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GENDER INCLUSION AND TAX REVENUE MOBILIZATION IN AFRICA : DO ICTS MODERATE THE RELATIONSHIP ?

by

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Abstract:

This study examines the role of information and communication technologies (ICTs) in modulating gender inclusion on tax revenue mobilization in Africa. It focuses on a sample of 42 African countries from 2000 to 2022. Empirical evidence is based on the generalized method of moments. The following findings are established. Strong empirical evidence shows that while the unconditional effects of gender inclusion remain predominantly positive on tax revenue mobilization, those of ICT remain substantially positive. To this end, (i) There are negative net effects of ICT in moderating the impact of gender inclusion on resource and non-resource tax revenues. (ii) There are positive net effects of ICT in moderating the impact of gender inclusion on total and non resource tax revenues in Africa. Thus, threshold analysis through interactions reveals that for an improvement in resource-related tax revenue mobilization, a minimum Internet penetration threshold of 0.33 (as a percentage of total population) is required for female employment (ii) 4 to fixed broadband subscriptions for female unemployment. Consequently, beyond these ICT thresholds, complementary policies are needed to induce the overall positive impact of gender inclusion on tax revenue mobilization in Africa. Policy recommendations are provided at the end.

Keywords: Africa; Gender; ICT; Panel data ; Tax revenues.

Classification JEL: C33, H2, H71, I28, J21, O33 O55.

Introduction

Africa is currently experiencing a critical period in which substantial financial resources have become indispensable. To this end, the UN's Agenda 2030 identifies the financing of policies and strategies that support the Sustainable Development Goals - which essentially aim to end poverty, tackle inequality and address the climate emergency - as a top priority. These many challenges facing the governments of African economies, as they navigate between various socio-economic objectives, have intensified competition for limited resources, thus necessitating the mobilization of additional funds (OECD, 2020) at both national and international levels.

Nevertheless, a limited number of African nations are successfully harnessing their full potential for economic acceleration, as many continue to face challenges related to inadequate financing, hampering their concrete commitments to achieving the Sustainable Development Goals. Given the shortcomings of development aid strategies, there has been significant discourse on the imperative for individual countries to mobilize domestic resources, which is essential to initiate their progress (Baiardi et al., 2019). Furthermore, the emergence of the COVID-19 pandemic, characterized by the volatility of external financing channels, has further underscored the importance of public revenues, intensifying the urgency of this issue (Yao, 2023). Consequently, the effectiveness of the African tax system in generating the resources needed to support vital initiatives aimed at fostering resilient growth trajectories becomes of paramount importance.

Faced with this situation, many African nations have encountered obstacles in recent years or continue to view their respective objectives with discouragement, particularly when their development plans fail to meet their deadlines (Matei and Drumasu, 2015). Multiple elements, such as the granting of substantial concessions, the implementation of a complicated tax system characterized by numerous rates, and deficiencies in tax administration, are frequently cited as fundamentally contributing to delays in achieving incremental steps towards the Sustainable Development Goals. Insufficient tax revenue mobilization has been recognized in the discourse as both a symptom and a factor of underdevelopment (World Bank, 2020). While tax revenues as a proportion of GDP can be as high as 40% in rich, developed countries, much of Africa struggles to generate tax revenues at

this level (World Bank, 2020), hampering efforts to reduce disparities in health, education, opportunity and social protection (OECD, 2020).

Against this backdrop, many economies have implemented tax reforms, achieving promising levels of resource mobilization. Nevertheless, with tax/GDP ratios ranging from 16.3% to 22% (IMF, 2021), most remain below the crucial 20% threshold required to finance the Millennium Development Goals (MDGs). Clearly, one of the factors contributing to these results is the progress of information and communication technologies (ICTs)[1], which have provided varied and extensive means for the dissemination of information via the Internet, telephones and other media needed to achieve these goals (Asongu et al., 2021; Latif et al., 2017). Indeed, although Africa is the continent with the lowest rate of ICT use in the world, the adoption of these technologies has grown rapidly since the late 1990s. By 2018, countries such as Botswana, South Africa and the Seychelles had already surpassed 150 cell phone subscriptions per 100 inhabitants, compared with just 2 per 100 at the turn of the century (World Bank, 2020).

Advances in ICT are thus becoming a crucial instrument for bridging the gap in public revenue mobilization in many nations: For example, e-tax platforms have enabled Rwanda to increase revenue by 18% between 2018 and 2022 (Ndiaye & Shimeles, 2023), while in Kenya, the integration of mobile systems (M-Pesa) has expanded the tax base by 25% by formalizing small businesses (Suri & Jack, 2022). At the same time, the widespread adoption of information and communication technologies (ICTs) over recent decades represents a significant opportunity in African countries for under-represented groups, particularly women, who constitute a substantial economic force.

Given these considerable advantages, recent years have seen notable initiatives aimed at integrating women in Africa, although there remains an opportunity disparity compared to men when it comes to economic involvement (Fabrizio et al., 2020). Legislative changes favoring female entrepreneurship have led to a 7% increase in women's engagement in the formal sector in Sub-Saharan Africa (World Bank, 2020). Consequently, by bringing more

[1] In addition, the emphasis on information and communication technologies stems from their significant proliferation in Africa since 2003 and the dominant discourse suggesting that these technologies can (i) improve the efficiency of revenue collection by reducing the additional cost of tax collection, (ii) reduce corruption and non-compliance in the tax framework, and (iii) enhance the clarity of tax administration.

women into the formal sector, nations broaden their tax base while improving economic productivity (Rogan, 2019). One strategy for achieving this is the widespread adoption of ICT.

Information and communication technologies (ICTs) play a significant role in tax revenue collection in Africa, particularly by enhancing the inclusion of women. As highlighted by Ofori et al (2021) and Asongu et al. (2021), digital tools help increase tax revenues by reducing administrative expenses, curbing tax evasion (OECD, 2020) and broadening the tax base through the formalization of economic activities mainly run by women - an essential strategy given that women account for 58% of the informal workforce in Sub-Saharan Africa (World Bank, 2020). By joining the digital economy, women can find employment, increase their taxable income (Cirera et al., 2016) and gain greater financial independence.

