A G D I Working Paper

WP/21/058

Towards Efforts to Enhance Tax Revenue Mobilisation in Africa: Exploring Synergies between Industrialisation and ICTs

Isaac K. Ofori
Department of Economics,
University of Insubria,
Via Monte Generoso, 71, 21100, VA, Varese, Italy.
E-mail: isaac.ofori1@ucc.edu.gh
ikofori@uninsubria.it

Pamela E. Ofori
Department of Economics,
University of Insubria,
Via Monte Generoso, 71, 21100, VA, Varese, Italy.
E-mail: peofori@studenti.uninsubria.it

Simplice A. Asongu
(Corresponding Author)
African Governance and Development Institute,
P. O. Box 8413, Yaoundé, Cameroon
E-mails: asongusimplice@yahoo.com
asongus@afridev.org

2021 African Governance and Development Institute WP/21/058

Research Department

Towards Efforts to Enhance Tax Revenue Mobilisation in Africa: Exploring Synergies between Industrialisation and ICTs

Isaac K. Ofori, Pamela E. Ofori & Simplice A. Asongu

September 2021

Abstract

Motivated by the momentous rise in ICT diffusion, the implementation of the African Continental Free Trade Area agreement, and the expected rebound of foreign direct investment inflow to Africa from 2022, this study examines the joint effects of industrialisation and ICT diffusion on resource mobilisation in Africa. To this end, we use data on 42 African countries for the period 1996 – 2020 for the analysis. First, we provide evidence robust to several specifications from the dynamic system GMM to show that although unconditionally both industrialisation and ICT diffusion enhance (i) goods and services tax (GST), and (ii) profits, corporate and income tax (PCIT) mobilisation efforts in Africa, the effects of the former are rather remarkable in the presence of the latter. Particularly, the results show that, while ICTs amplify the effect of industrialisation on GST, only ICT usage and ICT skills matter for PCIT. Second, the study unveils ICT thresholds for complementary policies. Accordingly, industrialisation and ICTs are necessary and sufficient conditions for tax revenue mobilisation only below some ICT thresholds. Above these ICT thresholds, complementary policies are needed to maintain the overall positive incidence on tax revenue mobilisation. Policy recommendations are provided in the end.

Keywords: AfCFTA; Africa; ICT access; ICT diffusion; Industrialisation; Tax; Revenue
***JEL Codes*:** C33; F6; H2; H71; O33; O55

1.0 Introduction

Even before the emergence of the coronavirus pandemic were African countries' hydra-headed problems of high ***inequality, informality***, ***debt burden***, and ***aid dependency***. Currently, Africa has entered into a period where resources have become crucial than ever. First, as the OECD (2020, 2019), World Bank (2020, 2019) and United Nations (2015) reckon, adequate resources are needed to fund policies and strategies underpinning the United Nation's Agenda 2030 (i.e., the Sustainable Development Goals), which fundamentally seek to end poverty, lessen inequality, strengthen institutions, and combat climate change. Second, adequate resources are imperative for realising Africa's Agenda 2063 dubbed, the '*Africa We Want'*— a long term goal of fostering shared prosperity while reducing aid dependency, strengthening institutions to address frailties in economic, political and institutional governance (African Union 2015).

The above perspectives boil down to the ability of the African tax systems to generate the needed resources to fund projects essential for resilient growth trajectories (Piancastelli and Thirlwall 2021; IMF 2018; Mascagni *et al.* 2014; De Paepe and Dickinson 2014). Indeed, the unreliability of aid flows, the long-term growth implications of concessional loans, and the macroeconomic instability associated with seigniorage mean that African leaders are left with the options of strengthening resource mobilisation efforts or slowing down capital expenditure— the latter obviously with its deleterious growth implications. Generating adequate tax revenue from Africa's tax systems thus remain a key objective. However, information gleaned from the 2020 edition of the Organisation for Economic Co-operation and Development (OECD) Revenue Statistics indicates that, compared to other continents, Africa countries report low tax revenue mobilisation efforts. In specifics, the average tax-to-GDP[1] for Africa stood at 16.6%, compared to Europe (41.1%), Asia and Pacific (21%), and Latin America and Caribbean (22.9%). Ironically, it is the likes of Africa who need more resources to reduce inequalities in health, education, opportunities, and social protection (OECD 2020; World Bank 2019; Cody 2018; Lustig *et al*. 2019; Lustig and Higgins 2018; OECD 2014b).

Enhancing Africa's tax revenue performance calls for concerted efforts aimed at addressing tax evasion, corruption, and the high cost of collecting taxes. Aside from the

[1] In 2018, the performance of Africa was 16.5% compared to Europe (41.2%), Asia and Pacific (20.8%), and the Latin America and Caribbean (23.1%). On the African continent, while the likes of Seychelles (32.4%); Tunisia (32.1%); South Africa (29.1%); Morocco (27.8%) mobilise significant resources from their tax systems, the likes of Nigeria, 6.3%; Equatorial Guinea, 6.3%; Chad ,7.1%; DR. Congo, 7.5%, are still struggling to reach 10%.

