also called the marginal product of X_1) is increasing. Also, the average product of X_1 (total output y divided by total input X_1) is increasing. In stage B, both the marginal product and average product of X_1 are declining but the marginal product remains positive. In stage C, the marginal product of labour becomes negative, meaning that any additional units of X_1 are leading to a reduction in output.

A profit-maximizing firm will not aim to produce in either Stage A or C but rather in stage B. This is because in stage A, a firm can increase its output by increasing the units of any inputs employed in production while stage C is not profitable because additional units of any input are leading to reductions in output. It is hence profitable for the firm to produce in stage B. However, the point of optimal production does not only depend on the state of technology but also on input and output prices (Bromley, 1990). Subsection 3.4 discusses this further by considering the choice of optimal production in line with economics of scale.

3.3 Input and output-oriented production processes

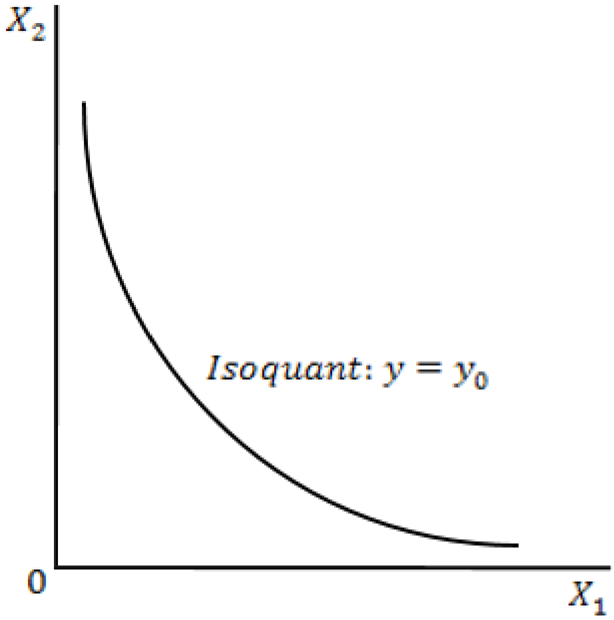
Section 3.2 described a production function that characterizes a firm's behaviour in the short run when there is no variation in at least one factor of production. This section discusses a production process when there is variation in all factors of production. Equation 2 is a production function that includes variation in all inputs (X_1 and X_2):

$$y = f(X_1, X_2) \dots\dots\dots\dots (2)$$

Given this production function, profit-maximizing firms can either focus on reducing the volume of inputs (X_1 and X_2) used in production holding output constant or increasing the volume of output (y) holding the quantity of inputs constant. When a firm opts to use as few input quantities as possible, it is deemed to follow an input-oriented production process. In contrast, a firm that focuses on increasing the quantity of output at any level of inputs is deemed to follow an output-oriented production process.

Graphically, we make use of an isoquant to depict the input-oriented production process instead of a simple line as previously done (see line P in Figure 5). The isoquant is more convenient when there is variation in all inputs. It also proves essential in understanding the concept of efficiency as discussed in subsection 3.4. An isoquant maps out different combinations of inputs that efficiently produce the same level of output (Varian, 2010, p. 334).

Figure 6: An input-oriented production process

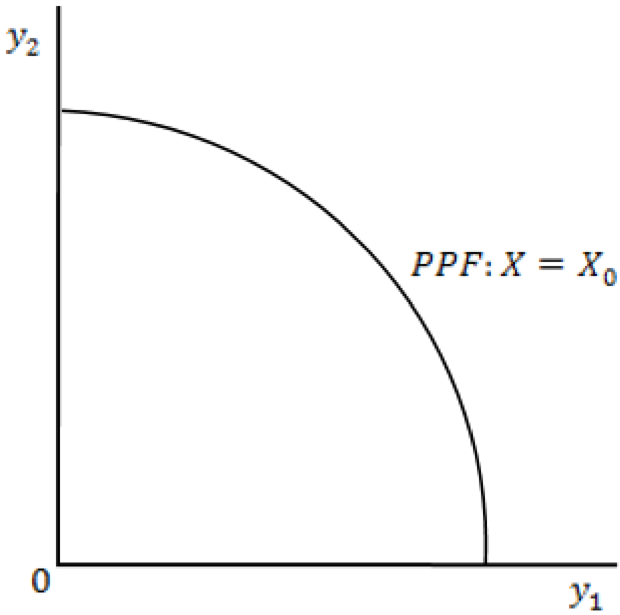


Source: Author's own depiction, adapted from Coelli (1998, p. 17)

Figure 6 shows the input-oriented production process in which firms maximize profits by ensuring the optimal use of inputs. The focus is on how to use the smallest volume of inputs without reducing the amount of output produced. The isoquant in Figure 6 is a combination of inputs X_1 and X_2 that gives a constant level of output ($y = y_0$)[8]. This is key in understanding efficiency because all points mapped out by the isoquant are considered to be efficient levels of production for the firm. This is further discussed in subsection 3.4.

[8] The isoquant is derived from equation 2 by setting Y to a fixed value and making X_2 the subject of formula.

Figure 7: An output-oriented production process



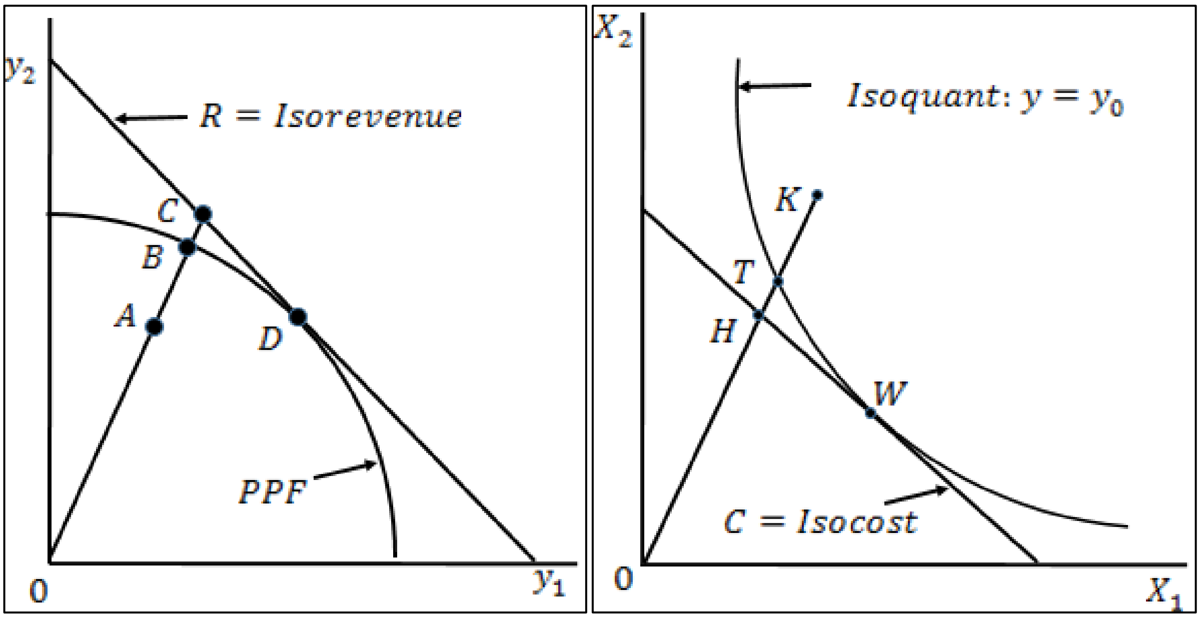
Source: Author's own depiction

Figure 7 makes use of a Production Possibility Frontier (PPF) to capture an output-oriented production process. This is where firms aim at producing as much output as possible given the available set of inputs. The focus is on expanding output levels without changing the levels of inputs used. The line marked PPF in Figure 7 represents different combinations of output (y_1 and y_2) that can be produced using the same level of input ($X = X_0$). Similar to the isoquant, all points on the PPF are considered to be efficient production points for a firm as expounded in the next subsection.

3.4 Deriving efficiency from production functions

The work of Farrell (1957) forms the basis for understanding the concept of efficiency from production economics. He built on the writings of Koopmans (1951) and Debreu (1951) to establish a way of measuring firm efficiency that is applicable to organizations beyond goods-producing firms. Tax administrations count among the organizations whose efficiency can be established based on the theoretical discourse of Farrell (1957). In subsections 3.2 and 3.3, we established the idea of an isoquant (for input-oriented production process) and a production possibility frontier (for output-oriented production process). In this subsection, we discuss how these two concepts are used to derive ways of measuring efficiency.

Figure 8: Input and output oriented production processes



Source: Author's own depiction, adapted from Coelli (1998, p. 8)

Technical efficiency measures whether a firm employs the minimum amount of inputs to produce a given amount of outputs (for an input-oriented process) or whether it produces the maximum level of outputs given a fixed amount of inputs (for an output-oriented process) (Kyj & Isik, 2008, p. 5). The left panel of Figure 8 gives an output-oriented production process while the right panel is an input-oriented process. The isoquant in the input-oriented process maps out all combinations of inputs that efficiently produce a constant level of output y_0. According to Farrell (1957), an efficient firm produces along the isoquant[9]. Technical inefficiency arises in cases where more of each input is used than required to produce a given level of output.

A firm producing at point K in the right panel of Figure 8 can reduce the quantities of both inputs (X_1 and X_2) without experiencing a reduction in output. In this case, such a firm is said to be inefficient. Equation 3 gives the measure of technical efficiency for the firm producing at point K. The measure is a ratio between zero and one with the value of one indicating that the firm is technically efficient (production along the isoquant).

$$TE_i = {}^{0K}/_{0T} \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

[9] Efficiency defined at this stage does not take into account costs (prices of inputs). The efficiency that takes into account prices is further discussed under allocative efficiency.