Given the above, this study aims to examine the role of information and communication technologies (ICTs) in modulating gender inclusion on tax revenue mobilization in Africa. Rather surprisingly, there is no comprehensive literature on this particular topic. While the factors influencing public revenue mobilization (Mawejje, 2019) are well documented, as is the effect of ICT on socio-economic outcomes (Avom et al., 2020; Samargandi, 2019; Asongu, 2019), none have yet examined how ICT influences women's economic inclusion to boost public revenues in Africa. The influence of ICT on increasing tax revenues through women's inclusion in Africa remains unclear and raises concerns. On the one hand, ICTs diminish the positive effects of women's inclusion on public revenues, but on the other, they can amplify them if supported by appropriate policies. This complexity raises two key practical questions: (i) Firstly, does ICT diffusion and gender inclusion significantly affect tax revenues in Africa? What are the minimum ICT policy standards needed to encourage the inclusion of women and improve tax revenue collection in Africa?

The rise of information and communication technologies (ICTs) in Africa offers exceptional opportunities to improve fiscal performance through gender mainstreaming. In this respect, the contributions of this research are threefold. Firstly, this study has identified a dearth of work examining the role of ICT in modulating gender inclusion on tax revenue mobilization in Africa. Consequently, this work enriches the scientific discourse on the externalities of ICTs on tax revenue mobilization in enhancing women's economic inclusion in Africa. Second, unlike other studies that mainly use a limited set of tax revenue mobilization variables, our measures

are comprehensive, as we use several recent indicators associated with tax revenue mobilization, including total tax revenue, resource-related tax revenue and non-resource tax revenue. Furthermore, the diversity of indicators relating to ICT and women's inclusion offers the advantage of producing compelling results, leading to widely applicable conclusions and presenting strong evidence of the nature of this link. Finally, this study offers a comprehensive policy framework, demonstrating, using current data, how African governments can develop gender-inclusive digital strategies to improve tax revenue mobilization. Understanding how these factors influence public revenue collection can contribute significantly to the development and implementation of regional policies in line with Agenda 2063 and the UN Sustainable Development Goals.

The rest of the article is structured as follows. Section 2 reviews the relevant theoretical foundations and empirical studies. Section 3 discusses the estimation techniques and their foundations, including variables and data sources. Section 4 explains the results and provides an analysis. Section 5 concludes with an articulation of the implications and suggestions for prospective research trajectories.

1 Theoretical foundations and empirical review

This section is structured around two angles : first, to set the theoretical stage, and then to systematically review the existing empirical literature.

1.1 Theoretical highlights and insights

The theoretical foundation consolidating the link between information and communication technologies (ICTs), the inclusion of women on tax revenue mobilization rests fundamentally on the central role of knowledge diffusion in socio-economic progress (Kwan and Chiu, 2015). Essentially, neoclassicals support the idea that ICTs are essential to the political, economic and social progress of nations, particularly when they are in the early stages of industrialization (Abramowitz, 1986).

Recent studies using neoclassical theoretical frameworks to highlight the importance of information and communication technologies (ICTs) in development include Bongomin et al. (2018) and Muthinja and Chipeta (2018). The theoretical literature supports the idea that ICTs

offer development opportunities due to several factors : (i) they take advantage of networks that minimize distances between economic agents and entrepreneurs who might otherwise need to travel physically (Efobi et al., 2018). (ii) ICTs also reduce the information asymmetry associated with economic activities.

The integration of women into the economic framework through information and communication technologies (ICT) holds great potential for expanding the productive base. Suri and Jack's (2022) work on mobile banking in Kenya has definitively demonstrated that the financial empowerment of women through ICT results in a marked improvement in their productivity and earning power. This phenomenon can be explained by several mechanisms: improved market access, reduced information asymmetries and the ability to bypass traditional structural barriers. This theoretical perspective aligns with that of Efobi et al. (2018), who identified that ICT increases women's participation in the economy. Consequently, the logic of conducting this study focuses on the impacts of ICTs on modulating the influence of women's integration into the economic sphere on tax revenue generation. The interactive analytical model thus proposes that a certain threshold of ICT adoption is required for ICT to effectively amplify the positive effects of women's current degree of economic inclusion on tax revenues. Engaging more women in formal economic activities through ICT clearly suggests an increase in tax revenues.

1.2 Empirical review

A review of the empirical literature highlights the main results observed in the relationship between ICTs and tax revenue mobilization, on the one hand, and ICTs and the inclusion of women, on the other.

The literature indicates that numerous studies have explored the direct and indirect impacts of ICT on tax revenue mobilization in developing countries. For example, using an unbalanced panel of 157 countries over the period 1998-2013, Koyuncu et al. (2016) present compelling evidence that ICT penetration improves tax revenue mobilization. Specifically, the results highlight that of the four ICT penetration indicators (mobile subscriptions, Internet access, personal computers and fixed broadband subscriptions), fixed broadband subscriptions contribute significantly to three distinct measures of tax revenue : overall tax revenue, VAT and corporate income tax. In an analysis of sub-Saharan Africa, Ofori et al. (2021) explored the

independent and combined effects of ICT and industrialization on government revenues. The empirical analysis, framed by GMM methodology, revealed that ICT plays a vital role in the generation of all the tax categories tested in the analysis. Asongu et al. (2021) reported similar results for sub-Saharan Africa. At the firm level, Ali et al. (2017) examined the impact of using electronic sales records (ESRMs) on Ethiopia's fiscal capacity and the subsequent effect on VAT. The authors found that the implementation of the devices led to a considerable increase in the country's VAT revenues.