contribution of aid[2] to Africa's development course, there are two key contemporary development tendencies in Africa— the momentous rise in (i) ICT diffusion[3] and (ii) economic integration, evidenced by the African Continental Free Trade Area (AfCFTA). While industrialisation drivers such as foreign direct investment (FDI) and trade openness can constrain resource generation due to trade tax loss, offshore tactics, tax holidays/exemptions, the optimism with industrialisation is that it can be a brick for durable growth, shared opportunities, and sustained resource collection (Agbeyegbe *et al.* 2004; Gupta 2007). Indeed, the blessings associated with digital infrastructure are also enormous and key among them is that, in the developing world, ICTs[4] can be (i) a medium for addressing tax non-compliance, (ii) a boost to industrialisation by incentivizing FDI inflow, and (iii) an enabler of innovation and labour market participation (see, Asongu *et al.* 2021; Ofori and Asongu 2021a; Asongu and Nwachukwu 2017). ICT diffusion can also be employed to broaden the tax net particularly regarding goods and services, fight tax-related corruption and complexities associated with analogue based tax systems (Akitoby 2018). Also, with FDI inflow to Africa set to rebound in 2022 following the implementation of the AfCFTA (UNCTAD 2021), attention on the power of industrialisation and ICT diffusion in driving the SSA's industrialisation agenda and the enhancement of revenue generation effort is on the cards.

For instance, industrialisation presents opportunities for accelerating Africa's efforts aimed at reducing informality and precautious employment, which as Gupta (2007), and Teera (2007) reckon, are impediments to the two key tax revenue mobilisation sources in the developing world— goods and services tax (*hereafter*, GST), and profits, corporate and incomes taxes (*hereafter*, PCIT). Despite these potentials, rigorous empirical work(s) exploring whether plausible synergies exist between ICT diffusion and industrialisation for tax revenue performance in Africa is(are) hard to find. Further, comprehensive empirical works informing appropriate policy actions on industrialisation thresholds required for effective tax mobilisation in the presence of ICT diffusion are missing in the literature. These two voids in the literature are the motivation for this study. We test two hypotheses in this

[2] In 2020, for instance, Africa was the highest recipient of aid ($20.8 b), compared to South Asia ($11.7b); LAC ($7.8b); East Asia & Pacific ($7.313b); and Europe & Central Asia ($7.2b). According to the OECD (2019), over the period 2015 -2017, Ethiopia received US$ 3809m; Nigeria (US$ 2763m); Tanzania (US$2495m); Kenya (US$2376m); and DR. Congo (US$2327m).

[3]Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.

[4]As Gigler (2011) reckons, ICTs are a complete array of contemporary assets with/through which people can create opportunities for themselves.

regard. First, we test whether unconditionally, both ICT diffusion (composed of access, usage and skills) and industrialisation spur GST and PCIT revenue mobilisation in Africa. Second, we test whether ICTs amplify the effect of industrialisation on GST and PCIT revenue mobilisation in Africa. The contributions we make could prove valuable for aiding African leaders generate adequate resources needed for accelerating COVID-19 recovery especially in the areas of education, health and infrastructure. The contribution could also help African leaders free up fiscal space essential for reducing aid dependency and its attendant debt burden while building capacity to mitigate the impact of future crises.

The rest of the paper is structured as follows: the next section presents a review of the literature on industrialisation and ICT diffusion. Section 3 outlines the methods underpinning the empirical analysis. We present our results and discussion in section 4and the conclusion and policy recommendations in section 5.

2.0 Theoretical linkage, intuition and literature review

2.1 Theoretical linkage and intuition

The Technology Acceptance Model (TAM) predicts that when economic agents are offered new technologies, diverse features influence their choice on when and how they will use it and how it will be useful (Davis 1989). This usefulness implies how the digital system would enhance work performance and its easy access. The model indicates that a good tax administration should be proportional to incomes/abilities to pay payable on time, convenient and cheaper to both taxpayers and administer. Further, digital systems can play a role in enhancing revenue administration by assisting tax authorities to achieve better compliance of taxes, detect fraud and decoupling elude limited opportunities for corruption (McCluskey and Huang 2019). The TAM within the remit of a macroeconomic framework can be understood as industries accepting and using technologies that would improve their effectiveness and efficiency in the industrialisation process. By extension, such effectiveness and efficiency engender favourable industrialisation outcomes from which tax revenue is derived.

In the light of the above, the intuition for the study is premised on the fact that industrialisation increases avenues for tax revenue mobilization (Asongu *et al*. 2021) and ICT greases the process of industrialisation (Asongu and Odhiambo 2020a). In other words, the industrialisation process is associated with the transformation of commodities from which, added value is apparent and by extension, the whole process engenders opportunities for tax mobilisation on various fronts, *inter alia*; (i) personal income tax from the people employed in the industrial process; (ii) corporate tax when the industrialisation process is sanctioned

with a positive bottom line in terms of profits and (iii) value-added tax (VAT) which is practically associated with the transformation of commodities to higher perceived values.

2.3 Literature survey on drivers of tax revenue mobilisation

Mallick (2021) uses time-series data spanning 1990 – 2018 on India and finds evidence from the Autoregressive Distributed Lag (ARDL) estimation technique to show that ICT infrastructure does not have a significant positive effect on overall tax revenue collection. However, it is possible in the presence of governance quality and efficient machinery to identify loopholes and properly govern the taxation system of a country. Employing an unbalanced panel data spanning 1990 – 2013 for 157 countries, Koyuncu *et al.* (2016) provide strong evidence to show that ICT penetration drives tax revenue mobilisation. Particularly, the results suggest that among the four ICT penetration indicators (i.e., mobile subscription, internet access, personal computers, and fixed broadband subscription), fixed broadband subscription contributes the most to three different tax revenue indicators- overall tax revenue, VAT, and corporate tax.