The PPF in the left panel of Figure 8 maps the maximum production points at constant levels of inputs. For the output-oriented process, Farrell (1957) describes technical efficiency as a firm's ability to produce on the PPF. A firm is technically inefficient if it produces within the PPF. For example, if a firm produces at point A, it can increase its output to point B without requiring a corresponding increase in inputs. In such a case, the firm is said to be inefficient. Similar to equation 3 in the input-oriented process, equation 4 gives technical efficiency for a firm producing at point A in the output-oriented process.

$$TE_o = {}^{OA}/_{OB} \text{.............} \quad (4)$$

Apart from technical efficiency, profit maximizing firms are also interested in allocative efficiency, the ability of a firm to use inputs in optimal proportions given their respective prices (Akhtar, 2002, p. 3)[10]. While technical efficiency reflects the productivity of inputs, allocative efficiency deals with cost effective ways of producing the output. In the right panel of Figure 8, line C is the iso-cost line, mapping combinations of inputs (X_1 and X_2) which cost the same amount. The allocative efficiency of a firm operating at point K will be represented by the ratio:

$$AE_i = {}^{OH}/_{OT} \text{....................} \quad (5)$$

Point T is technically efficient but allocatively inefficient because a firm can reduce its production costs by operating at H. On the other hand, point H is allocatively efficient but not technically efficient because a firm can increase output without requiring any increase in input quantities. For the output-oriented process, line R in the left panel of Figure 8 is the iso-revenue line which maps out combinations of output that yield the same level of revenue. For a firm operating at point A, the allocative efficiency will be the ratio in equation 6, which captures the ability of a firm to increase its revenue by shifting production from point A to point C.

$$AE_o = {}^{OB}/_{OC} \text{................} \quad (6)$$

Another type of efficiency that can be used to evaluate firm performance is called X-efficiency. It is a combination of both technical and allocative efficiencies. It refers to the ability of a firm to maximize output by controlling not just input quantities but also the cost of inputs (Fung,

[10] The common understanding of allocative efficiency is that it considers costs, but also the preferences of society so that outputs are produced that align with the demand. However, the study uses the efficiency concepts from a purely production perspective and in line with stochastic frontier and data envelopment techniques. It does not include a discussion on the demand of the outputs produced which would be reflected in the prices at which a firm would sell its goods and services.

2006, p. 2). A firm is X-efficient if it is producing at a point that is both technically and allocatively efficient.

In Figure 8, an X-efficient firm will produce at point D in the output-oriented process (left panel) and at point W in the input-oriented process (right panel). These are points where the iso-cost and iso-revenue lines are tangent to the isoquant and PPF curves, respectively. X-efficiency is calculated as the product of technical and allocative efficiencies. However, the applicability of allocative efficiency is largely limited as it requires information on all input prices which is usually not available for most organizations including tax administrations (Drake & Simper, 2010, p. 3).

Furthermore, firms are also interested in scale efficiencies. The discussion of efficiency based on isoquants and production possibility frontier assumes that a proportional increase in inputs will lead to a corresponding proportional increase in output. However, this is only the case if a firm is operating under constant returns to scale. Returns to scale (RTS) is a concept that captures the response of output to changes in inputs (Varian, 2010, p. 342) . It reflects the extent to which a proportional change in all inputs leads to a change in output. A production process exhibits constant returns to scale (CRS) if a degree of increase in all inputs produces the same degree of increase in output. Variable returns to scale (VRS) take place when an increase in inputs does not necessarily lead to an equivalent increase in output.

As shown in Table 1, constant returns to scale (CTS) take place when an increase in inputs by any factor greater than one ($t > 1$) leads to an increase in output of the same magnitude ($t > 1$). Returns to scale are increasing if an increase in inputs leads to a proportionally greater increase (more than $t > 1$) in output. Decreasing returns to scale take place when output experiences an increase that is less than the proportional increase in inputs (less than $t > 1$).

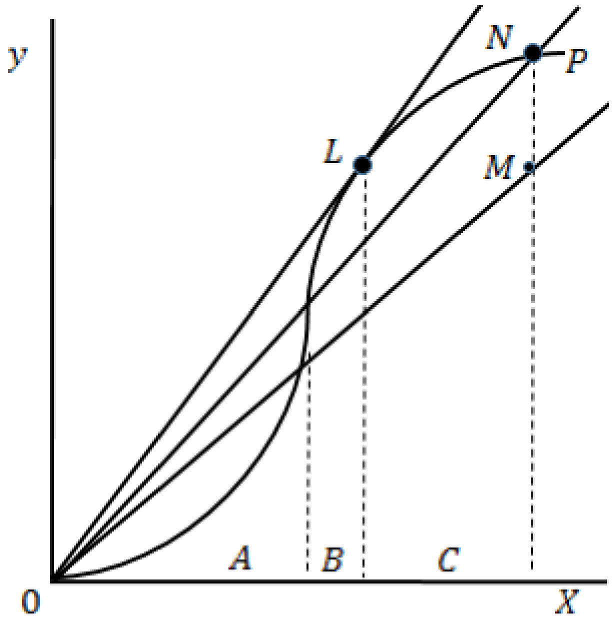
Table 1: Returns to scale

Returns to scale	**Scale Notation (t>1)**	**Description**
Constant	$f(tX_{1,}tX_2) = tf(X_{1,}X_2)$	Output increase same as input increase
Increasing	$f(tX_{1,}tX_2) > tf(X_{1,}X_2)$	Output increase exceeds input increase
Decreasing	$f(tX_{1,}tX_2) < tf(X_{1,}X_2)$	Output increase less than input increase

The returns to scale form the basis of another type of efficiency called scale efficiency. While X-efficiency is about the effectiveness of the use of resources, scale efficiency is about the relationship between optimal use of resources and the size of the firm (Kyj & Isik, 2008, p. 2).

In Figure 9 (similar to Figure 1), line P represents the production function which maps out the maximum output y that can be produced at different levels of input X ($X = X_1 + X_2$). Similar to Figure 1, A, B and C indicate the three stages of production. Based on the definition of technical efficiency, points L and N are efficient because they lie on the production possibility frontier but point M is inefficient as it lies below the frontier. Nonetheless, despite being efficient, point L and N are not operating at the same stages of production.

Figure 9: Input and output oriented production processes



Source: Author's own depiction, adapted from Coelli et al (1998, p. 5)

While a firm operating at point L is experiencing positive marginal returns, a firm at point N is experiencing negative marginal returns. Apart from being technically efficient, point L is also experiencing the highest level of productivity, hence it is scale efficient. When a firm experiences constant returns to scale, it is said to be scale efficient. This shows differences that might exist between firms which are solely based on the size of the firm as large and small firms may require a different optimal mix of inputs and outputs. Scale efficiencies can arise from an improved division of labour and specialization in a firm (Fung, 2006, p. 16). A small firm can experience increasing returns to scale due to enhanced specialization resulting from the increase in the number of employees. In contrast, a large firm may experience decreasing returns to scale due to challenges in managing a large workforce and firm operations (Kyj & Isik, 2008, p. 4).

3.5 Conclusion

This section has laid out the theoretical foundation on which methods of calculating efficiency are based. Using principles from production economics, the section has discussed the two concepts of isoquant and production possibility frontier. These concepts are essential in understanding the measurement of efficiency for goods-producing firms as well as organizations such as tax administrations. The methods of calculating efficiency developed in the next section apply linear programming or econometric techniques to estimate production possibility frontiers for tax administrations. The estimated frontiers are the basis on which the different types of efficiencies explained in this section are produced. However, this paper focuses on technical efficiency which is solely the ability of tax administrations to maximize tax revenue (output) given the resources at their disposal. Much as allocative and X-efficiency are relevant, the paper does not estimate these efficiency measures as their calculation requires information on the prices of inputs which is not available.

4 MEASURING EFFICIENCY: METHODOLOGICAL APPROACHES

4.1 Introduction

This section presents the methods that the paper applies to measure the efficiency of tax administrations as part of the explorative process of finding ways in which African countries can build greater state capacity. The methods are based on the concept of the production function as discussed in the previous section under the theoretical underpinnings of efficiency. Section 3 pointed out that measuring the performance of an institution or organization derives from production economics in which a firm employs inputs in a production process to produce outputs. It used Farrell (1957) to explain that an efficient firm maximizes production by operating along a production possibility frontier (See Figure 6 in Section 3).

However, the production possibility frontier is never known in practise. As such, Farrell (1957) recommended estimating the frontier from sample data using either parametric (econometric) or non-parametric (mathematical programming) methods. This section discusses two such methods, Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) as parametric and non-parametric techniques respectively. Cullinane, Wang, Song and Ji (2006, p. 3) stress that DEA and SFA are the two most important alternative approaches in measuring efficiency and have been extensively applied to a range of industrial and organisational contexts. Alm and Duncan (2014, p. 4) emphasize that these methods are the standard techniques used to explore relative efficiency of agencies and institutions.

The two techniques are similar in that they both use sample data to produce an efficient frontier against which the relative efficiency of the institutions in the sample are estimated. However, the techniques use different approaches to estimate the efficient frontier. SFA makes use of central tendencies in which a single estimated equation applies across all institutions in the sample (Akhtar, 2002, p. 6). In contrast, DEA analyses each institution separately and produces an efficiency measure for each institution relative to the entire dataset, taking into account extreme observations. It captures the closeness of an institution to the estimated best frontier (Kyj & Isik, 2008, p. 2).

The paper applies both techniques because not one of them dominates the other, hence, both are used in cognisance of their strengths and weaknesses since the true level of efficiency is unknown and can be no more than an estimate (Fung, 2006, p. 3). Literature has also shown that the estimates produced by the two techniques may vary (Kinaci, Najjari, & Alp, 2016; Moesen & Persoon, 2002). The techniques have, therefore, been adopted to augment each other and ensure robustness of results by minimizing chances of making conclusions that merely reflect the choice of technique.

Apart from SFA and DEA, the paper also applies a Tobit regression for the specific purpose of finding factors that drive efficiency. While the SFA accounts for the size and structure of the economy in which an organization operates, the DEA does not take into account such factors, but rather focuses on the internal capacity of the institution to use resources to achieve maximum output. As such, the Tobit regression is applied on the results generated from the DEA to assess the impact of factors that are excluded from the DEA's process of estimating efficiency. By adopting multiple techniques, the paper gains more insight into the data even though one technique does not necessarily overcome the weaknesses of another technique.

4.2 Stochastic Frontier Analysis (SFA)

The stochastic frontier analysis (SFA) is a technique for estimating an efficient production frontier developed by Aigner et al (1977). As introduced in subsection 4.1, it makes use of regression analysis to estimate the frontier which depicts the maximum attainable output for a given level of inputs. Deviations of an institution's actual production from the estimated frontier are assumed to be a result of either random shocks or inefficiencies in the institution

(Hassan & Tufte, 2001, p. 2). These deviations are the estimated counterparts of theoretical equation 3 and 4 in section 2 (See subsection 2.4 and Figure 4).