In addition, many researchers emphasize that information and communication technologies (ICTs) promote the integration of women. In particular, ICT is key to facilitating women's economic participation. A study by Asongu and Odhiambo (2019) assessed the influence of ICT on women's economic engagement in sub-Saharan African countries. Using the Generalized Method of Moments (GMM) on panel data encompassing 49 countries from 2004 to 2018, the researchers found that an increase in ICT adoption, particularly through fixed broadband subscriptions, positively affects women's employment levels. They identified the ICT penetration thresholds needed to optimize these results, such as an Internet penetration rate of 31.966 per 100 people in higher education institutions. In addition, a qualitative survey conducted by Malanga and Banda (2021) in Malawi revealed that the use of ICTs by women's microenterprises improves access to information, diversifies business opportunities and strengthens communication, thus contributing to women's economic empowerment. These studies imply that the increased adoption and use of ICTs by women can lead to greater formalization of their economic activities, thereby broadening the tax base.

Based on the above, numerous studies have demonstrated the positive influence of information and communication technologies (ICTs) on revenue mobilization. However, to our knowledge, no research has explored in depth the role of ICT in relation to the effect of gender inclusion on tax revenue mobilization in Africa. This study therefore advances the existing literature and fills this vital gap, proposing several relevant policy implications.

2 Methodology

The methodology adopted for this study is presented in this section. A first sub-section is devoted to the development of the estimation technique and another sub-section to the data used.

2.1 Estimation techniques

This study uses panel data estimation techniques to investigate the influence of ICT on the effect of gender inclusion on tax revenue mobilization in African nations from 2000 to 2022. Drawing on the current empirical literature (Asongu, 2019; Asongu, Adegboye and Nnanna, 2021), several main reasons justify the choice of the GMM estimator in the literature: (i) the number of cross-sectional units (N) must be greater than the number of corresponding time periods. Given that this research covers 42 African countries over a twenty-year period (2000-2022), the requirement for GMM estimation when N>T is met. (ii) Endogeneity is addressed, as it is managed from two main points of view. On the one hand, reverse causality is controlled by the use of internal instruments. On the other hand, unobserved heterogeneity is managed by considering time-invariant omitted variables in the estimation process.

In line with the recent literature (Avom et al., 2020; Asongu, 2019) on tax revenue mobilization, our empirical strategy involves the use of two-stage GMMs with forward orthogonal deviations rather than differentiation. This method extends the work of Arellano and Bover (1995) to Roodman (2009a, 2009b) and has the advantage of accounting for cross-sectional dependence and reducing instrument proliferation (Baltagi, 2008). Based on the literature review (Avom et al., 2020; Samargandi, 2019; Asongu, 2019), the following equations, in levels (1) and first differences (2), define the GMM estimation procedure for the system established :

$$Tax_{i,t} = \alpha_0 + \alpha_1 Tax_{i,t-\tau} + \sum_{j=1}^{3} \alpha_j Fe_{j,i,t-\tau} + \sum_{k=1}^{3} \alpha_k ICT_{k,i,t-\tau} + \sum_{l=1}^{3} \alpha_l X_{l,i,t-\tau} + \sum_{h=1}^{4} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_i + \varepsilon_i \quad (1)$$

$$\begin{aligned} Tax_{i,t} - Tax_{i,t-\tau} &= \alpha_0 + \alpha_1 (Tax_{i,t-\tau} - Tax_{i,t-2\tau}) + \sum_{j=1}^{3} \alpha_j (Fe_{j,i,t-\tau} - Fe_{j,i,t-2\tau}) \\ &+ \sum_{k=1}^{3} \alpha_j (ICT_{k,i,t-\tau} - ICT_{k,i,t-2\tau}) + \sum_{l=1}^{3} \alpha_j (X_{l,i,t-\tau} - X_{l,i,t-2\tau}) + \sum_{h=1}^{4} \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + \eta_i + \xi_t + \varepsilon_i \end{aligned} \quad (2)$$

Where $Tax_{i,t}$ trepresents the tax revenue mobilization indicators (corresponding to total tax revenue, resource-related tax revenue and non-resource tax revenue) for country i in period t. ICT represents the various ICT measures (i.e. cell phone penetration, Internet penetration and fixed broadband subscriptions) of country i at period t. Fe represents the measures of gender inclusion (i.e. female labor force participation, female unemployment and female employment), X denotes the interactions between the ICT indicators and the different measures of gender inclusion.W is the vector of the control variables (GDP per capita growth, Foreign Direct Investment and trade openness and government efficiency). Finally, η_i is the country-specific effect ; ξ_t is the time fixed effect and i ε is the idiosyncratic error term.

2.2 Data and variable justification

Using balanced panel methods, the study examines data spanning 22 years, from 2000 to 2022, and covering 42 African countries. The range is dictated by data accessibility, with a particular focus on the institutional factor of government efficiency. Three main tax revenue indicators[2] are used : (i) overall tax revenue, (ii) reported tax revenue from natural resources, and (iii) total non-resource tax revenue. These indicators align with recent literature on tax issues (Gamze, 2019 ; Mawejje, 2019).

In addition, the gender inclusion variables are women's participation in the labor market, women's unemployment and women's employment. Similarly, three ICT measures are used : cell phone coverage, internet access and fixed broadband subscriptions. These ICT measures are in line with recent research, which supports the inclusion of various ICT indicators in empirical studies to broaden the potential for policy implications (Efobi et al., 2018 ; Asongu, Amankwah-Amoah, Nting and Afrifa, 2019).

Other macroeconomic factors were recognized as determinants of tax revenues and were included to minimize errors due to omitted variable bias. Specifically, four control variables are incorporated such as economic growth, foreign direct investment (FDI), trade openness

[2] Several research studies have mobilized institutional databases to assess tax revenues (Ofori et al., 2021), but these approaches have generated methodological inconsistencies and divergent results in the scientific literature, which tends to complicate comparison and replication (Mawejje, 2019). The problems associated with current data are widely recognized.

and government efficiency. We expect these controls to have an impact on fiscal outcomes in Africa.