A similar contribution is seen in Brun *et al*. (2020) who examined the effect of ICT readiness and ICT usage on tax revenue mobilisation for a panel of 96 low- and middle-income countries over the period 2005 – 2016. The authors provide evidence from the fixed effect estimator to show that (i) though ICT readiness report a positive relationship with tax revenue, it is not statistically significant; and (ii) ICT usage is a significant tax revenue mobilisation enhancer. Additionally, the authors report that ICT usage boosts direct tax revenues through personal income tax, and indirect tax revenues through VAT and the pass-through effect is apparent via three channels— control of corruption, government effectiveness and tax compliance.

Using data for the period 1998 – 2008, Ahmed and Muhammad (2010) also investigate the tax buoyancy in 25 developing. The authors find that growth in import, manufacturing sector, services sector, monetization and budget deficit positively influence tax collection while growth in foreign aid (grants) hampers tax collection efforts. The pioneering works of Gupta (2007), Teera and Gupta (2004), Ghura (1998), Tanzi (1992), Lotz and Morss (1970), Krugman *et al.* (1992), Bahl (1971), Chelliah *et al.* (1975), and Morrissey (2015) identify factors such as political stability, corruption, accountability, trade liberalisation, foreign aid, and economic development as the key drivers of tax revenue generation in the developing world. Corroborative studies can be found in Garcia and von

Haldenwang (2016) who find that political regimes are crucial for tax revenue collection—with full autocracies and democracies raising higher revenues compared to regimes located between both margins. Also, regarding the effect of the real sector on tax revenue performance, Chaudhry and Munir (2010) and Emran and Stiglitz (2005) find that the agricultural sector hampers tax revenue mobilisation efforts as it is informal and records of activities are not usually kept as compared to the industry and service sectors.

Further, a strand of the literature argues that (i) aid can suppress tax revenue mobilisation efforts in the developing world if it comes in the form of development assistance (grants)as it becomes a substitute for domestic revenue mobilisation (Thornton 2014). On the contrary, authors such as Benedek *et al*. (2014) and Cordella and Ulku (2007) find that aid in the form of concessional loans enhances tax efforts due to repayment conditions attached to it. The literature also shows that economic development matters for tax revenue performance. Studies such as Brafu-Insaidoo and Obeng (2012), Teera and Hudson (2004) and Chelliah (1971) argue that rising per capita income signifies improved capacity of the masses to spend and therefore the ability of tax authorities to levy and collect taxes. In recent times, empirical works such as Ofori *et al.* (2021) and Ofori *et al.* (2018) find that key macroeconomic instability indicators— exchange rate volatility and inflation are harmful to tax revenue generation efforts.

2.4 The ICT-industrialisation-tax revenue relationship in Africa

While sceptics contend that ICT diffusion can be disastrous to resource mobilisation efforts in the developing world if not properly applied by taxpayers and administrators[5] (Akitoby 2018), there is also the notion that it can provide real opportunities for broadening the tax net, addressing tax evasion, and tax system corruption while reducing the cost of levying taxes (McCluskey & Huang 2019). Despite the consensus that the developing world failed to adapt to the industrial revolution, the story is quite different from the current wave of the digital revolution (Asongu and Ofori 2021a; Andrès *et al*. 2017; Asongu 2013). Indeed, in a region where informal activities are widespread and formal activities are generally analogue-based, ICT diffusion can prove momentous in (1) capturing the huge informal sector onto the tax net, (2) reducing the marginal cost of raising a unit of tax, and (3) the reduction in the cost of fulfilling tax obligations.

[5]It can present hackers and scammers opportunities to take advantage of such systems, especially in the early stages of adoption.

However, a conspicuous gap in the literature survey is the lack of comprehensive empirical works on Africa exploring the effects of industrialisation and ICT diffusion on GST and PCIT revenue generation. Considering the intensification of efforts in improving governance[6] (institutional effectiveness) in Africa in line with the UN Agenda 2030, the African Agenda 2063, and the implementation of the AfCFTA, policies aimed at developing the continent's industrial base and ICT infrastructure, could prove momentous for resource mobilisation efforts. Indeed, the graphical relationships between industrialisation, ICT diffusion and our tax indicators (i.e., GST and PCIT) as apparent in Figure 1 and Figure A.1, show that these gains are plausible. Indeed, the empirical evidence we present in section 4 shows that complementary policies aimed at strengthening Africa's industrialisation and digital infrastructure are crucial for boosting domestic resource mobilisation.

[6]Aspiration 3 of the Africa's Agenda 2063 is dedicated to achieving an Africa of good governance, democracy, respect for human rights, justice and the rule of law (Africa Union 2015)

