A Stochastic Frontier Estimation of Tax Efficiency in the Economic Community of West African States (ECOWAS)

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A Stochastic Frontier Estimation of Tax Efficiency in the Economic Community of West African States (ECOWAS)

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Abstract

The objective of this study is to investigate the determinants of non-natural resource tax revenue and estimate its efficiency in ECOWAS countries. A stochastic frontier tax function was estimated using annual data from 2001 to 2015 by use of Maximum Likelihood Procedure. The results show that trade openness, financial deepening and urbanization matter for tax revenue mobilization in ECOWAS, with the first two variables having a positive effect and the latter having a negative effect; tax inertia is found to be strong. The estimated non-natural resource tax efficiencies show that during the period 2001-2015, the tax efficiencies of ECOWAS countries were above 90.0% of their potential, except for Nigeria, which had 67.7%. The losses in non-natural resource tax revenue due to inefficiencies were generally low, ranging from 0.6% of GDP in Sierra Leone to a maximum of 1.8% in Liberia, followed by 1.7% in Cabo Verde, Ghana and Guinea Bissau. In addition, countries with high natural resource taxes tend to have low efficiency on non-natural resource taxes, and this efficiency tends to be high where non-natural resource tax is high. Tax revenue mobilization in the ECOWAS countries should therefore be strengthened through continued policy efforts to improve financial deepening, trade openness and decentralization that can reduce urbanization. It is also imperative for ECOWAS tax authorities to consider the level of their tax potential in setting targets for non-natural resource tax mobilization. In addition, more efforts should be put on raising non-natural resource tax revenue than the volatile natural resource tax. Tax restructuring policies that favour direct tax revenue, especially business income tax, and domestic indirect taxes such as Value Added Tax or Goods and Services Tax should be given priority, as the African tax structure and performance review shows that countries with high shares of direct and domestic indirect tax led on tax GDP ratios.

1.0 INTRODUCTION

Globally, tax revenue mobilization is considered an important activity of government as it is expected to improve government effectiveness in service delivery and accountability. In developing countries, it reduces the probability of strong aid dependency. Effective tax systems have, therefore, always been desired by all economies. It is globally recognized that investment in human and physical capital is important for sustainable growth. However, in Sub-Saharan Africa, there have often been limited resources for investment to ensure robust and sustained growth. Rooted in this, some donor partners of the developing countries have interest in the restructuring of tax systems to boost tax performance. Interest in tax mobilization thus remains important in the developing economies. The mobilization of tax revenue was a key resolution adopted at the Third International Conference on Financing for Development held in New York in July 2015. The conference emphasized the need to mobilize resources for development post-2015. However, what a government should raise from tax (target) and what it can raise (capacity) are different, making the efficiency of tax system imperative for policy-makers in Sub-Saharan Africa, where tax revenue (% of GDP) is low for a number of countries. This is also the case for a number of developing countries.

Governments have the obligation to spend on social services for the well-being of the people, and they also spend in other areas to run the State. The expenditure can be recurrent or capital, but it must be financed by revenue from the domestic economy or abroad. However, domestic resource mobilization is more important than foreign resource mobilization on the basis that the latter (grants and loans) are volatile. They are volatile because, among others, they depend on the performance of the economies where the resources come from. In addition, in the case of loans, domestic currency depreciation increases the burden of debt servicing in domestic currency terms. In this regard, domestic resource mobilization, especially taxation, is an important instrument for financing government expenditure. This is more important in countries of the Economic Community of West African States (ECOWAS) [1] given the need for more resources to close infrastructural gaps, and for poverty alleviation.

1The ECOWAS consists of 15 out of 16 West African countries, which are Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. The West African country that is not part of ECOWAS is Mauritania.

ECOWAS has various regional integration protocols, including trade integration under the ECOWAS Trade Liberalization Scheme (ETLS) and Common External Tariff-CET (under the ECOWAS CET), and is working towards monetary integration. However, the 15 countries as a group do not have a common tax regime, while, among them, there is a sub-union of eight (8) countries which has common directives on taxation.[2]

Based on data from the World Bank's African Economic Outlook and World Development Indicators,which is summarized in Table 1 of the next section,there has been improvement in the tax performance of ECOWAS member States, especially since the early 2000s. However, the tax-GDP ratio remains low. For example, the number of ECOWAS countries with tax-GDP ratios above the median of the African tax-GDP ratio increased from six (6) during the period 2001-2005 to nine (9) during the period 2011-2015. The number of ECOWAS countries above the average of the African tax-GDP ratio increased from three during the period 2001-2005 to five during the period 2011-2015, and the number of ECOWAS countries below the African bottom 25% of tax-GDP ratio reduced from four (4) during the period 2001-2005 to three (3) during the period 2011-2015. In addition, the median tax-GDP ratio of the ECOWAS countries increased from 11.5% during the period 2001-2005, to 14.9% during the period 2011-2015, and the average increased from 11.3% during the period 2001-2005 to 14.1% during the period 2011-2015.

The number of ECOWAS countries that were in the top 25% of African tax-GDP ratio remained at three (3) during the periods 2001-2005, 2006-2010 and 2011-2015. These countries were Cabo Verde, Ghana and Senegal during the period 2001-2005, Cabo Verde, Senegal and Liberia during the period 2006-2010, and Niger, Liberia and Togo during the period 2011-2015. However, none of these countries were in the top 15% of the African tax-GDP ratio. Moreover, Nigeria, which has more than 80% of the GDP of ECOWAS and the largest economy in Africa, consistently remained in the bottom 25% of African tax-GDP ratios.

During the periods 1996-2000, 2001-2005, 2006-2010 and 2011-2015, the African countries that were consistently in the top 15% of the distribution of the African tax GDP-ratios were Lesotho, Namibia, South Africa, Swaziland, Seychelles and Morocco. Cabo Verde, which is the only country from ECOWAS in this list, was in the top 15% for the period 2006-2010 only. During the period 2011-2015, the countries in the top 15% of African tax-GDP ratios were Lesotho (38.4%), Morocco (21.9%), Namibia (28.6%), Seychelles (25.9%), South Africa (24.9%), Swaziland (27.4%) and Zimbabwe (23.3%). These observations suggest that tax revenue is low in the ECOWAS countries, with median and average tax-GDP ratio being 14.9% and 14.1%, respectively, during the period 2011-2015.

In light of these observations from the ECOWAS tax performance, important research questions worth considering are:

- What are the determinants of tax revenue?

[2]These countries are referred to as the West African Economic and Monetary Union (WAEMU)) and use a common currency with fixed parity to the Euro (the CFA).

• What is the degree of efficiency in tax revenue mobilization?

The broad objective of this study is therefore to investigate the tax efficiencies of the various ECOWAS member States. The specific objectives are: to investigate the determinants of tax revenue in ECOWAS; and estimate the degree of efficiency of tax revenue mobilization in ECOWAS.

There are a number of studies on tax efficiency estimation, which include the stochastic efficiency estimations by Bothole (2010), who used corruption and voice and accountability among the regressors of a sample of 46 countries in Sub-Saharan Africa, with data from 1990 to 2007; Fenochietto and Pessino (2013), who included a measure of income inequality and public expenditure on education among the traditional variables; and Langford and Ohlenburg (2016), who included Massachusetts Institute of Technology's economic complexity index and ethnic tension, and private sector credit in the model variables.

In spite of the recent interest in tax efficiency estimation, there is no study that focuses specifically on all or only the ECOWAS countries, even though tax mobilization is still challenging in the region. The study focuses on estimation of tax revenue frontier and efficiency by using only non-natural resource taxes, since the natural resource component is volatile. It also includes natural resource tax revenue as an explanatory variable to capture the responsiveness of non-natural resource taxes to changes in natural resource tax revenue. The possibility of the existence of tax revenue inertia, which is the tendency for tax revenue to continue increasing once it has increased, is also tested. In addition, considering that real GDP and not GDP per capita reflects the effect of changes in tax base on tax revenue, real GDP is used to capture the impact of tax base. The study considers only the ECOWAS countries, given the tax mobilization challenges in the region.