Opinions are divided in the literature regarding the role of FDI in increasing tax revenues in developing regions (Hunady and Orviska, 2014). Some studies indicate that FDI enhances tax revenue efforts (Ahmed and Muhammad 2010 ; Agbeyegbe et al., 2006), while others highlight a diminishing impact due to tax deductions and offshoring strategies (Zucman, 2015). Furthermore, we find that GDP per capita, a sign of economic progress, has a positive impact on tax outcomes (Ofori et al., 2021). In fact, an increase in disposable income generally strengthens tax collection capacity and citizens' ability to pay taxes. As Elgin (2013) suggests, rising income levels encourage tax collection. Similarly, Alcalá and Ciccone (2004) identified a positive relationship between trade openness on tax efforts ; consequently, more open economies are linked to higher productivity levels. This leads to a predictably positive link between trade openness and tax revenue mobilization. Finally, it is essential to capture the essence of economic governance, not only to establish favorable conditions for private sector growth, but also to encourage voluntary tax compliance, economic growth and employment (Kaufmann and Kraay, 2017). Consequently, government effectiveness can be positively linked to tax revenue mobilization.

In addition, gender data is provided by the International Labour Organization (ILO). In addition to tax revenue data collected from the United Nations University World Institute for Development Economics Research (UNU-WIDER)/Government Revenue Dataset 2020 of the International Centre for Tax and Development (ICFTD), all other control and ICT variables were taken from the World Development Indicators (WDI, 2021). Variable definitions and sources are detailed in Appendix Table A1, while the list of countries is shown in Table A2.

2.2.1 Analysis of descriptive statistics

Table 1 below presents some descriptive statistics for the model variables, in order to give a general view of the data set. The results presented in Table 1 show that all series (except government efficiency) have positive mean values, implying that most series have an upward trend. Table 1 shows that total tax revenue averaged 13.8% for African countries over the period studied. This average share is below the minimum of 20% recommended by the World Bank. Also, non-resource and resource-related tax revenues have respective averages of 1.1%

and 11.9%, which is moderately low. This suggests that Africa's performance in terms of tax revenue mobilization is still very weak. Similarly, while we find an average value of 58.459% for women's participation in the labor market, those for the female unemployment ratio and the female employment ratio are 8.67% and 2.011% respectively. Table 1 also shows that the average proportion of individuals using the Internet (as a percentage of the total population) is 13.15%. Cell phone subscriptions (per 100 people) average 52.98%, and fixed broadband subscriptions (per 100 people) average 46.50%. In addition, the average government effectiveness score is -0.7, meaning that institutional quality is low in Africa.

Table 1. Descriptive statistics

Variable	Sign	Obser	Mean	Std. Dev.	Min	Max
Total taxes revenue	Tt	877	0.138	0.080	0.006	0.609
Non resource taxes	Nrt	776	0.011	0.044	0	0.392
Resources taxe	Rt	804	0.119	0.067	0.005	0.609
Female labor force participation	Flfp	943	58.459	15.947	14.451	87.825
Female unemployment	Fu	943	8.676	7.999	0.216	36.263
Female employment to population ratio	Fe	920	2.011	2.170	0.044	10.056
Mobile phone penetration	Mpp	951	52.980	44.248	0	191.51
Internet penetration	Ip	937	13.159	17.305	0.006	87.3
Fixed Broadband	Fbs	710	1.079	3.583	0	33.565
Foreign direct investments	Fdi	963	4.479	7.990	-17.292	103.337
GDP per capita growth	Gdp	966	1.607	4.412	-36.824	27.807
Government effectiveness	Ge	923	-0.728	0.611	-1.881	1.150

Source: authors

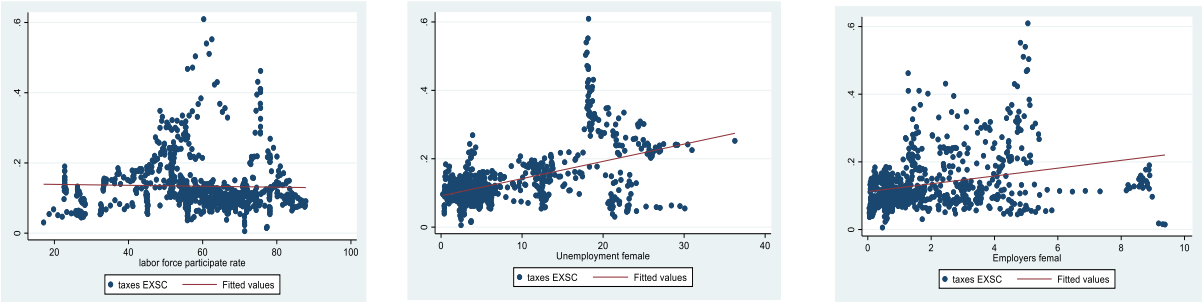
2.2.2 Correlation analysis

Table A2 in the Appendix presents the results of the correlation matrix in order to mitigate potential problems of multicollinearity. Tax revenues are negatively correlated with women's labor force participation (but statistically insignificant). On the other hand, a possibility of multicollinearity is observed between the different measures of tax revenue, which is due to the fact that the measures give very similar estimates.

The assumptions discussed are consistent with the stylized facts about the links between gender inclusion and tax revenues. Figure 1, below, illustrates the relationship between gender inclusion and total tax revenues. On the figure, from left to right are respectively the links between: (i) women's labor force participation rate and total tax revenues; (ii) women's unemployment and total tax revenues (iii) women's employment and total tax revenues. The

attached graphs show that gender inclusion is negatively associated with women's labor force participation rates (i.e. first graph) and positively related to women's unemployment and employment (i.e. second and third graphs).

Figure 1: Relationship between the inclusion of women and tax revenue mobilization in Africa (2000-2022)



Source : Authors

3 Results and Discussion

The results obtained with the baseline model are first reported and discussed before the threshold analysis is presented.

3.1 Presentation of the main results

This section examines the results presented in Tables 2 to 4. Each table is structured such that the first row lists the dependent variables, the second provides an overview of the ICT-related factors examined, and the third presents the associated gender inclusion factors. Table 2 illustrates the relationship between ICT, gender inclusion, and tax revenue mobilization. Table 3 explores the link between ICT, gender inclusion, and resource-based tax revenue mobilization, while Table 4 presents the results for ICT, gender inclusion, and non-resource tax revenue. The arrangement of the results in the tables includes three types of analysis for each aspect of ICT. These analyses focus on mobile phone use, internet access, and fixed broadband connections. For each aspect of ICT, the analysis is broken down into three different specifications, each focusing on one of the main factors of women's inclusion : women's labor market participation, women's unemployment, and women's employment.