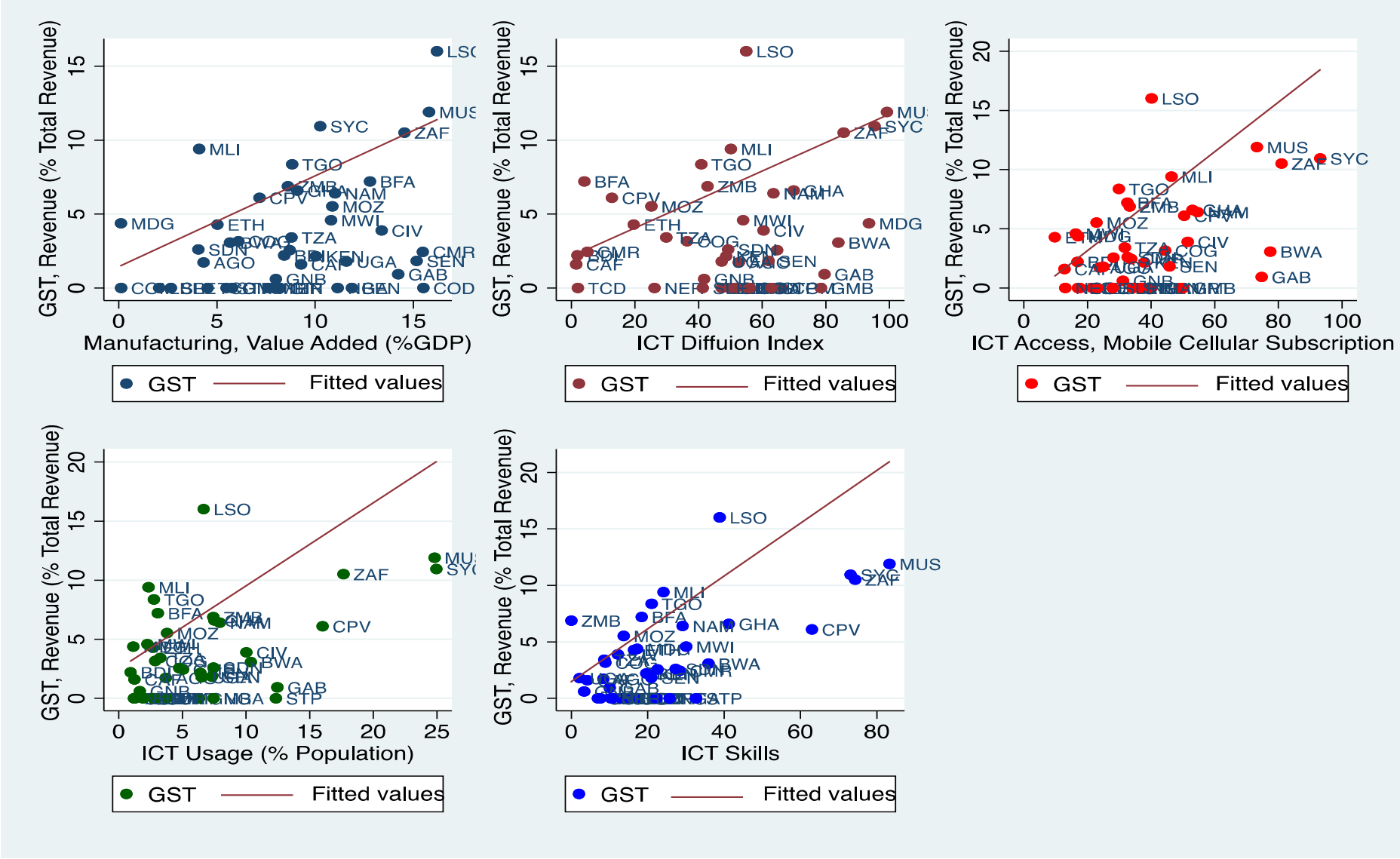

Figure 1: Within Country PCIT, ICT Diffusion and Industrialisation Nexuses In Africa, 1996 – 2020

3.0 Data and methodology

3.1 Data and variable justification

The study employs a panel dataset spanning 1996 – 2020 on 42 African countries [7] for the analysis. Two main tax revenue indicators namely, GST and PCIT, are used as outcome variables for the analysis. Both GST and PCIT are sourced from the World Development Indicators[8]and the UNU-WIDER Government Revenue Dataset (World Bank 2021; ICTD/UNU-WIDER 2021). The variables of interest in this study are ICT diffusion (including its key sub-components of access, usage and skills) and industrialisation. While we proxy the latter by manufacturing value-added as a percentage of GDP, the former is captured as a composite index on construction, extension, improvement, operation, and maintenance of communication systems. In terms of data sources, we draw industrialisation from the WDI and that of ICT diffusion from the African Infrastructure Knowledge Program (Africa Development Bank 2018; Lufumpa *et al.* 2017).

Our concentration on industrialisation is informed by the common goal on the part of African leaders to foster industrialisation through the AfCFTA. Additionally, the projection of a rise in FDI inflow into Africa from 2022 presents industrialisation prospects that can yield tax revenue mobilisation dividends. Also, our attention on ICTs follows the momentous rise in ICT adoption in Africa since 2003 (Ofori and Asongu 2021; Africa Development Bank 2018; Tchamyou *et al*. 2019a, 2019b), and the contemporary argument that ICTs can (i) enhance tax revenue mobilisation efficiency by reducing the marginal cost of levying taxes, (ii) reducing tax system corruption and non-compliance, and (iii) tax administration transparency. For appropriate policy actions/focus, three key sub-components of ICT diffusion- access (mobile cellular subscription per 100 people), usage (percentage of the population using the internet), and skills (gross secondary school enrolment in percentage terms) are also drawn from the WDI for the analysis

Some variables are also controlled for on grounds of econometric prudence. In specifics, six control variables are considered based on (i) intuition, (ii) the nature of the economies under consideration and (iii) the mitigation of omitted variable bias. These variables are economic development, vulnerable employment, foreign aid, inflation, foreign

[7] Angola; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; Congo DR.; Congo; Cote d'Ivoire; Ethiopia; Gabon; The Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Senegal; Seychelles; Sierra Leone; South Africa; Sudan; Sao Tomè and Principè; Tanzania; Togo; Uganda; Zambia.