The following is the specification of the SFA model:

$$Y_{it} = \alpha + \beta^{'} X_{it} + \varepsilon_{it} \text{ …………………….. (7)}$$

Where:

Y_{it} is output for institution i in year t

α is a constant

$\beta^{'}$ is a vector of unknown parameters

X_{it} is a matrix of factors used to produce output for institution i in year t

ε_{it} is a composite error term for institution i in year t

The composite error term (ε_{it}) in SFA is disentangled into two distinguishable error terms as follows:

$\varepsilon_{it} = v_{it} - \mu_{it}$

Where:

v_{it} captures the influence of the random (stochastic) variables for institution i in year t. It is assumed to be independent and identically distributed, $v_{it} \sim N(0, \sigma_v^2)$. It is also independent of μ_{it}.

μ_{it} captures inefficiency in production for institution i in year t. It is assumed to be independent and identically distributed $\mu_i \sim N(0, \sigma_\mu^2)$.

SFA is a parametric technique that requires the researcher to impose assumptions about the distribution of error terms (Aigner et al., 1977, p. 3). While v_{it} is assumed to be normally distributed, μ_{it} can take up three possible distributions: half-normal, truncated normal and exponential distributions.

The half-normal and the exponential distributions have similar shapes with a mode at zero. However, the exponential distribution has a high probability of allowing small values rather than larger values as the half-normal distribution (Aigner et al., 1977, p. 12). Nonetheless, the shape of the two distributions reduces the effect of inefficiencies and increases the chances of having more institutions being close to the efficient frontier (Drake & Simper, 2010, p. 12). On the other hand, the truncated normal distribution provides a wide range of shapes that includes both zero and non-zero modes. While the half-normal and exponential distributions assume a greater proportion of institutions being close to the efficient frontier, the truncated normal distribution allows for a variation in the proportion between efficient and inefficient cases.

The SFA is limited in that it requires a priori specification of the distributions of error terms since it is a parametric technique. Nonetheless, it is attractive in that it has a solid grounding in economic theory and accounts for random factors (individual country heterogeneity) that may affect the efficient operation of an institution. This is reflected in the SFA technique developed by Green (2005) which has the following formulation:

$$Y_{it} = \alpha_i + \beta' X_{it} + v_{it} - \mu_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

Where α_i is the group-specific constant which captures the cross-unit heterogeneity while μ_{it} captures the time-varying technical inefficiency. Using this specification, the technical efficiency of institution i at time t is derived as follows:

$$TE_{it} = \frac{Y_{it}}{exp(\alpha + \beta' X_{it} + v_{it})} = \frac{exp(\alpha + \beta' X_{it} + v_{it} - \mu_{it})}{exp(\alpha + \beta' X_{it} + v_{it})} = exp(-\mu_{it}) \ldots\ldots\ldots \text{(9)}$$

This paper adopts this model by Green (2005) because of its attractive attributes as it allows technical inefficiency to vary over time. It also differentiates between the inefficiency that originates from the institution itself and the effects of mere random shocks due to the specific characteristics in the resident country of the institution.

4.3 Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a technique that applies mathematical programming to estimate the efficient frontier (Charnes, Cooper, & Rhodes, 1978). It creates a non-parametric best frontier using sample data through the process of minimizing inputs and maximizing output (Coelli, 1998). As discussed in Section 3 (refer to Section 3.3), it is a technique that can either be input-oriented (minimizing inputs given the same level of output) or output-oriented (maximizing output given the same level of inputs) (Kinaci et al., 2016, p. 4). It benchmarks the institutions (called Decision Making Units - DMU) against the best practise institutions in the sample. It creates an efficient frontier against which the relative efficiency of individual institutions is determined (Jacobs, 2001, p. 3). The relative efficiency calculated by the DEA is the estimated counterpart of theoretical equations 3 and 4 in Section 3 (see Section 3.4 and Figure 6).

As explained in Section 3 (see Section 3.4 and Table 1), institutions operate under different returns to scale. The DEA technique estimates efficiency based on constant returns to scale (DEA-CCR) or variable returns to scale (DEA-BCC). The DEA-CCR technique scales inputs and outputs either up or down in proportional magnitude while the DEA-BCC allows the scaling between inputs and outputs to vary. Under the DEA-BCC technique, output may either increase more than the increase in inputs (increasing returns to scale) or it may increase less than the increase in inputs (decreasing returns to scale).

Using notation and following Cullinane et al (2006, p. 4):

Let $x_k = (x_{1k}, x_{2k} \Lambda x_{Mk}) \in R_+{}^M$ represent inputs used to produce outputs.

Let $y_k = (y_{1k}, y_{2k} \Lambda y_{Nk}) \in R_+{}^N$ represent the outputs.

Let $\lambda = (\lambda_1, \lambda_2 \Lambda \lambda_k) \in R_+^K$ represent the linear combination of institutions (DMUs) where λ is a non-negative vector.

Let $e = (1,1,...,1)$ represent a vector of unity values.

x_k is a row vector that forms the kth row of the data matrix X while y_k is a row vector that forms the kth row of the data matrix Y.

The output-oriented DEA technique involves a series of k linear programming envelopment problems solvable using different constraints depending on the choice of returns to scale. The objective is to maximize U (ratio of all inputs over outputs) which is a function of u and λ where u is an M×1 vector of input weights. We maximize U subject to the following constraints:

1. DEA-CCR

a. $Uyk^{'} - Y^{'}\lambda \leq 0$

b. $X^{'}\lambda - xk^{'} \leq 0$

c. $\lambda \geq 0$

2. DEA-BCC

a. $Uyk^{'} - Y^{'}\lambda \leq 0$

b. $X^{'}\lambda - xk^{'} \leq 0$

c. $\lambda \geq 0$

d. $e\lambda^{'} = 1$

The DEA package solves these maximization problems and produces the desired measures of efficiency as follows:

1. Technical efficiency of the kth DMU (denoted as TE_k)

a. $TE_k = \frac{1}{U_k}$

2. Scale efficiency of the kth DMU (denoted as SE_k)

a. $SE_k = \frac{U_{CCR\_k}}{U_{BCC\_k}}$

Where U_{CCR_k} and U_{BCC_k} represent technical efficiency of kth DMU derived from the DEA-CCR and DEA-BCC models respectively. When $SE_k \equiv 1$, the DMU is deemed efficient in terms of scale because it is operating under constant returns to scale. Deviation from $SE_k \equiv 1$ indicates the presence of scale inefficiency. An institution can be scale inefficient due to the presence of either increasing or decreasing returns to scale. In the case of increasing returns to scale, the institution can obtain more output by increasing the quantity of at least one input. For decreasing returns to scale, the institution can increase output by reducing the quantity of at least one input. Data Envelopment Analysis provides a way to determine the type of inefficiency in a DMU. When the sum of weights, $e\lambda^{'}$ under the specification of the DEA-CCR model equals one, the law of constant returns to scale prevails. If this sum is not equal to one, the DMU has either increasing or decreasing returns to scale.

The DEA does not account for random shocks; it attributes all observed occurrences to either efficiency or inefficiency of the institution (Savić et al, 2015). However, it is a widely applied technique in the literature and is attractive because it does not require predefined assumptions about the functional relationship between inputs and outputs. It also avoids any assumptions on the specific statistical distribution of error terms thereby minimizing specification error occurrences by allowing the data to speak for itself. Moreover, Cook et al (2019) stress the inclusion of multiple inputs and outputs in analyses as one of the advantages of using DEA because institutions usually employ multiple inputs to achieve their objectives.

4.4 Tobit regression

As mentioned in Section 4.1, the paper applies the Tobit model to augment the results of the DEA technique. The DEA produces the efficiency estimates upon which the Tobit is applied to establish factors that affect the efficiency scores. The Tobit model is chosen because efficiency scores are censored between 0 and 1. Tobit is a regression model that is appropriate to use when the dependent variable is censored.

In line with Sisay et al, (2015, p. 4), the paper specifies the two-limit Tobit model as follows:

$$Y_j^* = \beta' X_{jk} + \mu_i \text{ ……………. (10)}$$

The censored variable Y_j would be denoted as:

$$y_i = \begin{cases} L & if \quad Y_j^* \leq L \\ Y_j^* & if \quad L < Y^* < U \\ U & if \quad Y_j^* \geq U \end{cases} \text{ ………………………… (11)}$$

Y_i represents the observed dependent variables (efficiency scores). X_{jk} is a vector of possible factors that drive efficiency where k represents the institution while j represents the factor. μ_i is the independently and normally distributed error term with mean zero and variance σ^2. The Tobit model generates results that show how significant various factors are in affecting the efficiency of the institution.

4.5 Applying the methods to tax administrations

This paper applies the three techniques, SFA, DEA and Tobit regression, to African tax administrations to achieve the three objectives of estimating efficiency scores, establishing factors that matter for efficiency and discussing the variation of efficiency across the administrations. Given that tax administrations are the institutions responsible for tax revenue collection, their objective is to collect as much revenue as they can. As such, tax revenue is regarded as the output variable that these institutions seek to maximize. Furthermore, with the focus on maximizing output (tax revenue), the institutions are deemed to follow the output-oriented production process.

The SFA and DEA techniques produce efficient frontiers using the sample data of 28 African tax administrations for the 2012-2017 period. The frontiers are used as a benchmark against which individual tax administrations are compared in the process of determining their relative efficiency. When there is a deviation between the output produced by a tax administration and that produced by the frontier, it is regarded as a possible indicator of either inefficiency on the part of the tax administration or other random shocks. Some of the factors that may lead to random shocks include trade openness, level of economic growth, and size of the informal sector, income inequality and education (Fenochietto & Pessino, 2013, p. 10). These factors may affect the performance of a tax administration despite being beyond the direct control of the tax authorities.

The SFA technique is able to distinguish between the deviation due to inefficiency and that due to random shocks (see Section 4.2). However, Section 4.3 points out that the DEA technique does not make such distinctions. It attributes all deviations to inefficiency on the part of the tax administration. For this reason, the paper applies the Tobit regression to the results generated by the DEA technique to gauge how other factors (relating to a country's economic outlook and the structure of the tax administration) affect the efficiency scores. A further explanation of the factors and the inputs that tax administrations use is given in section 6 which discusses the data.