Before delving into the explanation of the empirical results of this study, it is essential to emphasize that all specifications are relevant to validate the results and draw conclusions.

First, it is essential that the Arellano and Bond second-order autocorrelation test (AR 2) in difference, which checks whether the model has no autocorrelation in the residuals, is not rejected. Second, this research specifically emphasizes the validity of the Hansen test over the Sargan test, as the former is more reliable, although it may face problems related to too many instruments.

Therefore, there is strong evidence for the validity of the instruments used for estimation, since not all Hansen p-values are statistically significant. Third, the instrument exogeneity test, which uses the Hansen difference test (DHT), is also applied to assess the validity of the Hansen test results. Furthermore, it is essential to mention that to maintain the persistence of the model, the results of the GMM estimator in Tables 3 to 5 indicate that the coefficients of the lagged variables (adjustment coefficient) are positive and statistically significant. This satisfies the convergence criterion and suggests that the lagged period of total tax revenues and its components has a positive and notable impact on their current values at the 1% level.

Regarding the initial hypothesis of the article, Tables 3 to 5 provide compelling evidence indicating that information and communication technologies (ICTs) and gender inclusion are significant determinants influencing tax revenue mobilization in Africa. First, Table 3 shows that the coefficients of female labor force participation remain positive and statistically significant with respect to total tax revenue, in the context of mobile phone penetration and fixed broadband internet subscriptions. This suggests that an increase in female labor force participation directly boosts total tax revenue in Africa. This is because the inclusion of women improves their productivity and access to various goods and services, which increases the state's capacity to raise resources through taxes (Taiwo, 2018). These results are further supported by positive and statistically significant coefficients for the unemployment rate (columns 5 and 8) in relation to the mobilization of total tax revenue through variables such as internet penetration and fixed broadband subscriptions.

Table 2. ICT, Female economic inclusion and total taxes

	Dependent variable: total taxes (Tt)								
	Mobile phone penetration			**Internet penetration**			**Fixed Broadband subscriptions**		
Variables	Flfp	Fu	Fe	Flfp	Fu	Fe	Flfp	Fu	Fe
Ttr (-1)	0.7425***	0.652***	0.569***	0.753***	0.627***	0.612***	0.473***	0.503***	0.563***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mpp	0.0002	-0.00001	-0.00004						
	(0.255)	(0.822)	(0.378)						
Ip				0.001***	0.0001	-0.0001			
				(0.002)	(0.466)	(0.289)			
Fbs							0.0001	-0.0005	-0.002**
							(0.989)	(0.734)	(0.037)
Flps	0.0004*			0.0002			0.0014**		
	(0.054)			(0.347)			(0.020)		
Fu		0.00001			0.0011***			0.002***	
		(0.986)			(0.008)			(0.000)	
Fe			0.00057			-0.0004			0.0043*
			(0.697)			(0.841)			(0.020)
Mob*Flfp	0.000002			-0.000***			0.000003		
	(0.483)			(0.007)			(0.975)		
Mob*Fu		0.00001*			0.00001			-0.0001	
		(0.061)			(0.222)			(0.706)	
Mob*Fe			0.0001***			0.0002**			0.0003
			(0.000)			(0.004)			(0.619)
Fdi	-0.0005	-0.001***	-0.0006*	-0.002***	-0.002***	-0.001***	-0.002***	-0.0008*	-0.001***
	(0.112)	(0.007)	(0.073)	(0.000)	(0.000)	(0.000)	(0.000)	(0.026)	(0.003)
Gdp	0.0001	0.0004	-0.000	0.003***	0.002***	0.0001	0.0008*	0.0001	-0.001
	(0.781)	(0.380)	(0.867)	(0.000)	(0.000)	(0.609)	(0.020)	(0.880)	(0.195)
Open	0.001***	0.001***	0.0004*	0.0004*	0.001*	0.001***	0.001*	0.001***	0.001***
	(0.004)	(0.002)	(0.014)	(0.017)	(0.015)	(0.005)	(0.074)	(0.002)	(0.000)
Ge	0.0013	0.011*	0.0127***	0.0046	0.006**	0.009***	0.0235*	0.0118**	0.0196***
	(0.818)	(0.011)	(0.002)	(0.288)	(0.037)	(0.003)	(0.076)	(0.021)	(0.000)
Constant	-0.028*	0.017	0.037***	-0.0002	0.0138	0.028***	-0.014	0.036***	0.040***
	(0.066)	(0.201)	(0.000)	(0.987)	(0.116)	(0.002)	(0.721)	(0.001)	(0.000)
AR (1)	(0.028)	(0.023)	(0.048)	(0.008)	(0.015)	(0.038)	(0.062)	(0.045)	(0.047)
AR (2)	(0.215)	(0.216)	(0.256)	(0.155)	0.136	(0.289)	(0.329)	(0.292)	(0.333)
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	(0.723)	(0.943)	(0.940)	(0.588)	(0.818)	(0.362)	(0.436	(0.733)	(0.580)
DHT for instruments (a) instruments in levels H exclusing group	(0.703)	(0.875)	(0.852)	(0.693)	(0.493)	(0.772)	(0.367)	(0.633)	(0.774)
Dif(null, H=exogenous)	(0.554)	(0.817)	(0.833)	(0.379)	(0.903)	(0.132)	(0.461)	(0.639)	(0.309)
Instruments	23	23	23	23	23	23	23	23	23
Countries	42	42	42	42	42	42	42	42	42
Observations	679	679	659	670	670	650	548	548	528

Note :***,**,*: significance levels at 1%, 5% and 10% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. Dif: Difference. The failure to reject the null hypotheses of: a) no autocorrelation in the AR(2) tests and; b) the validity of the instruments in the Sargan and Hansen OIR tests.