[8]Hereafter, referred to as WDI

direct investment and government effectiveness, which except for the latest, are all drawn from the WDI. Government effectiveness accordingly, is sourced from World Governance Indicators (WGI) of the World Bank. The literature is divided on the implication of FDI on revenue generation efforts in the developing world (Hunady and Orviska2014). While in one breath, the literature indicates that FDI enhances tax revenue efforts (Ahmed and Muhammad 2010; Agbeyegbe *et al.* 2006), a section also reports a suppressing effect due to tax exception and offshore tactics (Zucman 2015). Also, we consider economic development as it presents opportunities for labour market participation in a region where unemployment is high, and thus the growing capacity of tax authorities to levy and collect taxes (see, Ofori *et al.*2021; Gupta 2007; Chelliah 1971). Vulnerable employment is also considered per the high informal sector of Africa and the empirical evidence that widespread informality characteristics of economies in which agriculture is the main source of employment breed tax non-compliance, tax system corruption, and the high marginal cost of levying taxes (Gammage *et al.*, 2020; Chaudhry and Munir 2010; Emran and Stiglitz 2005).

The effect of foreign aid is also inconclusive in the literature. On the one hand, the literature shows that foreign can be used as a substitute for domestic resource generation efforts (Morrissey and Torrance2015; Morrissey 2015; Thornton 2014). On the other hand, evidence also shows that due to repayment conditions attached to aid, it triggers greater revenue generation efforts (Benedek *et al.* 2014; Cordella and Ulku 2007; Gupta 2007). Similarly, the effect of inflation on tax revenue is ambiguous. While inflation boosts revenue generation through seigniorage (i.e., inflation tax associated with printing new notes), it can also prove deleterious to tax revenue mobilisation efforts through macroeconomic stability and income growth and sustainability setbacks (Ofori *et al.* 2018). Finally, we control for government effectiveness to capture the essence of economic governance, which is imperative not only for providing a conducive environment for the private sector to thrive but also for encouraging voluntary tax compliance, economic growth and employment (Kaufmann and Kraay 2017; Kaufmann *et al.* 2010). The data description of the variables is provided in Table 1.

Table A.1: Definitions and sources of variables

Variables	Descriptions	Sources
Dependent variables		
Goods and service tax	A value-added tax that is levied on most goods and services sold for domestic consumption, and is included in the final price and paid by consumers at the point of sale and sent to the government by the seller (% revenue).	WDI
Profit, income and corporate tax	Tax revenue levied on actual net income, on profits of corporation and gains (% revenue)	WDI
Variables of interest		
Industrialization	Manufacturing, value added (% GDP)	WDI
ICT Diffusion	Composite index on the construction, extension, improvement, operation, and maintenance of communication systems (postal, telephone, telegraph, wireless, and satellite communication systems).	AIKP
ICT Access	Mobile cellular subscription (per 100 people)	WDI
ICT Usage	Internet subscription (% population)	WDI
ICT Skills	secondary school enrolment (% gross)	WDI
Control variables		
Foreign direct investment	Foreign direct investment inflow, net (%GDP)	WDI
Government effectiveness	Perception on the effectiveness of governments in managing and introducing policies aimed at economic growth and development (estimate)	WGI
Economic growth	GDP per capita growth (annual %)	WDI
Foreign aid	Net official development assistance (%GNI)	WDI
Vulnerable employment	Contributing family workers and own-account workers (% total employment)	WDI
Inflation	Consumer price index (2010=100)	WDI

Note: WDI is World Development Indicators; WGI is World Government Indicators; AIKP is Africa Infrastructure Knowledge Program.
Source: Authors' construct, 2021

3.2 Estimation strategy

The theoretical foundation of our study rests on the argument that ICT diffusion and industrialisation are growth, employment and revenue mobilisation enhancers (McCluskey and Huang 2019; Davis 1989). The empirical rigour of the study begins with a test of the bivariate relationships between the outcome variables (i.e., GST, PCIT), ICT dynamics, and industrialization. In line with the objectives of the study, we specify a tax model, which depends on our set of control and key variables as seen in Equation (1).

$$tax_{it} = \lambda_0 + \delta_1 tax_{it-1} + \beta_1 ict_{it} + \beta_2 indus_{it} + \beta_3 gov_{it} + \beta_4 aid_{it} + \beta_5 gdpg_{it} + \beta_6 inf_{it} + \beta_7 vul_{it} + \beta_8 fdi_{it} + \beta_9 (ict_{it} \times indus_{it}) + \mathcal{I}_i + \mu_t + \varepsilon_{it} \quad (1)$$

A conspicuous empirical concern regarding the estimation of Equation (1) via the traditional fixed effects and random effects estimators is that potential endogeneity cannot be addressed. The first endogeneity concern arises due to the simultaneity between economic growth and tax revenue generation, and the second is the fact that $Tax_{it-\tau}$ depends on $\varepsilon_{it-\tau}$, which is a function of the country-specific effect $\mathcal{I}_i$. To the extent that failure to address these two endogeneity concerns can bias our estimates, we address it by applying the two-step system GMM estimation technique.