The rest of the paper is organized as follows. In section 2, the tax performance and structure in ECOWAS is discussed. Section 3 is the literature review, Section 4 presents the methodology, Section 5 is the empirical results and Section 6 is the conclusion and policy implications.

1.0 TAX PERFORMANCE AND STRUCTURE OF ECOWAS

2.1 ECOWAS Tax Performance

Table 1 shows a summary of African and ECOWAS non-natural resource tax revenue (% of GDP) and Table 2 shows the non-natural resource tax revenue (% of GDP) of only the ECOWAS countries. The median non-natural resource tax revenue (% of GDP) for the African countries was 10.8% during the period 1996 to 2000. It increased to 11.8% during the period 2001-2005 to 13.1% in the period 2006-2010, and to 14.4% in 2011-2015. The average for the African countries, which was 14.8% during 1996-2000, remained the same for 2001-2005, increasing to 15.6% during the period 2006-2010 and to 16.7% in 2011-2015. This suggests that non-natural resource tax revenue (% of GDP) for the African countries was on a rising trendin the 1996 to 2015 period.

The upward trend observed for Africa was also observed in the countries of the Economic Community of West African States (ECOWAS). In ECOWAS, the average non-natural resource tax revenue increased from 10.4% of GDP during the period 1996-2000, to 11.3% in 2001-2005, to 12.2% during 2006-2010 and to 14.1% in the period 2011-2015. The median non-natural resource tax-GDP ratio for ECOWAS also followed a rising trend, with 11.1% during 1996-2000, 11.5%, 13.5% and 14.9%, respectively, during the periods 20001-2005, 2006-2010 and 2011-2015. These figures imply that in spite of the rise in non-natural resource tax performance in the ECOWAS countries as a percentage of GDP, it remains low in the region.

During the period 1996-2000, only one ECOWAS country was among the top 25% of the tax-GDP ratio of African countries; Cabo Verde. During the period 2001-2005, Ghana and Senegal joined Cabo Verde from ECOWAS in the top 25% of African tax performance. While Cabo Verde and Senegal remained in the top 25% of African tax-GDP ratio during the period 2006-2010, Ghana was no longer among the group and Liberia joined Cabo Verde and Senegal in the top 25% of African tax-GDP ratio. During the period 2011-2015, Niger and Togo added to the African top 25% group, both Cabo Verde and Senegal dropped out of it and Liberia remained in the group. This also implies that there was improvement in the performance of some countries, but the good performance of others was not sustained for up to a decade, with the exception of Cabo Verde and Senegal.

Table 3 shows the countries in the top 15% of the African tax-GDP ratio. None of the ECOWAS countries was in this category. During the period 2011-2015, the countries in the top 15% of African tax-GDP ratios (excluding natural resource taxes) were Lesotho (38.4%), Namibia (28.6%), Swaziland (27.4%), Seychelles (25.9%), South Africa (24.9%), Morocco (21.9%) and Zimbabwe (23.3%). These were the countries in the top 15% during the periods 1996-2000, 2001-2005 and 2006-2010, with Cabo Verde replacing Zimbabwe in 2006-2010. Although Nigeria is the largest economy in Africa and has more than 80% of the GDP of ECOWAS, it is not among the countries in the top 15% of African tax-GDP ratio. Moreover, while Cabo Verde has the highest per capita income in ECOWAS, it was among the top 15% of the African tax GDP ratios only during the period 2006-2010 and it was ranked last in the group.

Table 1: Summary of African and ECOWAS non-natural resource tax revenue (% of GDP)

Source: Calculated from World Bank's African Economic Outlook and World Development Indicators

Table 2: ECOWAS non-natural resource tax-GDP ratio

		1996-2000	2001-2005	2006-2010	2011-2015
Average	ECOWAS	10.4	11.3	12.2	14.1
	Africa	14.8	14.8	15.6	16.7
	ECOWAS countries above the African average tax-GDP ratio	Cabo Verde	Cabo Verde Ghana Senegal	Cabo Verde Benin Senegal Liberia	Cabo Verde Niger Senegal Liberia Togo
Median	ECOWAS	11.1	11.5	13.5	14.9
	Africa	10.8	11.8	13.1	14.4
	ECOWAS countries above the African median tax-GDP ratio	Benin, Cabo Verde Cote d'Ivoire, Ghana Liberia, Mali, Senegal	Benin, Cabo Verde, Ghana, Mali, Senegal, Togo	Benin, Cabo Verde, Cote d'Ivoire, Gambia, Guinea, Liberia, Senegal Togo	Benin, Burkina Faso, Cabo Verde, Gambia, Guinea, Liberia, Senegal, Niger, Togo
3rd Quartile	ECOWAS	13.6	14.1	15.8	18.2
	Africa	15.8	16.4	16.8	18.3
	ECOWAS countries in the top 25% of African a tax-GDP ratio	Cabo Verde	Cabo Verde Ghana Senegal	Cabo Verde Senegal Liberia	Niger Liberia Togo
1st Quartile	ECOWAS	9.1	9.9	11.7	14.0
	Africa	8.7	9.4	9.9	11.1
	ECOWAS countries in the bottom 25% of African tax-GDP ratio	Gambia Nigeria Niger Sierra Leone	Guinea Bissau Nigeria Niger Sierra Leone	Guinea Bissau Nigeria Sierra Leone	Guinea Bissau Nigeria Sierra Leone

Source: Calculated from the World Bank's African Economic Outlook and World Development

Indicators

Country	1996-2000	2001-2005	2006-2010	2011-2015
ECOWAS countries				
Benin	14.0	14.4	16.4	14.9
Burkina Faso	10.8	11.1	12.2	15.3
Cabo Verde	15.8	19.0	20.0	18.2
Côte d'Ivoire	13.1	11.9	13.5	14.3
Gambia	8.7	10.6	14.5	14.8
Ghana	13.7	19.3	11.9	14.4
Guinea	10.2	11.5	14.6	16.3
Guinea Bissau	-	4.9	6.1	9.2
Liberia	11.4	11.0	18.4	19.3
Mali	12.6	12.5	12.1	13.7
Nigeria	7.3	7.0	4.1	1.4
Niger	7.2	9.1	11.5	19.8
Senegal	14.2	16.5	17.5	18.2
Sierra Leone	7.7	8.6	8.1	8.9
Togo	10.7	13.7	15.3	18.7
ECOWAS Average	10.4	11.3	12.2	14.1
ECOWAS Median	11.1	11.5	13.5	14.9
ECOWAS 3rd Quartile	13.6	14.1	15.8	18.2
ECOWAS 1stt Quartile	9.1	9.9	11.7	14.0

Table 3: African countries in the top 15% of non-natural resource tax-GDP ratio

Top 15% of countries from Africa	1996-2000	2001-2005	2006-2010	2011-2015
Lesotho	36.2	37.1	48.7	38.4
Morocco	20.5	19.1	22.0	21.9
Namibia	26.1	24.4	28.1	28.6
Seychelles	24.9	26.3	32.2	25.9
South Africa	22.1	22.4	25.0	24.9
Swaziland	27.8	27.2	32.2	27.4
Zimbabwe	24.3	22.1	-	23.3
Cabo Verde			20.0	

Source: Calculated from the World Bank's African Economic Outlook and World Development Indicators

2.2 ECOWAS Tax Structure

Due to coordination activities among the eight countries of the West African Economic and Monetary Union (WAEMU)[3], which is a monetary union in ECOWAS, some of their tax policies are the same, unlike the non-WAEMU member countries of ECOWAS. For example, the WAEMU[4] and non-WAEMU countries in ECOWAS have different treatments for Value Added Tax (VAT), which is the largest component of domestic indirect tax. Though there is an ECOWAS protocol for all countries to have VAT, there is no protocol yet on a common VAT rate in the region. Thus, VAT rates are not the same across the ECOWAS countries, while there is a common VAT rate in the WAEMU countries levied at 18%[5].