Table 3. ICT, Female economic inclusion and resource taxes

	Dependent variable: Resource taxes (Rt)								
	Mobile phone penetration			**Internet penetration**			**Fixed Broadband subscriptions**		
Variables	Flfp	Fu	Fe	Flfp	Fu	Fe	Flfp	Fu	Fe
Nrt (-1)	0.698***	0.731***	0.736***	0.701***	0.7171***	0.764***	1.019***	0.999***	1.014***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mpp	-0.0001	-0.000001	0.00001						
	(0.457)	(0.940)	(0.312)						
Ip				0.0001	-0.00004	-0.0001**			
				(0.773)	(0.376)	(0.024)			
Fbs							-0.0002	0.002***	0.0006***
							(0.767)	(0.003)	(0.005)
Flps	0.00009			0.0002			0.00004		
	(0.619			(0.118)			(0.734)		
Fu		0.000002			0.000001			0.0008	
		(0.986)			(0.990)			(0.000)	
Fe			0.0003			0.00001*			0.0013
			(0.572)			(0.040)			(0.036)
Mob*Flfp	0.000002			-0.000001			0.000007		
	(0.376)			(0.739)			(0.691)		
Mob*Fu		-0.000001			-0.000001			-0.0002**	
		(0.512)			(0.895)			(0.017)	
Mob*Fe			-0.00001			0.00003*			-0.0003**
			(0.498)			(0.040)			(0.029)
Constant	-0.021	-0.01***	-0.011***	-0.02*	-0.005	0.001	-0.008	-0.02***	-0.001
	(0.163)	(0.001)	(0.000)	(0.073)	(0.161)	(0.730)	(0.581)	(0.007)	(0.780)
AR (1)	(0.088)	(0.105)	(0.144)	(0.118)	(0.098)	(0.144)	(0.257)	(0.242)	(0.236)
AR (2)	(0.203)	(0.211)	(0.274)	(0.294)	(0.237)	(0.337)	(0.226)	(0.231)	(0.204)
Sargan OIR	(0.482)	(0.078)	(0.196)	(0.167)	(0.041)	(0.043)	(0.089)	(0.177)	(0.074)
Hansen OIR	(0.966)	(0.546)	(0.894)	(0.844)	(0.613)	(0.603)	(0.754)	(0.535)	(0.664)
DHT for instruments (a) instruments in levels H exclusing group	(0.843)	(0.684)	(0.785)	(0.744)	(0.506)	(0.590)	(0.654)	(0.504)	(0.533)
Dif(null, H=exogenous)	(0.921)	(0.337)	(0.785)	(0.722)	(0.585)	(0.487)	(0.644)	(0.474)	(0.633)
Instruments	23	23	23	23	23	23	23	23	23
Countries	42	42	42	42	42	42	42	42	42
Observations	590	590	570	578	578	558	461	461	441

Note :***,**,*: significance levels at 1%, 5% and 10% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. Dif: Difference. The failure to reject the null hypotheses of: a) no autocorrelation in the AR(2) tests and; b) the validity of the instruments in the Sargan and Hansen OIR tests.

Table 4. ICT, Female economic inclusion and non-resource taxes

	Dependent variable: Non- Resources taxes (Nrt)								
	Mobile phone penetration			**Internet penetration**			**Fixed Broadband subscriptions**		
Variables	Flfp	Fu	Fe	Flfp	Fu	Fe	Flfp	Fu	Fe
Rt (-1)	0.819***	0.780***	0.758***	0.785***	0.719***	0.679***	0.777***	0.573***	0.568***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mpp	0.0003	0.00002	0.0001*						
	(0.170)	(0.682)	(0.091)						
Ip				0.0003	0.0002	0.0003*			
				(0.245)	(0.185)	(0.016)			
Fbs							-0.002	0.01***	-0.0004
							(0.760)	(0.000)	(0.419)
Flps	0.001**			0.0002			0.002**		
	(0.017)			(0.238)			(0.012)		
Fu		-0.001			-0.0004			0.0008	
		(0.239)			(0.336)			(0.125)	
Fe			0.0028			0.007***			0.008***
			(0.162)			(0.003)			(0.000)
Mob*Flfp	-0.00001			-0.00001			-0.000001		
	(0.200)			(0.357)			(0.994)		
Mob*Fu		-0.000003			-0.00001			-0.001***	
		(0.489)			(0.263)			(0.000)	
Mob*Fe			-0.00003			-0.001***			-0.001**
			(0.194)			(0.002)			(0.010)
Constant	-0.039	0.377	0.0129	-0.004	0.019**	0.019***	-0.1457***	0.0086	0.042**
	(0.049)	(0.756)	(0.108)	(0.814)	(0.044)	(0.001)	(0.001)	(0.636)	(0.001)
AR (1)	(0.032)	(0.035)	(0.028)	(0.036)	(0.047)	(0.029)	(0.010)	(0.006)	(0.041)
AR (2)	(0.331)	(0.316)	(0.377)	(0.386)	(0.380)	(0.387)	(0.211)	(0.307)	(0.345)
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	(0.609)	(0.443)	(0.562)	(0.647)	(0.648)	(0.365)	(0.803)	(0.398)	(0.655)
DHT for instruments (a) instruments in levels H exclusing group	(0.898)	(0.933)	(0.667)	(0.524)	(0.663)	(0.433)	(0.597)	(0.676)	(0.600)
Dif(null, H=exogenous)	(0.245)	(0.112)	(0.369)	(0.616)	(0.483)	(0.313)	(0.774)	(0.197)	(0.551)
Instruments	23	23	23	23	23	23	23	23	23
Countries	42	42	42	42	42	42	42	42	42
Observations	616	616	596	606	606	586	485	485	465

Note : ***,**,* significance levels at 1%, 5% and 10% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. The failure to reject the null hypotheses of: a) no autocorrelation in the AR(2) tests and; b) the validity of the instruments in the Sargan and Hansen OIR tests.