Additional justifications for applying the two-step system GMM[9] technique is seen in (Asongu and Nwawchukwu 2016; Tchamyou 2019). First, the sample countries (i.e., N) used in the study is greater than the number of time period in each cross-section (i.e., T). Thus, with N>T, it guarantees that the application of the technique is satisfied. Second, the two outcome variables are persistent since the correlations that exist between their current levels and their first lags are above 0.8, which conforms to the rule thumb for satisfying persistence in a variable (Asongu and Odhiambo 2020b; Tchamyou and Asongu, 2017). And third, the panel dataset also reveals cross-country variation which is accounted for in the estimation. Consequently, we transform Equation (1) into Equations (2) and (3) to capture the level and first difference, which encapsulate the dynamic system estimation method.

$$tax_{it} = \lambda_0 + \delta_1 tax_{it-1} + \beta_1 indus_{it} + \beta_2 ict_{it} + \sum_1^5 \theta_k V_{kit-\tau} + \mathcal{I}_i + \mu_t + \varepsilon_{it} \quad (2)$$

$$tax_{it} - tax_{it-\tau} = \delta_1 (tax_{it-\tau} - tax_{it-2\tau}) + \beta_1 (indus_{it} - indus_{it-\tau}) + \beta_2 (ict_{it} - ict_{it-\tau}) + \sum_1^5 \theta_k (V_{kit-\tau} + V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \quad (3)$$

Next, to capture the hypothesised joint effect of industrialization and ICT diffusion on tax mobilisation efforts, Equation (3) is modified to obtained Equation (4).

$$tax_{it} - tax_{it-\tau} = \delta_1 (tax_{it-\tau} - tax_{it-2\tau}) + \beta_1 (indus_{it} - indus_{it-\tau}) + \beta_2 (ict_{it} - ict_{it-\tau}) + \beta_3 (ict \times indus_{it} - ict \times indus_{it_{it-\tau}}) + \sum_1^5 \theta_k (V_{kit-\tau} + V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \quad (4)$$

[9]The two step GMM approach employed in this study is the Roodman (2009) approach and is an augmentation of the Arellano and Bover (1995) strategy. This strategy accounts for limited proliferation of instruments as well as cross-sectional dependencies (see, Fosu and Abass 2019).

Where, $\boldsymbol{tax_{it}}$ is the tax revenue mobilisation indicator for (i) ***GST***, and (ii) ***PCIT***; $\boldsymbol{i}$ is countries; $\boldsymbol{t}$is time in years; $\boldsymbol{\lambda_0}$ is intercept; $\boldsymbol{indus}$ is industrialisation;$\boldsymbol{ict}$ is an indicator for ICT diffusion in general, ICT usage, ICT access and ICT skills. Also**,** $\boldsymbol{ict \times indus}$is the interaction term for ICT indicators and industrialisation; and $\boldsymbol{V}$ is the matrix of control variables defined as ***gdpg*** for economic growth; ***aid*** for foreign aid, ***fdi*** for foreign direct investment, ***gov*** for government effectiveness, and ***vul*** for vulnerable employment. Finally,$\boldsymbol{\tau}$ is the coefficient of auto-regression; $\boldsymbol{\mathcal{J}_i}$ is the country-specific effect; $\boldsymbol{\mu_t}$ is the time fixed effect and ε_{it} is the idiosyncratic error term. For a priori signs, we expect industrialization, ICT diffusion, economic growth, FDI and government effectiveness to increase tax revenue mobilisation. Further, we expect foreign aid and inflation to lessen tax revenue mobilisation. To inform policy on the extent to which industrialisation impacts both PCIT and GST through ICT adoption, an expression of the partial effect from Equation (4) is specified in (5).

$$\frac{\partial(tax_{it})}{\partial(indus_{it})} = \beta_1 + \beta_9\overline{(ict_{it})} \tag{5}$$

Where, $\overline{ict_{it}}$ is the mean of our various ICT diffusion indicators (i.e., ICT diffusion in general, ICT access, usage and skills). We point out that in evaluating the reliability of the estimates on PIT and GST revenue mobilisation, we test whether (i) our instruments are valid based on the Hansen test of overidentification, (ii) overall, our model is significant, and (iii) the absence of second-order serial correlation in the residuals.

4.0 Results and discussion

4.1 Summary statistics

The section presents the summary statistics of the variables considered in this empirical analysis. The data as presented in Table 2 shows average direct tax (PCIT) revenue of 9.9%, which is moderately low.

Table 2: Summary statistics, 1996- 2020

Variables	Obs.	Mean	SD	Min	Max
Income-Profit-corporate tax	1050	9.904	14.074	0.000	55.983
Goods and services tax	1050	3.645	5.334	0.000	24.338
Manufacturing, value-added	931	9.964	4.898	0.233	40.064
Foreign direct investment	994	4.309	7.927	-11.625	103.337
Economics growth	1050	4.112	4.616	-36.392	33.629
Vulnerable employment	984	70.698	21.914	8.830	94.98
Foreign aid	997	9.105	9.138	-0.251	92.141
Government effectiveness	882	-0.694	0.608	-1.885	1.057
Inflation	947	14.988	138.434	-9.616	4145.106
ICT diffusion	864	6.997	10.946	0.000	71.813
ICT Access	947	41.864	43.277	0.001	198.152
ICT usage	1050	6.234	10.913	0.000	64.000
ICT skills	581	41.778	24.43	5.283	114.381

Note: SD: Standard deviation. Min: Minimum. Max: Maximum. Obs: Observations.
Source: Authors' construct, 2021

Also, the data reveals a mean indirect tax (i.e., GST) revenue of 3.6% over the study period. Similarly, while we find an average value of 9.9% for industrialisation (i.e., manufacturing, value-added), that of ICT diffusion, access, and usage are 6.9%; 41.8%, and 6.2%, respectively. Further, the average government effectiveness score of -0.6, signifies a case of weak institutional quality in Africa. The attendant correlations between these variables are presented in Table A.1 in the Appendices section.