5 REVIEW OF EMPIRICAL STUDIES ON EFFICIENCY

Using the theory described in Section 3 and the methods given in Section 4, researchers have conducted studies on efficiency. The empirical literature is replete with these studies as extensively applied to a range of industrial and organisational contexts. This section reviews the studies by examining their similarities and differences in terms of their techniques, the field of study, the choice of inputs and outputs, and the type of data they use and the robustness of their findings.

As discussed in Section 4.1, the standard efficiency measurement techniques of Data Envelopment Analysis and Stochastic Frontier Analysis (SFA) have been applied to study the efficiency of different institutions in different fields. González and Rubio (2013) used the techniques to establish the efficiency of tax agencies in Spain. Similarly, Moesen and Persoon (2002) focused on the efficiency of tax agencies in Belgium. Markovits-Somogyi (2011) and Cullinane et al (2006) used the techniques in the transport industry. Geys and Moesen (2009) applied them in the public sector to establish the efficiency of local governments while Kinaci, Najjari and Alp (2016) focused on the efficiency of hydroelectricity centres.

The choice of inputs and outputs depends largely on the field of study and the type of institution being assessed. In studying the efficiency of tax administrations, Alm and Duncan (2014) and Barros (2005) used the cost of administration as an input. Kinaci, Najjari and Alp (2016) used average annual operating hours as an input in hydroelectricity centres while Geys and Moesen (2009) used total current expenditures in each municipality in studying the efficiency of local governments. Inputs may also differ in the same industry depending on the availability of data for the assessed institutions. While some (Alm & Duncan, 2014; Barros, 2005) used the cost of administration as an input in studying the efficiency of tax agencies, Katharaki & Tsakas (2010) and González and Rubio (2013) used number of staff as an input. In the transport industry, Moesen and Persoon (2002) used labour while Cullinane et al (2006) used the size of terminal area of a container port as an input.

Furthermore, most studies use more than one input because most institutions apply multiple inputs to produce their intended outputs. Kinaci, Najjari and Alp (2016) and Barros (2005) used two inputs with the former using domestic consumption and average annual operating hours while the latter employed labour as an input. Moesen and Persoon (2002) used labour, total quay length, size of terminal area, number of quayside cranes, number of yard gantry cranes, and the number of straddle carriers worked as inputs. Geys and Moesen (2009) used total current expenditures in each municipality, number of subsistence grants beneficiaries, number of students in local primary schools, surface of public recreational facilities (in hectare) and total length of municipal roads (in km) as inputs.

The type of output used also differs depending on the field of study and the availability of data. Barros (2005) used tax revenue while Moesen and Persoon (2002) used the number of audit returns as outputs in studying tax administrations. Cullinane et al (2006) used container throughput in the port industry while Kinaci, Najjari and Alp (2016) used plant gross production in the energy sector. Some researchers have used multiple outputs to capture the efficiency of various institutions. Alm and Duncan (2014) used total tax revenue in its different types as outputs (Personal Income (PIT), Corporate Income Tax (CIT) and Value Added Tax (VAT)).

The techniques for analysing efficiency vary across studies but most researchers have applied both the SFA and DEA techniques. Whereas González and Rubio (2013) and Barros (2005) used one technique, Kinaci, Najjari and Alp (2016), Cullinane et al (2006) and Alm and Duncan (2014) among others applied both techniques, arguing that both DEA and SFA have been extensively applied as the two most important alternative techniques. Some studies focused on exploring the variation in results across techniques with Geys and Moesen (2009) and Markovits-Somogyi (2011) as examples.

The results reported in empirical studies show considerable variation depending on the technique, the sample and the period of analysis in line with the discussion in Section 4.1. Alm and Duncan (2014) and González and Rubio (2013) found that only a few tax agencies in the sample operated in line with their efficient capacity. Geys and Moesen (2009) found that the choice of technique used exerted substantial effect on the efficient scores of local governments. Kinaci, Najjari and Alp (2016) reported a variation in the efficiency of hydroelectricity centres in Iranian across the SFA and DEA and Cullinane et al (2006) established a high degree of correlation between the DEA and SFA efficiency estimates. The structure of the economy and the operations of an institution are among the factors identified as correlates of variation in efficiency across institutions (Katharaki & Tsakas, 2010; Moesen & Persoon, 2002).

This review shows the diverse nature of efficiency studies as applied in various fields. However, there have not been attempts made to investigate the efficiency of African tax agencies, either at the country-level or cross-country level. This paper investigates the efficiency of these institutions as part of the process of identifying ways in which African countries can create sustainable revenue bases and build state capacity. The reviewed studies recommend the use of panel data and multiple techniques to ensure robustness of results. This paper adopts both recommendations by making use of a panel dataset (see Section 6) and three techniques (see Section 4).

6 DATA ON INPUTS, OUTPUT AND STRUCTURAL FACTORS

6.1 Introduction

This paper makes use of a dataset compiled by the African Tax Administration Forum (ATAF) that contains administrative information on 31 African tax authorities for the 2012–2017 period[11]. The choice of the countries and the study period is entirely based on data availability. ATAF is an international organization for African tax administrations and provides a platform for collecting tax administrative data to enhance research and initiate improvement in tax administration in Africa. It compiles the dataset based on responses from different tax authorities on administrative variables. The paper also uses data extracted from the World Development Indicators of the World Bank (WB) for the same 2012-2017 period. The World Bank sourced data relate to the structure of the economy. This section presents the data from these two sources (ATAF and WB) and expounds on its usage in estimating the efficiency of African tax administrations.

6.2 Variables on inputs and output

Estimating the efficiency of an institution requires understanding the inputs and outputs of the institution. A production process uses inputs to produce outputs as pointed out in Section 3.2. The techniques (SFA and DEA) discussed in Section 4 use the information about inputs and outputs as the basis of estimating the efficiency of an institution. A tax administration is one such institution whose operations can be defined in terms of a production process. Table 2 gives a list of variables used in this study as inputs and output.[12]

Table 2: Inputs and output variables

Variable	Category	Method	Source
Tax revenue	Output	SFA/DEA	ATAF/WB
GDP per capita	Input	DEA	WB
Total operational cost	Input	SFA/DEA	ATAF
Number of taxpayers	Input	SFA/DEA	ATAF
Number of Staff	Input	SFA/DEA	ATAF

Notes: Gross Domestic Product (GDP), Stochastic Frontier Analysis (SFA), Data Envelopment Analysis (DEA), African Tax Administration (ATAF), World Bank (WB), Output variable (Output) and Input variable (Input).

Tax revenue is given in Table 2 as the output variable. This aligns with the main objective of tax authorities which is to optimize how much tax revenue they collect within the legal mandate of tax regulations. It has also been used in other studies as an output variable. Alm and Duncan (2014, p. 3) used it to estimate the efficiency of 28 OECD countries for the 2007-2011 period.

[11] The author was granted permission by ATAF to use the data and received ethical clearance (number 11400) on the use of the data from the University of Stellenbosch.
[12] These are not the only variables used in the analysis. Other variables are described subsequently.

Similarly, González and Rubio (2013, p. 5), Barros (2005, p. 8) and Katharaki and Tsakas (2010, p. 6) treated tax revenue as an output variable. However, other factors can be used to measure the output of tax administrations. Barros (2005, p. 8) used clear-up rates of contested cases regarding tax demands by taxpayers. Moesen and Persoon (2002, p. 8) used the number of audited returns as an output variable. The challenge with such variables is lack of comparable data when the research involves tax administrations spanning across countries. Tax revenue is attractive because it is available and comparable. It also aligns well with the ultimate goal of tax authorities to collect revenue.

Table 2 also lists the variables used as inputs in this paper namely, total operational cost, number of staff, number of taxpayers and Gross Domestic Product (GDP) per capita. The operational cost incurred by an institution is one of the main inputs in analysing its efficiency. It is the backbone against which the performance of any institution is evaluated. Markovits-Somogyi (2011, p. 4) made use of administrative costs as input in examining different efficiency approaches while Geys & Moesen (2009, p. 9) used total current municipal expenditures as an input to analyse the efficiency of local governments in Belgium. Most research into the efficiency of tax administrations includes the cost of administration as an input variable (Carlos, Brockmeyer, Kleven, Waseem, & Best, 2015; Huang et al, 2017; Tennant & Tennant, 2017). This is also because tax administrations face constant pressure to minimize the costs incurred during collection.

The number of staff is another variable used as an input in estimating the efficiency of various institutions. Tax administrations employ people to help in the tax collection process. In analysing efficiency, the total number of staff employed by a tax administration matters. It has a bearing on the total cost incurred by the administration (i.e. salaries, benefits and rewards) and the quality of service delivery provided to taxpayers (Baurer, 2005, p. 17). It has also received wide application in efficiency studies with researchers such as Aparicio et al (2018) and Moesen and Persoon (2002).

The amount of tax revenue collected also depends on the magnitude of taxpayers that a tax administration reaches. On average, the more taxpayers the tax administration is able to reach, the higher the chances of collecting more revenue (Zhuk, 2018, p. 5). Tax administrations spend a great deal of effort to widen the tax base by implementing strategies that aim to reach more potential taxpayers. Therefore, the number of taxpayers (tax base) is one of the inputs used by tax authorities in their process of maximizing tax revenue and has been employed as such in other studies (Katharaki & Tsakas, 2010).

Empirical studies have established that the capacity to collect and pay taxes expands as the level of economic development increases (Fenochietto & Pessino, 2013, p. 16; Gupta, 2007, p. 13; Yohou & Goujon, 2017, p. 12). There is therefore a positive relationship between a country's Gross Domestic Product (GDP) per capita and the tax revenue that tax authorities manage to collect. Being a proxy for the level of economic development, GDP per capita is used in this study as an input variable to function as a scale variable. Most studies on efficiency do not use GDP per capita as an input because it is regarded as a non-discretionary variable (not under the control of tax administrations). However, in a cross-country study, GDP per capita helps in scaling tax administrations as it entails resources and capacity available for revenue collection. There are similar studies that have used GDP per capita as an input variable (Jha & Sahni, 1997; Maekawa & Atoda, 2001).