In Table 4, the coefficients for female employment remain positive and statistically significant with respect to resource-based tax revenue, particularly under conditions of internet penetration (column 6) and fixed broadband subscriptions (column 9). This indicates that increasing female employment directly increases resource-based tax revenue in Africa.

Interestingly, contrary to expectations, the coefficient on female unemployment remains positive and statistically significant for resource-based tax revenues. Similar trends are observed for the coefficients on female employment for resource-based tax revenues in the case of the specification based on internet penetration (column 6) and fixed broadband internet subscriptions (column 9). Furthermore, the results presented in Table 5 show positive and statistically significant coefficients of female labor force participation (column 7), female employment (column 8), and female unemployment (column 9) on non-resource-based tax revenues in the specification based on fixed broadband subscriptions. These results are also consistent with (i) the specification of mobile phone penetration, where the coefficient on female labor force participation is positive and statistically significant with respect to non-resource tax revenues, and (ii) the specification of internet penetration, where the coefficient on female employment is positive and statistically significant with respect to non-resource tax revenues.

Indeed, convincing evidence highlighting the overall impact of different ICT measures on total tax revenue mobilization and its various components is verified. According to Table 3, internet penetration (column 4) generally improves total tax revenue, while Table 4 indicates that fixed broadband internet subscriptions (columns 8 and 9) have positive and significant coefficients on resource-based tax revenue. Furthermore, Table 5 reveals that mobile phone usage, internet access, and fixed broadband internet subscriptions have positive and significant coefficients on non-resource-based tax revenue. Therefore, ICT increases tax revenue by broadening the tax base through job creation and improving productivity through innovation. ICT could increase taxable income and profits within the economy, thereby increasing the amount of tax revenue collected (Olamide et al., 2022). An intriguing and paradoxical observation is the recurring presence of negative and statistically significant coefficients between fixed broadband Internet subscriptions and total tax revenue (Table 3), and Internet penetration (column 6) on resource tax revenue (Table 4). One possible explanation for this result is that more frequent Internet use or the growing number of fixed Internet subscriptions facilitates online transactions, which could help firms and households evade taxes (Goolsbee, 2001). This hypothesis is consistent with that of Elgin (2013), who pointed out that in developing countries, the Internet is not a magic solution to reduce the underground economy.

To assess the overall effect of ICTs in moderating the impact of gender inclusion on tax revenue mobilization, this study calculates the net effects following recent research, using interactive regressions (Asongu and Odhiambo, 2019). In Table 2, the net impact of fixed broadband internet subscriptions (column 6) in moderating the effect of women participating in the labor force on total tax revenue mobilization is 0.00033 = ([0.0003 × 1.079] + [0.00001]). Here, the average value for fixed broadband internet subscriptions is 1.709; the unconditional impact of female labor force participation is 0.00001, while the interactive effect between fixed broadband internet subscriptions and female labor force participation is 0.00033.

Table 3 reveals a net positive effect of internet access in moderating the impact of female employment (column 6) on total tax revenue mobilization. Moreover, the same Table 3 indicates net positive effects of mobile phone access both in moderating the impact of female unemployment (column 2) on total tax revenue mobilization and for the impact of female employment (column 3) on tax revenue. Meanwhile, Table 4 highlights the net positive impacts of internet access in moderating the impact of female employment (column 6) on resource-specific tax revenue mobilization. It is important to note that, in Table 4, the net effects of broadband internet subscriptions in modulating female unemployment and female labor force participation with respect to resource-based tax revenue mobilization are systematically negative.

In Table 5, there are significant net negative impacts on non-resource tax revenue mobilization, particularly with respect to: (i) the role of internet penetration in moderating female employment (column 6) on non-resource tax revenue and (ii) the importance of broadband internet subscriptions on the role of female unemployment (column 8) on non-resource tax revenue mobilization, and also in moderating the effect of female employment (column 9) on non-resource tax revenue collection. These conditional or interactive effects suggest that employed women in Africa are often found in informal jobs, where technology helps to evade taxes instead of promoting inclusion, by serving mainly female users engaged in informal transactions.

Our strong empirical evidence suggests that while gender inclusion promotes tax revenue mobilization in Africa, there are additional benefits or disadvantages when ICTs are taken into account. Finally, regarding the control variables, the results are consistent with expectations.

3.2 Discussions on threshold effects

The threshold concept aligns with current development studies that involve interactive regressions (Asongu, 2019 ; Batuo, 2015). In this context, Table 5 shows that the positive threshold is 33.33 with respect to internet usage (0.001/0.00003). At this level of internet penetration, its net impact on resource-based tax revenue becomes neutral ([0.00003 × 33.33] + [-0.001]). Beyond this threshold, increasing internet access modulates women's employment in such a way that it has a positive effect on resource-based tax revenue mobilization. Furthermore, for this threshold to be economically and politically viable, it must fall within the statistical interval (minimum to maximum) presented in the summary statistics. This target is realistic, given that the minimum and maximum recorded internet penetration rates are 0.006 and 87.3 respectively. It is therefore crucial to push ICT growth beyond these established levels so that the inherent benefits of internet use on gender inclusion can be harnessed, which would ultimately produce a net positive effect on tax revenue mobilization. Similarly, Table 5 highlights negative thresholds for resource-based tax revenue mobilization : (i) 4 for broadband internet connections and those for female unemployment ; (ii) 4.33 for broadband connections and those for female employment. In addition, Table 6 reveals negative thresholds on non-resource tax revenue mobilization : (i) 7 for internet access and those for female employment ; (ii) 8 for fixed broadband connections, and those for female employment and female unemployment. These information and communication technology (ICT) thresholds for non-resource tax revenue are both economically sound and politically important, as they align with statistical trends in ICT developments. These findings therefore indicate that increased use of fixed broadband internet makes it easier for women in the informal sector to conduct online transactions, which could lead to increased tax evasion rather than improved inclusion (Goolsbee, 2001). The positive outlook for ICTs stems from the idea that their influence varies depending on the measures used. In regions such as Africa, where women are the majority in informal sectors and institutions tend to be fragile, the expansion of ICTs could play a role in improving or hindering tax revenue mobilization through gender inclusion.