[3]The WAEMU countries are Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo. Therefore, Cabo Verde, Ghana, Guinea, Liberia, Nigeria and Sierra Leone are not part of the WAEMU, while they form the ECOWAS together with the WAEMU countries. The WAEMU countries have a monetary union which has been in existence for over 40 years.

[4] Following fiscal challenges in the 1980s and 1990s, which contributed partly to the decision to devalue the CFA Franc in 1994, the WAEMU members signed the Dakar Treaty of 1994 for tax policy coordination. Common policies on Value Added Tax and Excise Tax were introduced in 1998. In 1999, the directives on Capital Income Tax were introduced, and in 2000, the Common External Tariff, which brought the WAEMU into a Customs Union, was introduced.

[5] All the WAEMU countries have a single VAT rate of 18%, which came from the WAEMU 1998 directive on VAT. Before then, VAT had existed with multiple rates in the member countries.

In the non-WAEMU countries (Nigeria, Ghana, Guinea, Liberia, Sierra Leone and Gambia), VAT rates are not the same. Ghana has a rate of 15%, plus a health insurance levy of 2.5% on most goods and services, making it a total of 17.5%. There is a reduced VAT rate levied on a flat-rate basis on small enterprises. In Liberia, the Goods and Services Tax (GST), which is a quasi-VAT counterpart, is in existence at multiple rates, with 10% for hotels and travel services, and 7% for the other goods and services that fall in this tax category. Gambia replaced the sales tax with VAT on 1st January 2015 and the rate is 15%. In Guinea, the VAT rate was raised to 20% from 18% in January 2016. In Nigeria, the VAT rate is 5% and it is the least in the ECOWAS region. In Sierra Leone, GST is levied at a rate of 15%. It was introduced here in 2010 by replacing four existing taxes, including the cascading sales tax.

When international trade tax dominates a country's tax revenue, the country is vulnerable to volatility in international trade. Low levels of income, attributed to large informal sector operations, and the big role of agriculture in most developing economies are responsible for this tax structure. In ECOWAS as a group, international trade tax was higher than both domestic indirect tax and direct tax during the period 2001-2005, with a tax revenue share of 36.8% (Table 4). It remained higher than both domestic indirect tax and direct tax in 2006-2010, though the share declined to 31.0%. During the period 2011-2015, the share of international trade tax declined to 25.9%, and both domestic indirect and direct taxes were higher than international trade tax. In addition, the number of countries where international trade tax share was greater than the share of domestic indirect tax and direct tax was nine (9) during the period 2001-2005. This declined to six (6) in 2006-2010, and further declined to three (3) in 2011-2015. During the period 2011-2015, the countries where the share of international trade tax was greater than the share of domestic indirect tax and direct tax were Togo, Liberia and Benin. This suggests that reliance on distortionary taxation and the vulnerability to changes in import, which is the base for import tax revenue, had declined by the mid-2000s to 2015, though tax GDP ratios remained low in the region.

Another observation from the tax revenue data of ECOWAS countries shows that there are a few countries which carry about a total of 90% of the GDP of the region, but yet have a significant share of taxes from natural resources.[6] For example, Nigeria, Cote d'Ivoire, Liberia and Mali had 79.9%, 21.5%, 19.4% and 15.9%, respectively, of their total taxes from natural resource rent during the period 2001-2005, and each of the rest of the countries had natural resource tax shares of less than 6.5%. In the period 2006-2010, the countries with high shares were Nigeria with 78.3%, Mali with 15.9%, Cote d'Ivoire with 15.1% and Ghana with 13.8%, while the rest had less than 7.0% each. During the period 2011-2015, Nigeria, Sierra Leone, Cote d'Ivoire and Mali had natural resource rent share in total tax at 81.5%, 16.1%, 12.5% and 11.7%, respectively, while each of the remaining countries had less than 7.5%. As Nigeria has over 80% of the GDP of the ECOWAS region, and it has about 80% of its tax from natural resource taxes (Table 4) and its tax-GDP ratio (excluding natural resource shares) is less than 5% (Table 2), the low level of non-natural resource taxes in some ECOWAS countries

[6] The data on indirect tax and direct excludes natural resource tax.

can be attributed to reliance on natural resource taxes, which gives little incentive to restructure and revamp the domestic indirect and direct tax systems.

In addition, Table 4 reveals that during the period 2011-2015, in all the countries where either indirect tax or direct tax share was more than 40% of total tax, the share of natural resource tax was less than 8%. This also suggests that countries with low performance on natural resource taxes tend to put more effort in raising domestic indirect taxes and/or direct taxes.

Table 4: The tax composition of ECOWAS countries (% of total tax)

Period	2001-2005				2006-2010				2011-2015			
Tax type	Trade	Indirect	Direct	Resources	Trade	Indirect	Direct	Resources	Trade	Indirect	Direct	Resources
Benin	52.1	22.5	25.4	0.0	54.0	23.3	22.7	0.0	51.4	27.2	21.4	0.0
Burkina Faso	32.9	40.0	25.7	1.4	18.5	57.0	23.3	1.2	16.5	53.8	28.8	0.8
Cabo Verde	44.4	16.7	33.8	5.1	20.5	44.8	29.9	4.8	21.0	46.0	30.3	2.7
Côte d'Ivoire	30.2	22.2	26.1	21.6	33.2	21.8	30.2	15.1	31.4	23.4	32.7	12.6
Gambia	57.0	13.0	29.7	0.3	51.4	36.8	30.6	1.3	21.5	43.8	34.0	0.8
Ghana	22.5	43.7	31.3	2.5	17.8	36.3	31.9	13.8	18.8	32.1	41.7	7.8
Guinea	20.8	44.1	35.3	0.0	18.0	39.1	42.9	0.0	18.8	38.8	44.4	0.0
Guinea Bissau	34.3	43.7	21.6	0.8	28.7	36.3	30.4	5.8	24.7	38.3	31.7	7.3
Liberia	33.9	21.7	25.0	19.4	44.6	18.4	33.3	2.8	41.0	16.7	40.1	2.2
Mali	51.0	14.7	18.3	15.9	42.6	14.1	27.6	15.9	18.3	38.7	32.3	11.7
Nigeria	7.7	4.6	7.8	79.9	5.4	7.6	8.8	78.3	4.2	8.6	7.8	81.6
Niger	52.6	17.7	25.6	6.2	38.7	18.8	34.8	6.8	31.5	16.7	46.3	5.5
Senegal	17.3	54.7	23.7	4.4	16.5	52.3	25.1	6.1	15.5	51.2	27.2	6.1
Sierra Leone	48.1	20.7	27.6	2.7	38.8	25.3	29.9	4.8	17.8	28.5	37.4	16.1
Togo	46.6	22.7	29.1	1.8	54.1	20.8	23.4	2.1	54.8	23.0	20.0	2.2
ECOWAS Average	36.8	26.8	25.6	10.8	31.0	30.1	28.3	10.6	25.8	31.8	31.7	10.6
ECOWAS Median	34.3	22.2	25.7	2.7	31.4	25.3	29.9	4.8	21	32.1	32.3	6.5

Source: Calculated from thev World Bank's African Economic Outlook and World Development Indicators

3.0 BRIEF REVIEW OF THE LITERATURE

There is a plethora of empirical studies on tax efficiency, which is used interchangeably with the term "tax effort". These studies can be broadly divided into three groups in terms of the methodology used. The estimation of tax revenue model based on Ordinary Least Squares (OLS) is one approach, and the others are estimations based on panel data estimation techniques and the Stochastic Frontier Estimation method. In each of these cases, the tax efficiency or effort is estimated as the ratio of actual to predicted values from the model estimated.