6.3 Structural variables

The technical efficiency of tax administrations may be influenced by factors beyond the direct control of the administration itself. These factors relate to country-specific characteristics such as the economic outlook, demographic dynamics and institutional set up. Tax administrations may not have direct control over these characteristics as they reflect the greater country dynamics beyond the control of one institution. Nonetheless, their impact on revenue mobilization and state capacity building cannot be ignored. They may enhance or hinder tax authorities' execution of their duties as they form the environment in which tax administrations operate.

Table 3: Structural Variables

Variable	Category	Method	Source
Trade Openness	Economic	SFA/Tobit	WB
Agricultural Value Added	Economic	SFA/Tobit	WB
Income Distribution	Economic	SFA/Tobit	WB
Population Density	Demographic	SFA/Tobit	WB
Education	Demographic	SFA/Tobit	WB
Corruption Index	Institutional	SFA/Tobit	TI

Notes: Stochastic Frontier Analysis (SFA), Data Envelopment Analysis (DEA), African Tax Administration (ATAF), World Bank (WB), Transparency International (TI), High Net worth Individuals (HNWI) and Tobit regression (Tobit).

Table 3 gives the list of the structural variables used in this study, their sources and the method in which they are applied. Trade openness is captured as the sum of imports and exports as a percentage of GDP. As a country opens up to trade, its tax capacity increases as it experiences increases in customs revenue which is deemed easier to collect because of monitored trade inflows and outflows (Baunsgaard & Keen, 2010, p. 7). However, trade openness may have a negative effect on tax revenue depending on a country's level of economic competitiveness since opening up to trade may lead to crowding out of the smaller domestic company tax base. Furthermore, early years of trade liberalization may reduce tax revenue collected on exports and imports as countries adjust tariffs to attract international investments. For example, there has been a general shift in tax structure with most trade taxes being replaced by consumption-based taxes due to global trade liberalization processes (Mabugu & Simbanegavi, 2015, p. 5).

Agricultural value added is the output of the agricultural sector including forestry, hunting and fishing (the sum of all outputs minus intermediate inputs). It is used as an indicator of the informal economy because a larger share of the agricultural sector limits a country's potential to collect revenue. Pessino and Fenochietto (2010, p. 21) point out that some countries exempt the agricultural sector from VAT and the producers from income tax. Moreover, the informality of agricultural activities in most African countries make it difficult for tax administrations to maximize revenue collection due to challenges in monitoring economic transactions and the uncertainty of income inflows in the sector (Gupta, 2007, p. 13). Though the informal economy might present a high potential for revenue generation especially in Africa, the collection might come at the expense of significant administration costs (Besley & Persson, 2013; Ndikumana & Abderrahim, 2010; Pessino & Fenochietto, 2010).

Another factor is a country's income distribution. The tax burden in an unequal society depends highly on the higher income group which usually has control over the political power and may devise ways to evade taxes through mechanisms that reduce their tax liabilities (Gupta, 2007, p. 28). Such evasion would substantially reduce collections. Besides, a large informal sector may give rise to a more unequal society making tax collection a difficult task (Cyan, Martinez-Vazquez, & Vulovic, 2013, p. 20).

Population density captures the demographic dynamics of a country. It is measured as the number of people per square kilometres of land area. High density areas may either have a positive or negative effect on tax collection. When people are highly concentrated, taxation might be easier. However, high concentration may encourage informal activities which make tax collection complex and difficult (Fenochietto & Pessino, 2013, p. 10).

In line with population density, the level of education (mean years of schooling) in a country may have an ambiguous effect on tax collection. As a country becomes educated, people's ability to pay rises and brings about increases in tax collection (Cyan et al., 2013, p. 22). Nevertheless, when a society has more educated people, they may devise advanced ways to avoid and evade taxes and this may negatively affect revenue collection.

Institutional factors such as corruption may have a significant impact on tax revenue collection. When a society has high levels of corruption, tax morale is negatively affected and taxpayers may not be willing to honour their tax obligations (Bird, Martinez-Vazquez, & Torgler, 2008, p. 11). Moreover, corruption may hinder economic activity by discouraging domestic and foreign investments, which limits the expansion of the tax base.

6.4 Conclusion

This section has discussed the data used in this paper, its sources and the factors included in the analysis. The variables used as inputs and output in the efficiency estimation have been sourced from the African Tax Administration Forum (ATAF) and the World Bank (WB). These relate to tax administration and the specific structure of the economy. A discussion of these factors as used in the analysis helps in exploring ways of building a sustainable revenue base through the efficient performance of tax administrations as further expounded in the next section.

7 RESULTS AND DISCUSSION

7.1 Introduction

This section presents the findings of the paper. It begins with the descriptive statistics of the variables that have been used in the analysis. Then it gives the results (efficiency scores) of the Stochastic Frontier Analysis (SFA) and the Data Envelopment Analysis (DEA), as discussed in Section 4. By giving the efficiency scores, the paper answers the first objective of estimating the efficiency of African tax administrations. Following this, the section presents the results of the Tobit regression coupled with a discussion of the factors that drive efficiency. The results of the Tobit regression together with the comparison between the five most and five least efficient countries, address the two other objectives of examining the variation of efficiency across tax administrations and establishing the factors that influence it.

7.2 Descriptive statistics

Table 4 contains the summary statistics of the variables used in the analysis. The mean of tax revenue as a percentage of GDP (15.98%) is higher than the mean of non-tax revenue (4.38%); an indication that the sampled countries collect more revenue through taxation than using non-tax sources. There is a wide range of variation in the number of staff (ranging from 213 to 14 198), number of taxpayers (ranging from 1 020 to 25 900 000) and total operational cost (ranging from 1 018 to 586 000 000). This captures the differences that exist among African tax administrations in terms of size of the institution and their operations. It is likely a reflection of the size and structure of the economy because similar variations are observed in GDP per capita, trade openness (20.72% to 216.48%), agricultural value added (1.91% to 60.28%), population density (3 to 623 people per square kilometre of land area) and education (1.60 to 10.10 mean years of schooling).

Table 4: Summary Statistics on key variables

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita (million US$)	168.00	529,099.80	719,483.40	657.94	3,687,643.00
Tax revenue (% GDP)	166.00	15.98	6.02	5.28	33.75
Non-tax revenue (% GDP)	163.00	4.38	4.62	0.34	22.75
Trade Openness (% GDP)	168.00	76.15	32.80	20.72	216.48
Agricultural Value Added (% GDP)	168.00	20.45	14.11	1.91	60.28
Income Inequality	168.00	30.39	12.02	12.30	68.30
Population Density	168.00	126.03	145.35	2.75	622.96
Corruption Index	168.00	36.26	12.20	15.00	65.00
Education (Mean Years of schooling)	168.00	5.58	2.19	1.60	10.10
Total operational cost	168.00	55,400,000.00	137,000,000.00	1,018.33	586,000,000.00
Number of Staff	168.00	2,618.72	2,993.97	213.00	14,198.00
Number of taxpayers	168.00	1,162,067.00	4,005,221.00	1,020.00	25,900,000.00
Strategies for Informal Sector (Dummy)	168.00	0.64	0.48	0	1
Strategies for HNWI (Dummy)	168.00	0.11	0.31	0	1
Semi-Autonomous Structure (Dummy)	168.00	0.71	0.45	0	1
Integrated structure (Dummy)	168.00	0.71	0.45	0	1

Notes: Data is for 28 African countries and sourced from ATAF and WB (See section 6).

7.3 SFA and DEA efficiency estimates results

The results reported in Table 5 give the SFA efficiency scores for three distributions (half-normal, truncated and exponential) and the DEA scores for constant (CRS) and variable returns to scale (VRS). The scores are averaged across the six-year period (2012-2017) for each country. As explained in Section 5, a score of 1 indicates maximum efficient operation while a score less than 1 indicates some form of inefficiency. The closer the score is to a value of 1, the more efficient (inefficient) the tax administration is.

Table 5: SFA and DEA efficiency estimates results

Country	**SFA (Halfnormal)**	**SFA (Truncated)**	**SFA (Exponential)**	**DEA (CRS)**	**DEA (VRS)**
Angola	0.93	0.95	0.93	0.64	0.73
Botswana	0.95	0.93	0.96	0.72	0.74
Burundi	0.90	0.90	0.91	0.85	0.86
Cameroon	0.90	0.89	0.89	0.77	0.84
Cape Verde	0.95	0.98	0.96	0.93	0.96
Chad	0.78	0.63	0.78	0.76	0.92
Côte d'Ivoire	0.95	0.86	0.95	0.84	0.91
Eswatini	0.93	0.92	0.94	0.83	0.84
Gambia	0.91	0.87	0.91	0.77	0.79
Ghana	0.93	0.83	0.94	0.80	0.81
Liberia	0.88	0.87	0.89	0.95	0.97
Madagascar	0.95	0.88	0.95	0.78	0.79
Malawi	0.92	0.87	0.91	0.82	0.83
Mauritius	0.96	0.97	0.98	0.79	0.86
Mozambique	0.91	0.93	0.91	0.96	0.96
Namibia	0.91	0.95	0.89	0.98	0.99
Niger	0.91	0.91	0.92	0.94	0.96
Nigeria	0.90	0.84	0.91	0.69	0.72
Rwanda	0.97	0.95	0.97	0.81	0.85
Senegal	0.95	0.95	0.94	0.79	0.84
Seychelles	0.95	0.90	0.96	0.97	0.99
Sierra Leone	0.89	0.87	0.91	0.85	0.96
South Africa	0.95	0.95	0.95	0.91	0.95
Tanzania	0.94	0.88	0.93	0.64	0.74
Togo	0.90	0.92	0.89	0.89	0.93
Uganda	0.90	0.86	0.88	0.71	0.78
Zambia	0.90	0.89	0.89	0.81	0.82
Zimbabwe	0.92	0.94	0.92	0.97	0.98
Average	**0.92**	**0.90**	**0.92**	**0.83**	**0.87**

Notes: DEA constant returns to scale (DEA-CRS) and DEA-variable returns to scale (DEA-VRS); Efficiency scores are averaged at country level for the 2012-2017 period.

As expected, the SFA half-normal distribution gives an average score (0.92) that is the same as the exponential distribution but relatively higher than the truncated normal distribution (0.90). This is because the truncated distribution allows for a variation between efficient and inefficient cases unlike the half-normal and exponential distributions whose estimates lean towards more efficient outcomes (see section 5).