4.2 Preliminary results on the effects of Industrialisation and ICTs on GST

We begin the presentation of the contribution of this paper to the extant literature by first looking at the bivariate results in Table 3 and Table A.2. The results specifically centre on the relationship between our variables of interest- ICT diffusion, access, usage, skills, and industrialization, and direct and indirect taxes.

Table 3: Bivariate results on the effects of industrialisation and ICTs on GST

Variables	(1)	(2)	(3)	(4)	(5)
Industrialisation	0.1472***				
	(0.0364)				
ICT diffusion		0.0432***			
		(0.0076)			
ICT usage			0.2055***		
			(0.0137)		
ICT access				0.0484***	
				(0.0038)	
ICT skills					0.1129***
					(0.0089)
Constant	2.3968***	2.2489***	2.3639***	1.9689***	-0.1564
	(0.4042)	(0.4235)	(0.1721)	(0.2291)	(0.4311)
Observations	931	756	1,050	947	581
R-squared	0.0173	0.0413	0.1768	0.1459	0.2171
Adjusted R-squared	0.0162	0.0401	0.176	0.145	0.216
F-Statistic	16.34***	32.51***	225.01***	161.39***	160.56***
P-Value	0.0001	0.000	0.000	0.000	0.000

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

The results show that all our key variables exert a positive influence on GST. All the relationships are strong at the 1% level of significance, with the effect of ICT usage being the most remarkable of all. Similar results are observed in the case of PCIT as apparent in Table A.2 in the Appendices section.

4.2 Presentation of Results

4.2.1 GMM results on the effects of industrialisation and ICTs on GST mobilisation

This section presents the findings on the conditional and unconditional effects of industrialisation and ICTs on GST (see Table 4). Following the extant empirical literature that is based on the GMM approach (Asongu and De Moor 2017), the study adopts three post-diagnostic information criteria to investigate the validity of the models used for estimation. Considering these established information criteria, all the specifications are valid. Especially, this research pays critical attention to the validity of several diagnostic tests. First, the absence of second-order serial autocorrelation in the residual, which is evidenced in the (AR [1]) and (AR [2]) statistics whose null hypothesis for no autocorrelation should not be rejected. Second, is the test for over-identification restriction and validity of the instruments, which is addressed by the Hansen test since all the p-values are insignificant. Finally, issues about the number of instruments that can compromise the validity of the model has been

addressed (i.e., instrument proliferation) since the number of instruments for each specification is less than the corresponding number of countries.

On the first objective of the paper, we provide evidence in Table 4 to show that industrialisation and ICTs are remarkable channels for inducing GST mobilisation (see Columns 2-6). First, the coefficient of industrialisation is 0.24, meaning that a 1% increase in industrialisation directly enhances GST generation in Africa by 0.24%. This can be attributed to the fact that industrialization improves productivity, which signifies economic agents growing access to goods and services in the market and by extension, the capacity of the state to generate resources through the tax system (Taiwo 2018). Second, there is strong empirical evidence on the unconditional effect of ICT diffusion, ICT access, ICT usage and ICT skills on GST revenue mobilisation. The results show that while ICT diffusion, in general, improves GST revenue generation by 0.04%, ICT usage and ICT skills report 0.01%, and 0.03%, respectively. The results unveil that, compared to other components of ICT diffusion, ICT usage is the most relevant in inducing GST mobilisation in SSA. This appeals to logic as well, since ICT usage is required to make sense of both ICT skills and ICT access.

Third, considering the second hypothesis, we investigate the conditional effect of enhancing industrialisation on GST in Africa through ICT diffusion, ICT access, ICT skills and ICT usage. We find strong empirical evidence to show that though industrialisation spurs GST mobilisation in Africa, there are equally pronounced additional effects in the presence of ICTs. The uniqueness of our results is that all our ICT dynamics are effective moderators on the effect of industrialisation on GST in Africa. Particularly, we find that ICT access is key for forming a synergy with industrialisation on GST revenue mobilisation in Africa. In a region where sharp disparities in ICT access exist across the rural-urban divide, enhancing ICT access could even prove more crucial for resource mobilisation. In specifics, the net effect of industrialisation and ICT access is 0.02, compared to 0.03, for the industrialisation-ICT usage pathway. These net effects are computed following Equations (5), given the average industrialization value of 9.964.