Early studies include Lotz and Morss (1967), Bahl (1971) and Chelliah et al. (1975), which used the Ordinary Least Squares (OLS). Lotz and Morss (1967) used developing and developed countries in their study, while the focus of Bahl (1971) and Chelliah et al. (1975) was on developing countries.

Studies that used panel data estimation techniques include the works of Stotsky and WoldeMariam (1997), who applied the fixed effect estimator to 43 Sub-Saharan African countries with annual data from 1990 to 1995; Martinez-Vazquez (2001) who applied fixed effect estimators to 32 developing countries with annual data from 1990 to 1996; and Brun et al. (2014) who used the random effect estimator for 85 developing countries with annual data from 1980 to 2003. A problem with the OLS and panel data regression methods is the possibility to have tax efficiency that is more than 100%, implying there are countries which can be more than 100% efficient.

The third generation of studies is the category that explicitly considers that the error term from an econometric specification of tax-ratio model can be decomposed into the conventional disturbance term and a country-specific one-sided error capturing inefficiency. The Maximum Likelihood is used to obtain the coefficients of the tax frontier function, and tax efficiency is consequently obtained as the ratio of actual tax to the potential (maximum) tax. In this group, the efficiency of a country cannot be more than 100%; that is, every country is below or at its potential, and the tax gap is the tax inefficiency. Studies in this group include the works of Langford and Ohlenburg (2016) for 85 countries which are not rich in natural resources; Ndiaye and Korsu (2014) for 15 countries from West Africa that are in the Economic Community of West African States, four (4) countries from Southern Africa and one (1) country from East Africa; Fenochietto and Pessino (2010) for 99 developing and developed countries over the period 1991-1996; Barros (2005) for tax offices in Portugal; Alfirma

(2003) for local governments in Indonesia; and Jha et al. (1999) for 15 Indian States.

There have also been differences in the empirical literature from the point of the explanatory variables in the tax revenue regression. The conventional explanatory variables have included GNP or GDP per capita, trade openness, a measure of financial development, urban population relative to total population, a measure of sectoral composition (the share of agriculture in GDP, the share of mining in GDP, the share of services in GDP, the share of manufacturing in GDP, inflation rate, and a measure of education). However, all of these variables have not been included in a single study. Some studies have also included measures of the quality of institutions and some other macroeconomic variables among the conventional variables used. For example, Bothole (2010) used corruption and voice and accountability among the regressors of a sample of 46 countries in Sub-Sahara Africa with data from 1990 to 2007; Fenochietto and Pessino (2010) included a measure of income inequality and public expenditure on education among the traditional variables; and Langford and Ohlenburg (2016) included the Massachusetts Institute of Technology's economic complexity index and ethnic tension and private sector credit among the model variables.

In spite of the idea that it is changes in the tax base, in addition to changes in the rate, compliance, enforcement strategy and other structural and institutional factors that change tax revenue, GDP per capita, which is a proxy for the level of development and not tax base, has been used in previous studies that use an income variable, though the idea is to capture the effect of level of development. While GDP per capita has been shown to have a positive and significant impact, the same has also been observed in some other studies. However, a negative effect has equally been found, as in Alm and Martinez-Vazquez (2003).

This study departs from previous studies in several folds. First, in this study we use real GDP instead of GDP per capita. The argument is that real GDP better reflects the base of tax than GDP per capita, which can vary due to population changes. Therefore, real GDP captures the role of economic activities in tax mobilization. Second, we estimate the non-natural resource tax revenue frontier instead of total tax frontier, and obtain tax efficiency for only the ECOWAS countries. Third, we include natural resource tax as an explanatory variable to capture the degree of responsiveness of non-natural resource taxes to natural resource taxes. In addition, the possibility of the existence of tax revenue inertia, which is the tendency for tax revenue to increase in the next period once it has increased in the previous one, is tested.

4.0 METHODOLOGY

4.1 From Production Frontier to Tax Frontier

Aigner, Lovell and Schmidt (1977) were the first to develop the Stochastic Frontier Function, which was meant for estimating technical efficiency in production. Recently, it has been used to estimate tax potential, which is unobservable, from which tax efficiency is obtained. The efficiency in the mobilization of tax revenue is then obtained, as in the technical efficiency framework in the production function by Aigner, Lovell and Schmidt (1977) and Kumbhakar and Lovell (2000).

In its original form, the Stochastic Frontier Production Function from Aigner, Lovell and Schmidt (1977) is given as in equation (1).

$$Y_{it} = \exp(\beta_0 + \beta X_{it} + V_{it} - U_{it}) \quad \text{i = 1,2,3..... N: t = 1,2,3.....T} \qquad (1)$$

Where Y is output, X is the vector of input variables, β is a vector of parameters, V is the disturbance term while U is the inefficiency term. U is a random variable with non-negative values while V is the usual stochastic disturbance term found in an econometric model, which can take both positive and negative values. U follows a normal distribution with mean μ and variance σ_u^2 and V follows a normal distribution with zero mean and variance of σ_v^2. In addition, the U and V are statistically independent.

According to the Stochastic Frontier literature, as in Kumbhakar and Lovell (2000), the technical efficiency level of individual i at time t is the ratio of the actual output (Y) to potential or maximum output (Y) and technical inefficiency in production is one minus the measured efficiency (which is always less than one).

According to Fenochietto and Pessino (2010), the inefficiency concept in production can be applied to tax mobilization, where output (Y) becomes the tax-GDP ratio and the inputs to production, which are contained in the vector X in equation (1), become the determinants. Technical efficiency in the Stochastic Frontier Production Function is given as the ratio of actual production to the Stochastic Frontier (maximum) output. In the case of tax frontier, this ratio is referred to as tax effort (TAX_EFFORT) or efficiency, which is the ratio of actual tax revenue to the Stochastic Frontier (potential) tax revenue. This is given as in equation (2).

$$TAX\_EFFORT = \frac{Yit}{\exp(\beta_0 + \beta X_t + V_t)} = \frac{\exp(\beta_0 + \beta X_t + V_t - U_t)}{\exp(\beta_0 + \beta X_t + V_t)} = \exp(-U_t) \quad (2)$$

4.2 Choice of Variables in the Tax Frontier

An important consideration is the determination of the elements of the vector X in equation (4.1). The literature reveals that developmental, structural and institutional factors determine tax mobilization (IMF, 2011). IMF (2011) gives details of theoretical determinants of tax mobilization. The elements of vector X are chosen based on observations from the literature. The following variables were used in the vector X: Real GDP, openness of the economy to trade, agricultural share of GDP, urban share of total population, M2/GDP ratio as a measure of financial deepening, and inflation as a measure of macroeconomic instability. In what follows, the expected signs of the coefficients of the variables in the vector X are discussed.

Income: It is expected to have a positive effect on tax revenue performance. The conventional wisdom is that as the economy develops, measured by increase in GDP per capita, the administrative and compliance capacity increases, thereby increasing tax mobilization. In addition, more developed countries have higher probability of leveraging on technology to mobilize tax. However, GDP per capita does not capture the tax base, while GDP itself does. Therefore, real GDP can represent the tax base or the extent to which the real sector is performing, which is expected to reflect in tax revenue.

Openness to trade: This is expected to have a positive effect on tax revenue on the basis that it is easier to levy taxes on trade. Moreover, increased openness increases imports, which is the tax base for import tax. It is on this basis that landlocked countries are often expected to have less on international trade than their counterpart non-landlocked countries.

Agricultural share of GDP: The agricultural sector of a developing country is hard to tax as it operates mostly in an informal setting. Therefore, increase in the share of agriculture in GDP stifles tax mobilization effort. Thus, the coefficient of agricultural share of GDP in a tax revenue regression is expected to have a negative coefficient.

Financial deepening: When the financial sector is deep, cash transactions are reduced and the financial institution becomes like a monitoring institution; that is, it monitors the performance of economic activities of corporations. In this regard, countries with robust financial institutions have higher tax revenue performance. Financial deepening is therefore expected to have a positive effect on tax revenue.