Table 5 also shows that, as one would expect, the DEA constant returns to scale (CRS) estimation yields lower average scores (0.83) than the DEA variable returns to scale (VRS) (0.87). This is because CRS gives both technical and scale efficiency while VRS provides technical efficiency only (Cullinane et al., 2006, p. 8). The table shows that the scores range from 0.63 to 0.99 across the techniques and tax administrations for the entire 2012-2017 period. This trend is similar to results reported in other studies where average scores are rarely found to attain a value of 1, to indicate maximum efficiency, or a value less than 0.50, to indicate high inefficiency (Alm & Duncan, 2014; González & Rubio, 2013). Understanding these findings lies in the fact that efficiency scores reflect the dispersion of efficiencies within the sample, with the best institutions in the sample forming the underlying frontiers against which all other institutions are compared (see section 4). However, given the diverse challenges on the continent, one would expect the scores to be relatively lower for African tax administrations than their counterparts elsewhere.

Furthermore, the summary statistics in Section 7.2 show considerable variation in the variables across tax administrations. Given this variation, one would expect to see similar variations in efficiency scores across the different administrations. The results in Table 5 show that the scores range from 0.63 to 0.99 with the average scores ranging from 0.83 to 0.92. Apart from being generally high, there is not much variation in scores across the techniques and the administrations. A similar observation is made in Table 6 where scores are high and do not have significant variation over time.

Table 6: SFA and DEA efficiency results over time

Year	SFA (Half-normal)	SFA (Truncated)	SFA (Exponential)	DEA (CRS)	DEA (VRS)
2012	0.93	0.87	0.93	0.84	0.87
2013	0.91	0.87	0.91	0.83	0.86
2014	0.92	0.91	0.93	0.83	0.86
2015	0.93	0.90	0.93	0.83	0.85
2016	0.93	0.92	0.92	0.83	0.88
2017	0.91	0.92	0.91	0.82	0.88
Average	0.92	0.90	0.92	0.83	0.87

Notes: Efficiency scores are averaged at year level for the entire sample.

7.3 The results of Tobit regression

The results of the Tobit regression are given in Table 7. The results identify trade openness, agricultural value added, non-tax revenue, semi-autonomous revenue authorities (SARAs), and reliance on strategies to deal with the informal sector and high net-worth individuals as key factors that affect the efficiency scores. These results align with the discussion in Section 2 which showed that tax administrations operating as SARAs and using strategies to deal with the informal sector and high net-worth individuals collect more revenue than those that do not adopt these strategies. There are differences observed in the results where some variables such as agricultural value added are significant under DEA-CRS while others such as non-tax revenue are significant under DEA-VRS. This reflects the difference in assumptions between the two specifications since DEA-CRS assumes scale efficiency together with technical efficiency but DEA-VRS assumes technical efficiency only.

Table 7: Results of the Tobit regression

VARIABLES	(1) DEA-CRS Scores	(3) DEA-VRS Scores
Trade Openness (%GDP)	-0.329***	-0.257***
	(0.034)	(0.026)
Population Density	-0.013	-0.010
	(0.011)	(0.008)
Agricultural Value Added (%GDP)	-0.040*	-0.025
	(0.021)	(0.016)
Non-tax revenue (%GDP)	-0.002	0.019*
	(0.013)	(0.010)
Corruption Index	0.038	0.021
	(0.043)	(0.033)
Education	0.178***	0.130***
	(0.040)	(0.031)
Income Inequality	-0.073**	-0.029
	(0.035)	(0.027)
Strategies for Informal Sector	0.147***	0.101***
	(0.028)	(0.022)
Semi-Autonomous	0.021	0.045
	(0.054)	(0.042)
Integrated structure	0.074	0.039
	(0.059)	(0.045)
Strategies for HNWI	0.094***	0.078***
	(0.036)	(0.028)
Observations	153	153

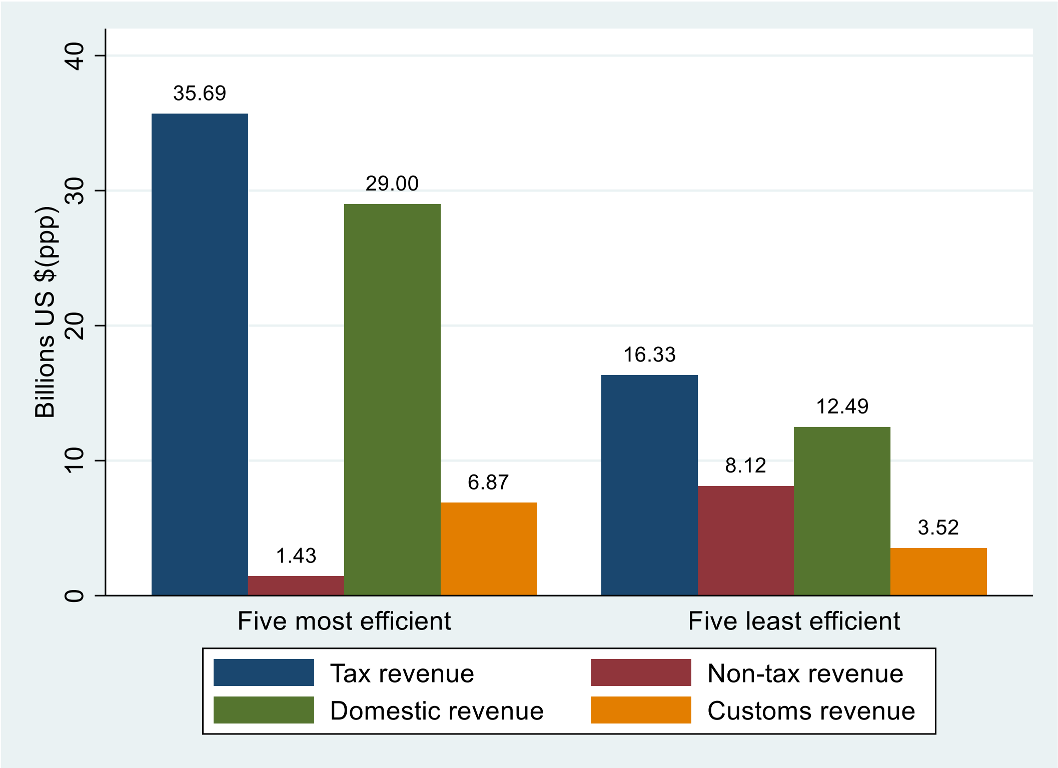
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Furthermore, Section 6 explained how a large informal sector (as captured by agricultural value added) limits the extent to which a tax administration can collect revenue. The section also discussed how trade openness might negatively affect tax collection due to reduction in the contribution of trade taxes as a consequence of trade liberalization.

7.4 Comparing five most efficient and five least efficient countries

Using the efficiency scores derived from the SFA and DEA, this section compares the five most and five least efficient tax administrations. The list of the tax administrations (listed as names of countries) is given in the Appendix (see Table A.2). Figure 10 shows that the five most efficient tax administrations dominate the five least efficient tax administrations in terms of total tax revenue, domestic tax revenue and custom duties. Also, the difference between domestic revenue and customs revenue is larger for the five most than for the five least efficient administrations. As pointed out in Section 2, efficient tax administrations seem to be performing better in terms of mobilizing resources on the domestic front than the least efficient administrations.

Figure 10: Revenue comparison between tax administrations

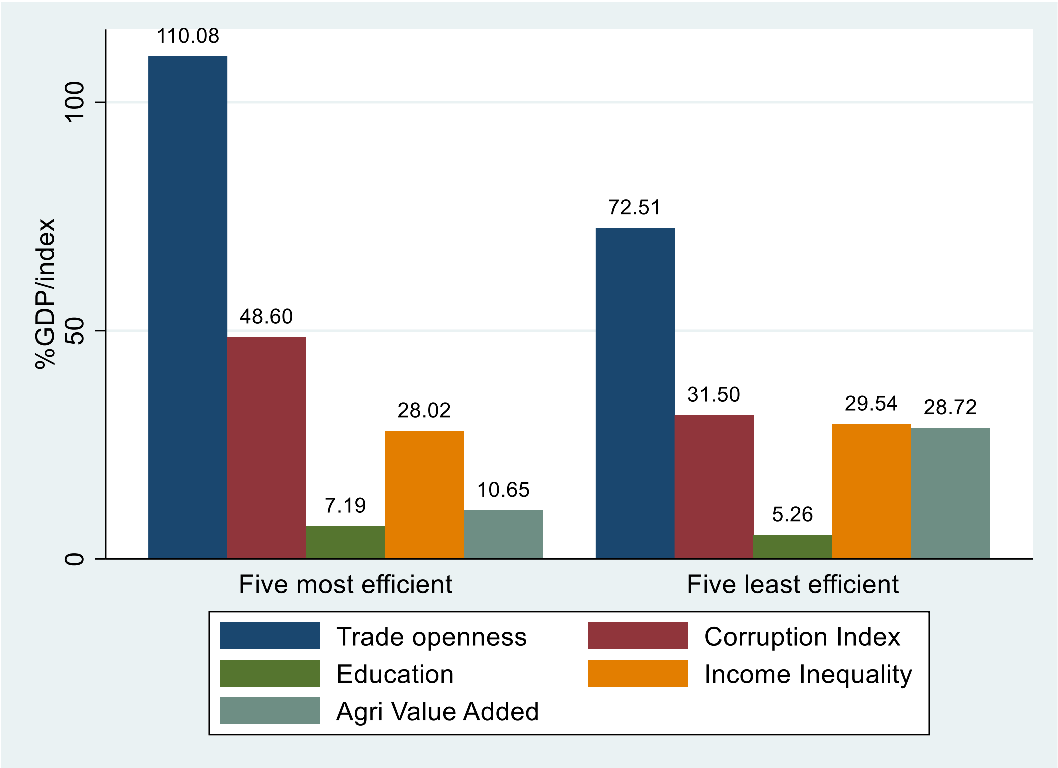


Notes: Author's own calculations using data from ATAF.

The five least efficient tax administrations have a larger share of non-tax revenue than the five most efficient administrations. Countries such as Nigeria, Democratic Republic of Congo and Botswana derive considerable revenue from non-tax sources. This has the potential to reduce the effort that tax administrations in these countries exert to collect tax revenue. This is a possible explanation behind the observation that the five most efficient tax administrations obtain relatively low revenue from non-tax sources.