4 Conclusion

This study examines the role of information and communication technologies (ICTs) in modulating gender inclusion in tax revenue mobilization in a panel of 42 African countries over the period 2000-2022. The study uses three ICT indicators : cell phone use, internet access and fixed broadband subscriptions. Gender inclusion is measured by women's labor force participation, unemployment rates and employment levels, while tax revenues are assessed through total tax revenues, resource-based revenues and non-resource-based revenues. The Generalized Method of Moments (GMM) was used for the analysis.

The following findings are established. Strong empirical evidence shows that while the unconditional effects of gender inclusion remain predominantly positive on tax revenue mobilization, those of ICT remain substantially positive. To this end, with regard to interactions (i) There are negative net effects of ICT in moderating the impact of gender inclusion on resource and non-resource tax revenues. (ii) There are positive net effects of ICT in moderating the impact of gender inclusion on total and non-resource tax revenues in Africa. Thus, threshold analysis through interactions reveals that for an improvement in resource-related tax revenue mobilization, a minimum Internet penetration threshold of 0.33 (as a percentage of total population) is required for female employment (ii) 4 to fixed broadband subscriptions for female unemployment.

The results underline the need for proactive policies to improve Africa's digital infrastructure. Investments should aim to reach the 0.33% internet penetration threshold, which is essential to maximize the impact of women's employment on resource-related tax revenues. Simultaneously, governments should strive to increase fixed broadband subscriptions to 4% to counter the negative effects of female unemployment. Public-private partnerships could facilitate the achievement of these objectives, by offering tax incentives to telecoms operators in underserved areas, particularly those with a high concentration of working women . Training programs focusing on digital skills for women could boost their productivity and tax contributions. On the tax front, incentives such as tax credits for companies that employ a large number of women could be beneficial. In addition, simplifying the formalization process for women's micro-enterprises could help overcome administrative obstacles. Successful policy implementation requires a solid institutional framework.

Future research should use appropriate estimation techniques to verify the robustness of these findings in different national contexts.

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Annexes

Table A1. Définitions and sources of variables

Variables	Definition	Sources
Tax	The total taxes revenue excluding social contributions	GRD
Tax resource	Component of reported tax revenue (i.e. from natural resource sources, most often corporate taxation of resource firms)	GRD
Non resource	Total non-resource taxes (i.e total taxes resource minus resource taxes)	GRD
Female Economic Participation	Labor force participation rate, female (% of female population ages 15+) (modeled ILO estimate)	ILO
	Unemployment, female (% of female labor force) (modeled ILO estimate)	ILO
	Employment to population ratio, 15+, female (%) (modeled ILO estimate)	ILO
Mobile Phones	Mobile cellular subscriptions (per 100 people)	WDI (2022)
Internet	Internet users (per 100 people)	WDI (2022)
Fixed Broad Band	Fixed broadband subscriptions (per 100 people)	WDI (2022)
Foreign direct investment	Foreign direct investment inflow, net (% Gdp)	WDI (2022)
Economic growth	GDP per capita growth (annuel %)	WDI (2022)
Foreign Direct investment	Foreign direct investment inflow, net (% Gdp)	WDI (2022)
Government effectiveness	Perception on the effectiveness of governments (estimate)	WGI

WDI : World Bank Development Indicators of the World Bank, WGI : World Governance Indicators of the World, ILO : International Labour Organisation, GRD : ICTD/UNU-WIDER Government Revenues.

Source : Authors

Table A2. List of countries

Development level	High income	Upper middle income	Lower middle income	Low income
countries	Botswana, Mauritius, Namibia , Seychelles, South Africa	Angola, Cap-Vert, Congo , Côte d'Ivoire, Gabon , Ghana, Kenya , Lesotho, Mauritania, Nigeria, São Tomé and Príncipe, Zambia	Benin, Burkina Faso, Cameroon , Comores, Congo DR , Ethiopia, Gambia , Guinea, Liberia Guinea-Bissau, Madagascar, Malawi, Mali, Mozambique, Niger ,Rwanda, Senegal , Sudan , Tanzania, Togo Uganda	Burundi, Centrafrique, Chad, Sierra Leone.

Source: Authors based on World Bank data.

Table 2: Correlation matrix

	Taxes			**Gender inclusion**				**ICT**		**Control variables**		
	Tt	Nrt	Rt	Flfp	Fu	Fe	Mpp	Ip	Fbs	Fdi	Gdp	Ge
Total taxes revenue	1.00											
Non resource taxes	0.4732*	1.00										
Resources taxe	0.8284*	-0.1068	1.00									
Female labor force participation	-0.0273	0.1413*	-0.115*	1.00								
Female unemployment	0.4953*	0.2475*	0.3420*	-0.4412*	1.00							
Female employment to population ratio	0.2843*	0.0345	0.2976*	-0.1360*	0.2668*	1.00						
Mobile phone penetration	0.3447*	-0.0493	0.4600*	-0.2691*	0.2888*	0.0477	1.00					
Internet penetration	0.3640*	-0.0217	0.4452*	-0.2828*	0.3419*	0.1898*	0.8087*	1.00				
Fixed Broadband	0.2757*	-0.0531	0.3713*	-0.1494*	0.1291*	-0.0127	0.4776*	0.5921*	1.00			
Foreign direct investments	0.0576	-0.0585	0.0957*	-0.0094	0.0142	0.0286	0.0457	0.0194	0.0576	1.00		
GDP per capita growth	0.0101	0.0269	0.0195	0.0626	-0.0746*	0.0297	-0.0771*	-0.0845*	-0.0253	0.0414	1.00	
Government effectiveness	0.4923*	-0.0762*	0.6104*	-0.1059*	0.3564*	0.1208*	0.3765*	0.4292*	0.5163*	0.0145	0.1383*	1.00

Note : *** Significance at 1% level, ** Significance at 5% level, * Significance at 10% level.
Source: authors

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