Urban-rural population structure: The provision of public services has higher social returns in the urban setting than in the rural setting, and it is easier to tax the urban setting than the rural setting. It is expected, therefore, that as the share of urban population grows relative to the rural population it becomes easier to tax the society. The idea is that taxes are easier to collect in an urban setting than a rural

setting, where there is a less developed mechanism for tax collection. It is therefore expected that a more urbanized society has a positive effect on tax revenue.

Inflation: Inflation is expected to have a negative effect on tax revenue as it acts as a single proxy for macroeconomic instability. This is because an increase in macroeconomic instability increases uncertainty on investment return, which reduces investment and leads to the erosion of tax performance.

Natural-resource tax-GDP ratio: To account for the effect of natural resource taxes on performance of non-natural resource tax revenue mobilization, natural resource tax-GDP ratio was introduced in the model. This can reveal whether policies that increase natural resource taxes have positive externalities on non-natural resource taxes in ECOWAS, or whether as countries increase their natural resource taxes their performance on non-natural resource taxes weakens. The introduction of natural resource tax-GDP ratio was done through a linear transformation by adding 1 to it and consequently taking its natural log. This was to ensure that all model variables are in log, which is the spirit of the Stochastic Frontier model, given that some countries have zero natural resource tax-GDP ratios.[7]

$$LnTAXR = \beta 0 + \beta 1 LnTAXRit - 1 + \beta 2 \sum_{j=0}^{j=1} LnRGDPit - j + \beta 3 \sum_{j=0}^{j=1} LnM2GDPit - j + \beta 4 \sum_{j=0}^{j=1} LnOPNit - j + \beta 5 \sum_{j=0}^{j=1} LnAGDPit - j + \beta 6 \sum_{j=0}^{j=1} LnURBit - j + \beta 7 \sum_{j=0}^{j=1} Ln(1 + INF)it - j + \beta 8 \sum_{j=0}^{j=1} LnNRTAXRit - j + Vit - Uit \quad (3)$$

Where TAXR is non-natural resource tax as a percentage of GDP, RGDP is real GDP, AGDP is agricultural share of GDP, URB is urban share of total population, M2GDP is M2 as a percentage of GDP, INF is inflation rate (divided by 100),[8] and NRTAXR is natural resource tax as a percentage of GDP and i and t are individual and time subscripts.

4.4. Model and Tax Efficiency Estimation Technique

[7] This conforms to the idea that ln (1+X) $\cong\cong$ X and it is done to ensure that all variables entering the frontier are in logs, which is a requirement for frontier estimation.

[8] Inflation rate (in percentage) was divided by 100 and 1.0 was added to it so that it would be possible to have a log transformation of it as some countries have negative inflation rates during the estimation period, especially the WAEMU countries (Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Togo and Senegal). This is important because the Stochastic Frontier model estimation requires all variables to be in log transformation. This transformation leverages on the relationship given as x = ln (1+x).

The estimation of the Stochastic Frontier tax function in equation (3) was done using data over the period 2000-2015 for all the ECOWAS countries, applying the general-to-specific modelling in the spirit of the Aigner, Lovell and Schmidt (1977) and Kumbhakar and Lovell (2000) Maximum Likelihood approach. One lag of each variable was used to capture the delayed or dynamic effect of regressors. Insignificant variables were dropped from the estimation process one after the other until the parsimonious model was obtained. However, the static model, where delayed effects are not considered, was also estimated for comparison of the static and dynamic models.

The tax efficiencies were obtained by first estimating the Stochastic Frontier tax function. The Stochastic Frontier function assumes that there is maximum tax revenue that an economy can make, given its fundamentals. The efficiency in tax mobilization was then estimated as the ratio of the actual tax revenue ratio to the estimated frontier ratio. From the estimation of the tax efficiencies (in percentage), tax inefficiency (in percentage) may be obtained as 100 minus the efficiency component.

5.0 EMPIRICAL RESULTS

5.1 Estimated Tax Frontier Model

We first estimated a static version of the frontier, where only current values of the variables are used. The estimations were done under various assumptions about the inefficiency term. These assumptions are a half-normal distribution of the inefficiency term, an exponentially distributed inefficiency term and a truncated normal inefficiency term. These are the three distributions for the inefficiency terms in the Stochastic Frontier literature.

Table 5 shows the parsimonious Stochastic Frontier Model of tax revenue for these three versions. Appendix Table A1 presents the over-parameterized models. The results of the parsimonious model show that the three models are the same in terms of both the sign and significance of financial deepening (positive), openness to trade (positive) and urban population (negative). Differences are observed in either sign or significance of the other variables, which are inflation, real GDP, agricultural GDP and natural resource tax revenue. As the log-likelihood for the exponential inefficiency model is higher than those of the other two versions, we consider this model to be superior to the other two models.

The estimation, therefore, reveals that inflation is the only insignificant variable in the model, though it has the right sign in the over-parametized model (Appendix Table A1). In addition, natural resource tax revenue has a negative effect on non-natural resource tax revenue, and both urbanization rate and agricultural share of GDP have negative effects on non-natural resource tax revenue, while financial sector development, openness and real GDP have positive effects.

Table 5: The estimated parsimonious static tax revenue frontier model for ECOWAS

Variable	Model 1 (Half Normal Inefficiency)	Model 2 (Exponential Inefficiency)	Model 3 (Truncated Normal Inefficiency)
Ln(M2/GDP)	0.178 (0.000)	0.172 (0.001)	0.193 (0.000)
Ln(OPN)	0.532 (0.000)	0.552 (0.001)	0.315 (0.000)
Ln(NTAXR)	-	-4.302 (0.000)	1.498 (0.000)
Ln(URB)	-0.183 (0.000)	-0.177 (0.010)	-0.248 (0.000)
LnAGDP		-0.130 (0.010)	0.047 (0.000)
Ln INF	-0.581 (0.000)	-	-
LnRGDP	0.012 (0.000)	0.017(0.038)	-0.009 (0.000)
CONSTANT	0.918	0.965 (0.127)	2.193 (0.000)
Other Model Statistics			Mu=-2.679 (0.000)
LnSigma2_V	-28.282 (0.695)	-4.026 (0.000)	LnSigma2 = 0.517 (0.000)
LnSigma2_U	-0.972 (0.000)	-2.402 (0.000)	Ilgtgamma = 36.448 (0.228)
Sigma_V	7.22e-070	0.134	Sigma2 = 1.676
Sigma_U	0.679	0.300	Gamma = 1.000
Sigma2	0.453	0.108	Sigma_U2 = 1.676
Lamda	0.932	2.246	Sigma_V2 = 0.000
LR test for Sigma2_U=0	273.44 (0.000)	1.1e+02 (0.000)	-9.378(0.000)
Log Likelihood	-79.169	-39.813	-64.028

Note: Figures in parenthesis are p-values

The dynamic Stochastic Frontier tax revenue model was estimated by using one lag of each variable to obtain the over-parameterized model, where all the model variables of equation (3) were included. Insignificant variables were then dropped one by one to obtain the parsimonious model. The choice of one lag was to save the degrees of freedom.

Table 6 shows the parsimonious dynamic models. Appendix Table A2 presents the over-parameterized models. The results show that in all three versions of the model, tax revenue has inertia, as the lagged dependent variable is significant in all the versions of the model estimates at the 1% level. The dynamic model was considered superior to the static model on the basis of the significance of the lagged dependent variable. As in the static model, the model with the exponential inefficiency term was found to have higher log-likelihood than the models with half-normal and truncated normal inefficiency terms. The dynamic model with exponential inefficiency term was therefore chosen as the preferred congruent model of tax frontier.