Figure 11 shows that the five least efficient administrations have a larger proportion of their country's economy operating in the informal sector (high agricultural value added), are more open to trade and have slightly higher levels of income inequality than five most efficient tax administrations' countries. As discussed in Section 6, countries with high levels of these variables experience difficulties in collecting tax revenue due to among other things limited taxable capacity.

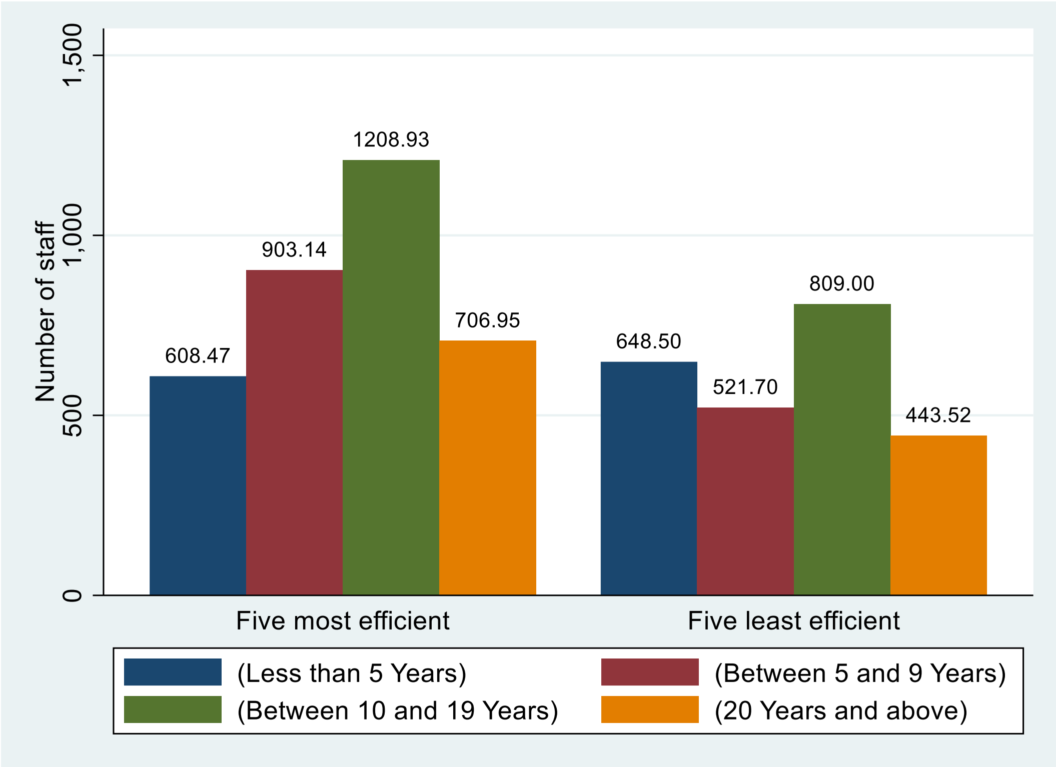
Figure 11: Comparison of structural factors between tax administrations



Notes: Author's own calculations using data from ATAF.

Figure 12 shows that the five most efficient administrations seem to have more staff in the range of 10 to 19 years' experience while the five least efficient administrations have most staff with over 20 years' experience. The longer length of service for most staff in the five least efficient administrations indicates possible effects of old age on the performance of tax administrations due to staff inability to adjust to new methods of tax collection in an era of technological advancement.

Figure 12: Comparison of Staff length of service between tax administrations



Notes: Author's own calculations using data from ATAF.

8 CONCLUSION

This paper makes use of the ATAF compiled administrative dataset, available for 28 African countries for the 2012 - 2017 period, to investigate the efficiency of African tax administrations at collecting tax revenue. It set out to achieve the three objectives of estimating the technical efficiency of tax administration in Africa, explaining the factors that drive efficiency and assessing the variation in technical efficiency. It used Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to achieve the first objective and the results of the Tobit regression together with the comparison between the five most and five least efficient tax administrations to address the other objectives.

The paper has found trade openness, availability of strategies to deal with the informal sector, the use of special sections to deal with various categories of taxpayers (such as HNWI), the use of semi-autonomous tax authorities (SARAs) and staff length of service, to be key in determining efficiency and tax revenue mobilization. Also, the size and availability of non-tax revenue has the potential to affect effort exerted in collecting tax either by forcing countries with particularly weak tax systems to rely more heavily on non-tax revenue or countries with a large non-tax base to exert little effort in tax collection.

On efficiency scores, the study found, as expected, that the SFA half-normal distribution gives an average score (0.92) that is the same as the exponential distribution but relatively higher than the truncated normal distribution (0.90). It also found that the DEA constant returns to scale (CRS) estimation yields lower average scores (0.83) than the DEA variable returns to scale (VRS) (0.87). Contrary to expectation, the study found efficiency scores to be generally high (closer to the maximum value of 1) suggesting that the operation of African tax administrations does not deviate much from efficient production. Apart from being generally high, there is not much variation in scores across the administrations despite the administrations operating within economies with different structures of levels of output.

The high scores and the lack of significant variation can be understood from various perspectives: (a) the operations of African tax authorities are not as (technically) inefficient as perceived, (b) there are no significant differences in performance among tax administrations, (c) the challenges prevalent on the continent affect revenue mobilization through other channels than efficiency (d) the inefficiency of tax administration manifests more in qualitative than quantitative variables, (e) the quantitative techniques do not fully capture the actual experiences of African tax administrations.

The first point, (a), suggests that the operations of African tax authorities are not as (technically) inefficient as perceived. Given the magnitude of the unexploited domestic resource base available on the continent and the various institutional adjustments African tax administrations have made over the recent decades, it is unlikely that their inefficiency levels are overestimated. In relation to the second point, (b), the variation in tax ratios is a good indicator of the existence of significant differences in performance among tax administrations. The third point, (c), suggests that the challenges prevalent on the continent affect revenue mobilization through other channels than efficiency. However, if such channels exist, it is more likely they would also have an impact on efficiency and certainly there would be a correlation between such effects and technical efficiency.

The fourth and fifth points, (d) and (e), suggest that the inefficiency in African tax administration manifests more in qualitative than quantitative variables and that quantitative techniques may not fully capture the actual performance of African tax administrations. This is a plausible explanation since the efficiency scores reflect the type of inputs and outputs used in analysis. This study could not include other relevant tax related variables such as audit returns, staff turnover and productivity and dispute resolution due to lack of data. Such variables may be effective in explaining the performance of a tax administration. This is also because the estimates produced by the SFA and DEA techniques may be biased if an important input or output is excluded. It is probable then that the quantitative approach does not capture the actual experience of African tax administrations. This will be the topic of discussion in the next paper.

9 REFERENCES

Aigner, D., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*. https://doi.org/10.1016/0304-4076(77)90052-5

Akhtar, M. H. (2002). X-efficiency Analysis of Commercial Banks in Pakistan : A Preliminary Investigation. *The Pakistan Development Review*, *41*(4), 567–580.

Alm, J., & Duncan, D. (2014). Estimating tax agency efficiency. *Public Budgeting and Finance*, *34*(3), 92–110. https://doi.org/10.1111/pbaf.12043

Aparicio, J., Cordero, J. M., Gonzalez, M., & Lopez-Espin, J. J. (2018). Using non-radial DEA to assess school efficiency in a cross-country perspective: An empirical analysis of OECD countries. *Omega (United Kingdom)*, *79*, 9–20. https://doi.org/10.1016/j.omega.2017.07.004

Asongu, S. A., & Leke, I. J. (2017). *External flows and inclusive human development in Sub-Saharan Africa*.

ATAF. (2018). African Tax Outlook 2018.

Barros, C. P. (2005). Performance measurement in tax offices with a stochastic frontier model. *Journal of Economic Studies*, *32*(6), 497–510. https://doi.org/10.1108/01443580510631388

Baunsgaard, T., & Keen, M. (2010). Tax revenue and (or?) trade liberalization. *Journal of Public Economics*, *94*, 563–577. https://doi.org/10.1016/j.jpubeco.2009.11.007

Baurer, L. I. (2005). *Tax Administrations and Small and Medium Enterprises (SMEs) in Developing Countries*. *World Bank*.

Besley, Tim, & Persson, T. (2011). Pillars of Prosperity. *Princeton University Press*.

Besley, Timothy, & Persson, T. (2013). Taxation and development. In *Handbook of Public Economics*.

Bird, R. M., Martinez-Vazquez, J., & Torgler, B. (2008). Tax Effort in Developing Countries and High Income Countries: The Impact of Corruption, Voice and Accountability. *Economic Analysis and Policy*, *38*(1), 55–71.

Bromley, D. W. (1990). The ideology of efficiency: Searching for a theory of policy analysis.

Journal of Environmental Economics and Management, *19*(1), 86–107. https://doi.org/10.1016/0095-0696(90)90062-4

Carlos, M., Brockmeyer, A., Kleven, H. J., Waseem, M., & Best, M. C. (2015). Production versus Revenue Efficiency with Limited Tax Capacity : Theory and Evidence from Pakistan Anne. *Journal of Political Economy*, *123*(6), 1311–1355. https://doi.org/10.1086/683849

Charmes, J. (2015). The Contribution of Informal Sector to GDP in Developing Countries : Assessment , Estimates , Methods , Orientations for the Future, (January 2000).

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, *2*(6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

Coelli, T. (1998). *A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program*.

Coelli, T., Rao, D. S. P., & Battese, G. E. (1998). *An introduction to efficiency and productivity analysis*.

Cook, W. D., Ramón, N., Ruiz, J. L., Sirvent, I., & Zhu, J. (2019). DEA-based benchmarking for performance evaluation in pay-for-performance incentive plans. *Omega (United Kingdom)*, *84*, 45–54. https://doi.org/10.1016/j.omega.2018.04.004

Cullinane, K., Wang, T. F., Song, D. W., & Ji, P. (2006). The technical efficiency of container ports: Comparing data envelopment analysis and stochastic frontier analysis. *Transportation Research Part A: Policy and Practice*, *40*(4), 354–374. https://doi.org/10.1016/j.tra.2005.07.003

Cyan, M., Martinez-Vazquez, J., & Vulovic, V. (2013). Measuring tax effort: Does the estimation approach matter and should effort be linked to expenditure goals? *International Center for Public Policy*.

Debreu, G. (1951). The Coefficient of Resource Utilization. *Econometrica*, *19*(3), 273–292.

Devas, N., Delay, S., & Hubbard, M. (2001). Revenue authorities: Are they the right vehicle for improvedtax administration? *Public Administration and Development*, *21*(3), 211–222. https://doi.org/10.1002/pad.174

Dincecco, M. (2015). The Rise of Effective States in Europe. *Journal of Economic History*, *75*(3), 901–918. https://doi.org/10.1017/S002205071500114X

Dincecco, M., & Katz, G. (2016). State Capacity and Long-run Economic Performance. *Economic Journal*, *126*(590), 189–218. https://doi.org/10.1111/ecoj.12161

Dom, R. (2017). Semi-autonomous revenue authorities in Sub- Saharan Africa: Silver bullet or white elephant. *CREDIT Research Paper*.

Drake, L., & Simper, R. (2010). X-efficiency and scale economies in policing : a comparative study using the distribution free approach and DEA. *Applied Economics*, *34*(15), 1859–1870. https://doi.org/10.1080/0003684021012681

Dube, G., & Casale, D. (2019). Informal sector taxes and equity: Evidence from presumptive taxation in Zimbabwe. *Development Policy Review*, *37*(1), 47–66. https://doi.org/10.1111/dpr.12316

Efobi, U., Beecroft, I., & Belmondo, T. (2019). Small Business Use of the Integrated Tax Administration System in Nigeria ICTD African Tax Administration Paper 8 Small Business Use of the Integrated Tax Administration System in Nigeria. *ICTD Working Paper*, (May).

Essop, H., & Yu, D. (2008). The South African informal sector (1997 – 2006). *Working Papers*.

Farrell, M. T. (1957). The Measurement of Productive Efficiency. *Royal Statistical Society*, *120*(3), 253–281.

Fenochietto, R., & Pessino, C. (2013). Understanding Countries' Tax Effort. *IMF Working Papers*.

Fjeldstad, O. (2013). A review of donor support to strengthen tax systems in developing countries. *WIDER Working Paper*.

Fossat, P., & Bua, M. (2013). Tax Administration Reform in the Francophone Countries of Sub-Saharan Africa. *International Monetary Fund*, 1–53.

Fung, M. K. (2006). Scale economies , X-efficiency , and convergence of productivity among bank holding companies. *Journal of Banking & Finance*, *30*, 2857–2874. https://doi.org/10.1016/j.jbankfin.2005.11.004

Geys, B., & Moesen, W. (2009). Measuring Local Government Technical (In)Efficiency.

Public Performance & Management Review, *32*(4), 499–513. https://doi.org/10.2753/pmr1530-9576320401

González, P. E. B., & Rubio, E. V. (2013). The Efficiency of The Regional Management Centres of The Tax Administration in Spain. *Journal of US-China Public Administration*, *10*(1), 49–56.

Greene, W. (2005). Fixed and random effects in stochastic frontier models. *Journal of Productivity Analysis*, *23*(1), 7–32. https://doi.org/10.1007/s11123-004-8545-1

Gupta, A. Sen. (2007). Determinants of Tax Revenue Efforts in Developing Countries. *IMF Working Papers*. https://doi.org/10.5089/9781451867480.001

Hassan, K., & Tufte, D. (2001). The X-E • ciency of a Group-Based Lending Institution : The Case of the Grameen Bank. *World Development*, *29*(6), 1071–1082.

Herbst, J. (2000). The Challenge of State-Building in Africa Book. In *States and Power in Africa*.

Huang, S. H., Yu, M. M., Hwang, M. S., Wei, Y. S., & Chen, M. H. (2017). Efficiency of Tax Collection and Tax Management in Taiwan's Local Tax Offices. *Pacific Economic Review*, *22*(4), 620–648. https://doi.org/10.1111/1468-0106.12235

Jacobs, R. (2001). Alternative methods to examine hospital efficiency: Data envelopment analysis and stochastic frontier analysis. *Health Care Management Science*, *4*(2), 103–115. https://doi.org/10.1023/A:1011453526849

Jha, R., & Sahni, B. S. (1997). Tax efficiency and productivity analysis: The case of Canadian Fiscal Federalism. *Public Finance/Finances Publiques*, *2*(52), 186–197.

Katharaki, M., & Tsakas, M. (2010). Assessing the efficiency and managing the performance of Greek tax offices. *Journal of Advances in Management Research*, *7*(1), 58–75. https://doi.org/10.1108/09727981011042856

Kinaci, H., Najjari, V., & Alp, İ. (2016). Using data envelopment analysis and stochastic frontier analysis methods to evaluate efficiency of hydroelectricity centers. *Gazi University Journal of Science*, *29*(1), 167–176.

Koopmans, T. C. (1951). Efficient Allocation of Resources. *Econometrica*, *19*(4), 455–465.

Kyj, L., & Isik, I. (2008). Bank x -efficiency in Ukraine : An analysis of service characteristics and ownership. *Journal of Economics and Business*, *60*, 369–393. https://doi.org/10.1016/j.jeconbus.2007.05.002

Le, T. M., Moreno-dodson, B., & Bayraktar, N. (2012). *Tax Capacity and Tax Effort : Extended Cross-Country Analysis from 1994 to 2009*. *World Bank Policy Research*. https://doi.org/10.1596/1813-9450-6252

Ligomeka, W. (2019). Assessing the Performance of African Tax Administrations : A Malawian Puzzle. *Institute of Development Studies*, (September).

Mabugu, R. E., & Simbanegavi, W. (2015). Tax and expenditure reforms in Africa: An overview. *Journal of African Economies*, *24*, ii3–ii15. https://doi.org/10.1093/jae/eju037

Maekawa, S., & Atoda, N. (2001). Technical inefficiency in Japanese tax administration. In *57th Congress of the International Institute of Public Finance*. Linz, Austria.

Magumba, M. (2019). Tax Administration Reforms : Lessons from Georgia and Uganda. *ICTD Working Paper*, (April).

Maisiba, G. J., & Atambo, W. (2016). Effects of Electronic-Tax System on the Revenue Collection Efficiency of Kenya Revenue Authority: A Case of Uasin Gishu County. *Imperial Journal of Interdisciplinary Research (IJIR)*, *2*(4), 815–827.

Markovits-Somogyi, R. (2011). Review and systematization of efficiency measurement methods used in the transport sector. *Promet - Traffic - Traffico*, *23*(1), 39–47. https://doi.org/10.7307/ptt.v23i1.147

Mascagni, G., Monkam, N., & Nell, C. (2018). *Unlocking the Potential of Administrative Data in Africa: Tax Compliance and Progressivity in Rwanda*. *Ssrn*. https://doi.org/10.2139/ssrn.3120309

Moesen, W., & Persoon, A. (2002). Measuring and Explaining the Productive Efficiency of Tax Offices: A Non-parametric Best Practice Frontier Approach. *Tijdschrift Voor Economie En Management*, *47*(3), 399–416.

Ndikumana, L., & Abderrahim, K. (2010). Revenue mobilization in African countries: Does natural resource endowment matter? *African Development Review*, *22*(3), 351–365. https://doi.org/10.1111/j.1467-8268.2010.00250.x

Pessino, C., & Fenochietto, R. (2010). Determining countries' tax effort. *Hacienda Publica*

Espanola, *195*(4), 65–87.

Rwandan Revenue Authority. (2018). *Annual Activity Report*.

Santoro, F., & Mdluli, W. (2019). Nil-Filing in Eswatini : Should the Revenue Administration be Concerned ? I Nil-Filing in Eswatini : Should the Revenue Administration b e Concerned ? *ICTD Working Paper*, (May).

Savić, G., Dragojlović, A., Vujošević, M., Arsić, M., & Martić, M. (2015). Impact of the efficiency of the tax administration on tax evasion. *Economic Research-Ekonomska Istrazivanja* , *28*(1), 1138–1148. https://doi.org/10.1080/1331677X.2015.1100838

Sisay, D., Jema, H., Degye, G., & Abdi Khalil, E. (2015). Technical, allocative, and economic efficiency among smallholder maize farmers in Southwestern Ethiopia: Parametric approach. *Journal of Development and Agricultural Economics*, *7*(8), 282–291. https://doi.org/10.5897/jdae2015.0652

Taliercio, R. R. (2004). Administrative reform as credible commitment: The impact of autonomy on revenue authority performance in Latin America. *World Development*, *32*(2), 213–232. https://doi.org/10.1016/j.worlddev.2003.08.008

Tennant, S., & Tennant, D. (2017). The Efficiency of tax Administration in Jamaica: An IntrospectivemAssessment. *Social and Economic Studies*, *56*(3), 71–100.

Van Heerden, Y. (2013). *Personal Income Tax Reform To Secure the South African Revenue Base Using a Micro-Simulation Tax Model*.

Varian, H. R. (2010). *Intermediate Microeconomics: A Modern Approach* (8th ed.). New York, London: W.W. Norton & Company Inc.

Yohou, H. D., & Goujon, M. (2017). “Reassessing Tax Effort in Developing Countries : a Proposal of a Vulnerability-Adjusted Tax Effort Index (VATEI).” *FERDI Working Paper*.

Zhuk, O. (2018). Tax Control in the System of Taxes Administration. *Journal of Vasyl Stefanyk Precarpathian National University*, *5*(3–4), 57–61. https://doi.org/10.15330/jpnu.5.3-4.57-61

10 APPENDIX

Table A.1: Sampled Countries

No	Country	No	Country
1	Angola	15	Mozambique
2	Botswana	16	Namibia
3	Burundi	17	Niger
4	Cape Verde	18	Nigeria
5	Cameroon	19	Rwanda
6	Chad	20	Senegal
7	Côte d'Ivoire	21	Seychelles
8	Eswatini	22	Sierra Leone
9	Gambia	23	South Africa
10	Ghana	24	Tanzania
11	Liberia	25	Togo
12	Madagascar	26	Uganda
13	Malawi	27	Zambia
14	Mauritius	28	Zimbabwe

Table A.2: The Five Most Efficient and Five Least Efficient Countries

Five most efficient	Five lease efficient
South Africa	Sierra Leone
Cape Verde	Nigeria
Seychelles	Uganda
Niger	Zambia
Mauritius	Liberia