In addition, the contemporaneous terms of the variables capturing openness, financial sector development and urbanization rate have the same signs in both the static and dynamic models, which are positive, positive and negative, respectively, and are significant. The results reveal that financial deepening and openness to trade have positive contemporaneous effects on tax revenue and are significant at the 1% level. In addition, while the one period lag effect of financial deepening has a negative and significant effect on tax revenue, the sum of the contemporaneous and lag impact is positive (with a coefficient of 0.044), implying that its net dynamic impact in one year is positive.

Table 6: The estimated parsimonious dynamic tax revenue frontier model for ECOWAS

Variable	Model 1 (Half Normal Inefficiency)	Model 2 (Exponential Inefficiency)	Model 3 (Truncated Normal Inefficiency)
Ln(TAXR)t-1	0.895 (0.000)	0.860 (0.000)	0.860(0.000)
Ln(M2/GDP)	0.233 (0.000)	0.165 (0.000)	0.165 (0.003)
Ln(M2/GDP)t-1	-0.202 (0.002)	-0.121 (0.034)	-0.121(0.034)
Ln(OPN)	0.137 (0.000)	0.125 (0.000)	0.125 (0.000)
Ln(NTAXR)	4.659 (0.000)	4.970 (0.000)	4.969 (0.000)
Ln(NTAXR)_1	-4.021 (0.000)	-3.797 (0.000)	-3.797 (0.000)
Ln(URB)	-	-0.079 (0.012)	-0.079 (0.012)
Ln(URB)t-1	-0.084 (0.017)	-	
Constant	0.102 (0.389)	0.154 (0.135)	0.154 (0.136)
Other Model Statistics			Mu=-138.596 (0.530)
LnSigma2_V	-4.632 (0.000)	-4.970 (0.000)	LnSigma2 = 2.614 (0.099)
LnSigma2_U	-3.948 (0.000)	-4.639 (0.000)	Ilgtgamma = 7.583 (0.000)
Sigma_V	0.099	0.083	Sigma2 = 13.653
Sigma_U	0.139	0.038	Gamma = 0.999
Sigma2	0.029	0.017	Sigma_U2 = 13.646
Lamda	1.408	1.180	Sigma_V2 = 0.007
LR test for Sigma2_U=0	2.74 (0.049)	20.51 (0.000)	-0.371(0.355)
Log Likelihood	142.511	151.372	151.348

Note: Figures in parenthesis are p-values

Urbanization is found to have a negative contemporaneous effect on non-natural resource tax mobilization and it is significant at the 5% level. However, this sign is contrary to the theoretical exposition that as the urban population increases, tax revenue grows because it is easier to collect taxes in urban than rural areas. It, however, suggests that as the urban population increases, governments put more effort in collecting taxes in urban areas, with reduction in tax revenue in the rural areas (due to the urban migration) outweighing the increase in taxes due to the population drift to urban areas, reflecting the relevance of decentralization to reduce urbanization.

Natural resource tax revenue has a positive contemporaneous and a negative lag impact on tax revenue mobilization, with a positive net impact (sum of coefficient being 1.18). This implies that as natural resource tax revue increases, so does the non-natural resource tax revenue in the same period, but after a year, it decreases, while the net impact within a year is positive. This suggests that the initial positive externality that an increase in natural resource taxes has on non-natural resource taxes dwindles within a year.

The share of agriculture in GDP, inflation and real GDP were not found to be

significant in the model in either the contemporaneous form or the lag form, and were therefore dropped in the estimation of the dynamic model, in the spirit of Hendry's general-to-specific modelling.

The variance of the inefficiency term is significant, as shown by the LR test for the significance of the inefficiency component of the error term, which implies that the inefficiencies in tax mobilization in ECOWAS are different from the idiosyncratic errors that make tax collection vary over time. This suggests that a Stochastic Frontier instead of an average regression, as in the OLS or the traditional panel data technique estimations, is preferred. This is not the case for the truncated model, which rejects the null hypothesis of the existence of inefficiency. However, as the log-likelihood for the exponential inefficiency model is higher than in the other two versions, the exponential inefficiency version is considered the preferred dynamic model. The inefficiency in tax mobilization in ECOWAS was therefore estimated using the parsimonious version of the dynamic frontier model, with exponentially distributed inefficiency terms.

5.2 Estimated Tax Efficiency and Tax Lost due to Inefficiency

Following the estimation of the Stochastic Frontier tax function, the tax efficiency estimates were obtained as the ratio of the actual tax-GDP ratio to the estimated Stochastic Frontier tax-GDP ratio. Table 7 shows the tax efficiencies for the ECOWAS countries. It shows the extent to which a country's tax-GDP ratio is closer to its tax potential (maximum collectable subject to existing fundamentals).

The estimated tax efficiencies show that in the last five years of the estimation period (2011-2015), the tax efficiencies of ECOWAS countries ranged from 66.3% in Nigeria to 94.2% in Mali, with an ECOWAS average of 90.2% and median of 90.2%. This suggests that the ECOWAS countries have the potential to improve tax revenue mobilization. During the period 2001 to 2015, tax efficiencies ranged from 67.7% in Nigeria to 93.7% in Benin.

It is observed that apart from Nigeria, all the countries have at least 90% of their tax potential, given the fundamentals of tax mobilization in these countries. This suggests that while countries may be having low tax GDP ratios, they have up to 90% of their tax potential. It is, therefore, observed that the ECOWAS countries are similar in terms of their tax efficiencies in spite of differences in tax-GDP ratios. The Nigerian exception could be due to high concentration of tax mobilization on natural resource taxes, very low VAT rate (5%) and low VAT compliance and tax leakages.

Table 7: Estimated tax efficiency in ECOWAS countries

Year	Benin	Burkina Faso	Cabo Verde	Cote d'Ivoire	Gambia	Ghana	Guinea	Guinea-Bissau	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone	Togo	ECOWAS Average
2001	93.8	88.3	86.4	85.2	88.8	87.8	85.5	98.3	82.8	93.5	83.2	81.8	93.7	88.2	86.2	93.0
2002	96.5	94.0	86.7	84.3	86.2	88.1	85.6	88.2	94.2	88.4	85.5	84.7	94.8	81.5	83.5	88.4
2003	86.5	88.3	88.5	84.1	86.1	85.2	87.4	98.3	73.5	93.7	87.3	71.8	92.4	82.5	97.1	90.0
2004	86.3	85.6	94.0	83.4	96.8	86.3	84.3	87.3	93.1	96.1	82.8	28.0	94.2	83.5	91.8	88.4
2005	96.0	90.5	86.8	82.7	91.2	88.8	87.3	97.8	86.8	92.3	90.4	87.8	94.7	88.2	88.0	93.0
2006	86.5	83.1	94.5	83.8	86.3	66.7	84.2	90.0	97.2	82.2	82.2	48.7	93.4	83.8	92.1	87.8
2007	86.7	84.0	89.0	83.4	94.5	87.6	82.4	74.9	86.9	96.8	81.6	98.8	92.1	88.2	91.1	91.6
2008	94.1	88.3	94.1	84.4	91.2	86.1	86.0	88.3	88.5	78.5	87.6	58.1	87.8	84.3	88.1	87.6
2009	91.8	84.0	86.5	84.6	93.2	81.4	84.7	98.0	79.0	98.2	83.7	87.0	91.7	82.2	91.0	92.1
2010	94.0	82.4	92.9	84.8	88.8	84.6	81.7	86.8	86.5	90.8	80.4	30.1	94.9	82.3	89.9	87.9
2011	92.7	96.2	94.0	78.8	94.2	86.6	82.3	83.5	83.5	94.8	88.4	47.9	92.2	83.6	90.8	88.1
2012	91.4	96.2	88.5	86.0	92.0	82.7	96.1	89.5	97.4	92.8	81.0	89.7	94.8	84.8	90.8	92.6
2013	94.9	83.6	91.5	87.2	90.9	96.4	88.7	91.9	81.8	93.5	86.6	77.8	94.8	87.6	86.3	88.8
2014	89.5	88.8	90.3	82.6	92.2	86.6	82.6	97.8	91.3	93.4	83.8	66.5	93.7	90.4	92.8	90.0
2015	90.1	96.6	86.3	86.3	97.1	88.1	86.1	98.9	85.2	98.5	82.8	80.8	91.8	87.4	90.5	90.3
Average	93.7	87.3	92.3	83.8	93.0	90.8	89.8	96.8	88.6	91.8	88.8	87.7	92.6	90.8	96.9	96.2
Median	94.1	88.1	93.9	84.1	93.1	82.8	84.3	93.8	93.9	93.8	82.3	84.7	93.4	90.8	91.0	96.0
Period Average																
2001-2005	95.2	91.8	93.5	93.9	93.4	93.5	94.0	98.8	89.9	92.4	91.6	70.4	93.9	91.2	90.7	91.8
2006-2010	94.2	92.6	91.2	94.2	92.6	83.9	93.6	89.0	90.2	98.7	91.1	66.3	92.0	92.4	90.0	88.4
2011-2015	91.7	92.5	92.0	83.4	93.1	92.7	93.2	93.7	89.8	94.2	92.5	66.3	91.4	96.0	92.0	96.2
2001-2015	93.7	92.3	92.1	92.5	93.0	90.0	93.6	90.5	89.6	91.8	91.8	67.7	92.4	90.5	90.9	96.2

Figure 1 shows the tax efficiency of ECOWAS as a group over the estimation period. It shows that in the ECOWAS region as a group, tax efficiency did not follow any general or long-term pattern during the period 2001-2015. It fluctuated between 87.6% (this least value was in 2008) and 93.0% (this maximum value was in 2005).

Figure 1: Tax efficiency in the ECOWAS during the period 2001-2015

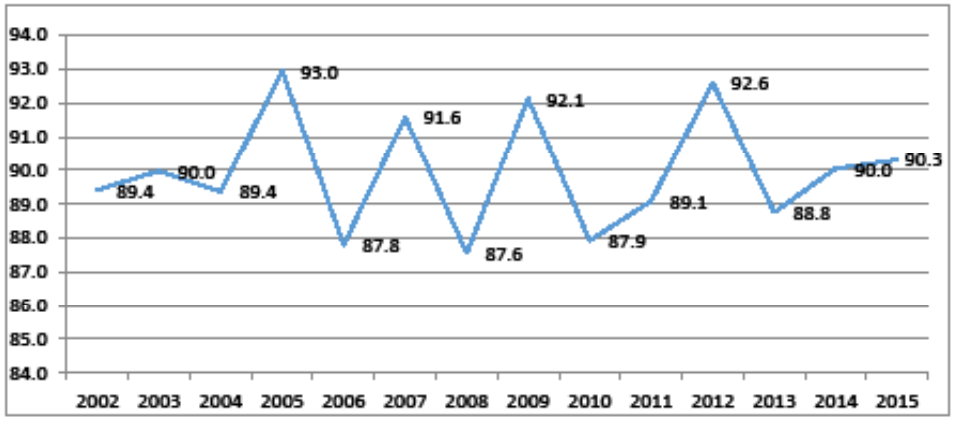

Table 8 shows the average estimated tax efficiencies, tax potential and tax lost due to inefficiency for each of the 15 countries for the period 2001-2015. It is observed that with the exception of Nigeria with a tax efficiency of 67.7%, tax efficiencies were high in the ECOWAS countries, though actual average tax-GDP ratios were low (less than

20%) in all the countries. In addition, the potential non-natural resource tax revenue was higher than the total tax revenue (including natural resource taxes) in most of the countries, the exceptions being Cote d'Ivoire, Mali and Nigeria. These exceptions were due to high natural resource taxes in these countries compared to the others.

Column (7) of Table 8 shows that the loss in non-natural resource tax revenue (% of GDP) due to inefficiencies was generally observed to be low, ranging from 0.9% of GDP in Sierra Leone to 1.8% in Liberia. It was 1.7% in Cabo Verde, Ghana and Guinea Bissau. This reflects the fact that tax inefficiencies were generally below 10%.

Table 8: Average estimated tax efficiencies of ECOWAS countries, tax potential and tax lost due to inefficiency (2001-2015)

(1)	(2)	(3)	(4)	(5)=100-(4)	(6)=(2)/((4)/100)	(7)= (6)-(2)
Country	Non-Natural Resource Tax (% of GDP)	Total Tax Revenue, including Natural Resource taxes (% of GDP)	Estimated Non-Natural Resource Tax Efficiency (% of potential tax revenue)	Non-Natural Resource Tax Inefficiency (% of potential tax revenue)	Potential Non-Natural Resource Tax (% of GDP)	Revenue lost due to inefficiency in non-natural resource tax mobilization (% of GDP)
Benin	15.2	15.2	93.7	6.3	16.2	1.0
Burkina Faso	12.8	12.9	92.3	7.7	13.9	1.1
Cabo Verde	19.6	20.4	92.2	7.8	21.3	1.7
Cote d'Ivoire	15.1	17.9	92.5	7.5	16.3	1.2
Gambia	13.1	13.2	93	7	14.1	1.0
Ghana	15.3	16.7	90	10	17.0	1.7
Guinea	13.9	13.9	93.6	6.4	14.9	1.0
Guinea Bissau	16.6	16.9	90.5	9.5	18.3	1.7
Liberia	15.9	17.1	89.9	10.1	17.7	1.8
Mali	12.7	14.9	91.8	8.2	13.8	1.1
Niger	13.1	14	91.8	8.2	14.3	1.2
Nigeria	2.3	10.6	67.7	32.3	3.4	1.1
Senegal	17.2	18.2	92.4	7.6	18.6	1.4
Sierra Leone	8.8	9.4	90.5	9.5	9.7	0.9
Togo	15.6	15.9	90.9	9.1	17.2	1.6
ECOWAS	13.1	14.5	90.2	9.8	14.5	1.4

5.3 Correlation of Tax Efficiency and Tax Revenue

Table 9 shows the correlation coefficients between tax efficiency (non-natural resource), natural resource tax revenue (% of GDP) and non-natural resource tax revenue (% of GDP). It shows that in countries where natural resource tax revenue is

high, non-natural resource tax efficiency tends to be low, with a correlation coefficient of -0.92, and significant at 1% level. Where non-natural resource tax revenue is high, its tax efficiency tends to be high, with a correlation coefficient of 0.78, and significant at the 1% level. In addition, in countries where natural resource tax revenue is high, non-natural resource tax revenue tends to be low, with a correlation coefficient of -0.71, and significant at the 1% level. While the correlation does not point out causality, and is limited to linear correlation, it suggests that to enhance both the level and efficiency of non-natural resource tax, less emphasis on natural resource tax and more on boosting non-natural resource tax mobilization is preferred for the ECOWAS countries.

Table 9: Correlation coefficients between tax efficiency and types of tax revenue*

Correlation (Probability)	Natural Resource Tax- Revenue	Tax Efficiency	Non-Natural Resource Tax Revenue
Natural Resource Tax Revenue	1.000000		
Non-Natural Resource Tax Efficiency	-0.920649	1.000000	
Non-Natural Resource Tax Revenue	-0.714131 (0.0028)	0.780237 (0.0006)	1.000000

*P-values are in parenthesis.

6.0 CONCLUSION AND POLICY IMPLICATIONS

6.1 Conclusion

Domestic revenue mobilization, in which tax revenue is an important element, is critical to the financing of infrastructure for development and the growing government expenditure of States. In the ECOWAS countries, tax revenue mobilization is a challenge despite the need for infrastructural development and poverty reduction. The study sought to estimate tax efficiencies in ECOWAS member countries. The focus was on non-natural resource tax since it does not depend on export commodity prices, implying that it can be relied upon for long-term planning. In addition, it is predictable and sustainable when its mobilization is well designed.

A Stochastic Frontier tax function for non-natural resource tax was estimated using annual data from 2001 to 2015. The estimation was done in the spirit of the Maximum Likelihood approach in the context of technical efficiency estimation proposed by Aigner, Lovell and Schmidt (1977) and Battese and Coelli (1992) and applied by Fenochietto and Pessino (2013) in the tax literature. The tax efficiencies were then obtained as the ratio of actual tax-GDP ratio to the estimated potential or maximum tax-GDP ratio. This approach is preferred to the average regression in panel and time series regression, which estimates average regression instead of a maximum (frontier) regression and does not allow for strictly positive inefficiency terms.

The results show that there is persistence in mobilization of non-natural resource taxes, and financial deepening, openness to trade and urbanization significantly determine tax revenue in the ECOWAS countries. While openness and financial deepening have positive effects, urbanization has a negative effect. In addition, agricultural share of GDP, inflation and real GDP are insignificant when we account for the impact of lagged dependent variable and other lags, though significant in the static model. The result further shows that the coefficient of the inertia term (lagged tax-GDP ratio) is 0.80, suggesting that a higher (lower) tax GDP ratio has a higher tendency to be replicated in the following year.

Natural resource tax revenue has a positive effect on non-natural resource tax revenue but, after a year, the impact is vitiated, though the overall impact remains positive. This suggests that resources from natural resource taxes do not go much into building non-natural resource tax revenue in ECOWAS on a sustainable basis.

In addition, countries with high natural resource tax revenue tend to be associated with low efficiency on non-natural resource taxes, and high non-natural resource tax countries tend to be associated with higher tax efficiency on non-natural resource tax.

The results of the tax efficiency estimates show that actual tax-GDP ratios for non-natural resource taxes of the ECOWAS countries were more than 90% of their potential during the period 2001 to 2015, with the exception of Nigeria, which was below 70%.

6.2 Policy Implications

As the tax efficiency estimates show that tax efficiencies in the ECOWAS countries are generally above 90%, tax authorities in the ECOWAS member countries should leverage on factors that can shift the tax frontier, thereby having higher tax revenue under the same efficiency. Moreover, because the efficiency figures do not have much disparity, it is important for the authorities to coordinate tax policies in an effort to keep the closeness in tax efficiencies among countries as they work on a strong Free Trade Area and Customs Union, with the ultimate aim of a common market and monetary union.

Because natural resource tax does not have a sustainable impact on non-natural resource taxes, it is useful for the countries to lower the shares of natural resource taxes in total taxes by putting in place more mechanisms to improve on non-natural resource tax collection. This is more important as high natural resource tax tends to be associated with low efficiency on non-natural resource tax. This can be done by giving more weight to policies focused on increasing direct tax revenue (such as business income tax) and domestic indirect taxes (such as the Value Added Tax or the Goods and Services Tax). This is imperative as the African tax structure and performance review also shows that periods and countries with high direct and domestic indirect tax shares led in tax GDP ratios.

Given the positive effects of financial deepening on tax-GDP ratio, further efforts to deepen the financial sector and thus increase monetization and financial inclusion are imperative. Strengthening of trade openness efforts, which include policies that can constrain non-tariff barriers, is also useful as trade openness has a positive effect on tax-GDP ratio. Efforts at decentralization that can reduce urbanization are important in the ECOWAS region, as urbanization has a negative effect on tax revenue.

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APPENDIX

Appendix Table A1: Over-parameterized static model of tax frontier for ECOWAS

Variable	Model 1 (Half Normal Inefficiency)	Model 2 (Exponential Inefficiency)	Model 3 (Truncated Normal Inefficiency)
Ln(M2/GDP)	0.175 (0.000)	0.151 (0.004)	0.151 (0.004)
Ln(OPN)	0.531 (0.000)	0.563 (0.000)	0.563 (0.000)
Ln(NTAXR)	-0.885 (0.616)	-4.302 (0.000)	-4.245 (0.000)
Ln(URB)	-0.162 (0.000)	-0.169 (0.015)	-0.169(0.015)
LnAGDP	0.030 (0.682)	-0.131 (0.010)	-0.131 (0.009)
Ln INF	-0.547 (0.000)	-0.382 (0.151)	-0.383 (0.150)
LnRGDP	0.018 (0.000)	0.015 (0.099)	-0.015 (0.085)
CONSTANT	0.606	1.059 (0.127)	1.059 (0.099)
Other Model Statistics			Mu= -423.243 (0.293)
$LnSigma^2\_V$	-27.003 (0.610)	-4.025 (0.000)	$LnSigma^2 = 4.846$ (0.000)
$LnSigma^2\_U$	-0.793 (0.000)	-2.406 (0.000)	Ilgtgamma = 8.896 (0.000)
Sigma_V	$1.37e^{-06}$	0.132	$Sigma^2 = 127.276$
Sigma_U	0.673	0.300	Gamma = 1.000
$Sigma^2$	0.452	0.108	$Sigma\_U^2 = 127.258$
Lamda	0.491	2.257	$Sigma\_V^2 = 0.017$
LR test for $Sigma^2\_U=0$	21.03 (0.000)	1.0e+02 (0.000)	-8.674(0.000)
Log Likelihood	-79.012	-38.845	-38.893

Appendix Table A2: Over-parameterized dynamic model of tax frontier for ECOWAS

Variable	Model 1 (Half Normal Inefficiency)	Model 2 (Exponential Inefficiency)	Model 3 (Truncated Normal Inefficiency)
$Ln(TAXR)_{t-1}$	0.908 (0.000)	0.880 (0.000)	0.880(0.000)
Ln(M2/GDP)	0.205 (0.000)	0.155 (0.006)	0.155 (0.006)
$Ln(M2/GDP)_{t-1}$	-0.180 (0.007)	-0.105 (0.063)	-0.108(0.063)
Ln(OPN)	0.208 (0.000)	0.165 (0.002)	0.166 (0.002)
$Ln(OPN)_{t-1}$	-0.098 (0.057)	-0.082 (0.085)	-0.082(0.084)
Ln(AGDP)	0.040 (0.637)	-0.062 (0.431)	-0.062(0.432)
$Ln(AGDP)_{t-1}$	0.035 (0.856)	0.063 (0.434)	-0.045(0.831)
Ln(INF)	-0.188 (0.205)	-0.139 (0.274)	-0.139(0.273)
$Ln(INF)_{t-1}$	0.041 (0.282)	0.098 (0.423)	0.098(0.424)
Ln(RGDP)	-0.041(0.834)	0.039 (0.853)	0.039 (0.854)
$Ln(RGDP)_{t-1}$	0.035(0.856)	-0.045 (0.829)	-0.045(0.831)
Ln(NTAXR)	4.706 (0.000)	5.262 (0.000)	5.266 (0.000)
Ln(NTAXR)_1	-3.792 (0.000)	-3.650 (0.000)	-3.659 (0.000)
Ln(URB)	0.176 (0.910)	-0.321 (0.813)	-0.320 (0.814)
$Ln(URB)_{t-1}$	-0.264 (0.863)	0.225(0.857)	0.224(0.867)
CONSTANT	0.373 (0.251)	0.470 (0.098)	0.154 (0.136)
Other Model Statistics			Mu=-138.627 (0.335)
$LnSigma^2\_V$	-4.631 (0.000)	-5.028 (0.000)	$LnSigma^2$ = 2.614 (0.011)
$LnSigma^2\_U$	-4.025 (0.000)	-4.639 (0.000)	Ilgtgamma = 7.642 (0.000)
Sigma_V	0.099	0.081	$Sigma^2$ = 13.660
Sigma_U	0.134	0.098	Gamma = 1.000
$Sigma^2$	0.028	0.016	$Sigma\_U^2$ = 13.654
Lamda	1.354	1.215	$Sigma\_V^2$ = 0.007
LR test for $Sigma^2\_U=0$	1.49 (0.111)	19.62 (0.000)	0.509(0.694)
Log Likelihood	145.627	154.695	154.669

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