Table 4: GMM results on the effects of industrialization, and ICTs on GST mobilisation (Dependent variable: GST)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GST (lag)	0.7971***	0.6955***	0.7843***	0.7735***	0.7895***	0.8134***	0.6213***	0.6487***	0.7200***	0.8479***
	(0.0103)	(0.0369)	(0.0251)	(0.0233)	(0.0212)	(0.0077)	(0.0610)	(0.0579)	(0.0433)	(0.0243)
FDI	-0.0046	0.0211	0.0056	-0.0052	-0.0056	0.0136***	0.0434	0.0618**	0.0230*	0.0243
	(0.0080)	(0.0159)	(0.0078)	(0.0087)	(0.0077)	(0.0049)	(0.0323)	(0.0237)	(0.0131)	(0.0155)
Economic growth	0.0267**	0.0448**	0.0127	0.0342***	0.0272**	-0.0124	0.2003***	0.1334***	0.0545***	0.0351
	(0.0098)	(0.0179)	(0.0201)	(0.0125)	(0.0107)	(0.0079)	(0.0478)	(0.0286)	(0.0162)	(0.0296)
Vulnerable employment	-0.0075	-0.0078	-0.0368***	-0.0047	-0.0057	-0.0331***	-0.1814***	-0.0253	-0.0042	-0.0269*
	(0.0057)	(0.0083)	(0.0110)	(0.0063)	(0.0063)	(0.0065)	(0.0297)	(0.0152)	(0.0104)	(0.0152)
Foreign aid	-0.0023	-0.0010	-0.0129	-0.0047	-0.0013	-0.0089*	-0.1241***	-0.0191	-0.0046	-0.0382
	(0.0058)	(0.0087)	(0.0149)	(0.0063)	(0.0065)	(0.0053)	(0.0382)	(0.0185)	(0.0103)	(0.0227)
Government effectiveness	0.4981***	0.6295**	0.7859***	0.6203***	0.4922***	0.6400***	0.5036	-0.2014	0.5371	-0.4024
	(0.1731)	(0.2374)	(0.2205)	(0.1968)	(0.1812)	(0.1315)	(0.9169)	(0.6502)	(0.3733)	(0.2550)
Inflation	-0.0005	0.0015	0.0156*	0.0011	-0.0006	0.0128***	0.0662*	0.0098**	0.0022*	0.0033
	(0.0023)	(0.0014)	(0.0082)	(0.0027)	(0.0023)	(0.0006)	(0.0351)	(0.0040)	(0.0012)	(0.0071)
Industrialization		0.2429***					2.2618***	0.9215***	0.2897***	0.8028***
		(0.0588)					(0.5280)	(0.0957)	(0.0557)	(0.1314)
ICT diffusion			0.0441**				0.2850***			
			(0.0186)				(0.0883)			
ICT access				0.0017				0.1235***		
				(0.0014)				(0.0116)		
ICT usage					0.0119***				0.1634***	
					(0.0035)				(0.0447)	
ICT skills						0.0335***				0.1142***
						(0.0021)				(0.0298)
industrialization ×ICT diffusion							-0.0476***			
							(0.0099)			
industrialization ×ICT access								-0.0106***		
								(0.0009)		
industrialization ×ICT usage									-0.0137***	
									(0.0038)	
industrialization ×ICT skills										-0.0126***
										(0.0025)
Net effects	na	na	na	na	na	na	1.9287	0.4777	0.2043	0.2764
Joint Significance Test Statistic	na	na	na	na	na	na	23.21***	126.32***	12.70***	24.51***
Joint Significance P-Value	na	na	na	na	na	na	0.000	0.000	0.001	0.000
ICT Thresholds	na	na	na	na	na	na	5.9874	11.6509	11.9270	9.0635
Constant	1.4861***	-0.6067	6.0425***	1.3947***	1.2831***	5.2358***	0.8755	-7.9446***	-1.7041*	-4.9178
	(0.3300)	(1.1094)	(1.6507)	(0.3543)	(0.3654)	(0.4444)	(5.4569)	(1.7353)	(0.9437)	(2.9859)
Observations	758	692	660	742	758	439	607	680	692	403
Countries	40	38	40	40	40	39	38	38	38	37
Instruments	30	30	30	30	30	30	30	30	30	30
Wald statistic	4163***	1636***	1169***	6003***	1761***	867091***	981.4***	658.2***	855.8***	1.709e+06***
Wald P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hansen P-Value	0.237	0.605	0.275	0.259	0.206	0.177	0.951	0.668	0.597	0.240
AR(1)	0.001	0.002	0.001	0.001	0.000	0.020	0.006	0.003	0.001	0.028
AR(2)	0.703	0.364	0.793	0.666	0.677	0.649	0.671	0.609	0.409	0.801

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

For instance, we calculate the net effect of the ICT diffusion and industrialisation interaction in Column 7, given that the mean value of the former is 6:997.

$\frac{\partial(GST)}{\partial(indus)} = 2.2618 + (-0.0476 \times 6.997) = 1.9287$, where 2.2618 is the unconditional effect of industrialisation; the conditional effect of industrialisation is -0.047, and 6.997 is the mean of ICT diffusion as apparent in Table 1.

Similar computations are followed in deriving the net effects for the industrialisation and ICT usage, ICT access and ICT skills interactions. The results are present in respective terms as.

$\frac{\partial(GST)}{\partial(indus)} = 0.9215 + (-0.0106 \times 41.864) = 0.4777$, where 0.9215 is the direct effect of industrialisation; -0.0106 is the indirect effect of industrialisation, and 41.864 is the mean of ICT access.

$\frac{\partial(GST)}{\partial(indus)} = 0.2897 + (-0.0137 \times 6.234) = 0.2043$, where 0.2897 is the unconditional effect of industrialisation; -0.0137 is the coefficient of the interaction term for ICT usage and industrialisation, and 6.234 is the average of ICT usage.

$\frac{\partial(GST)}{\partial(indus)} = 0.8028 + (-0.0126 \times 41.778) = 0.2764$, where 0.8028 is the direct effect of industrialisation; the conditional effect of industrialisation is -0.0126, and the mean ICT skills is 41.778.

As apparent in Columns 7 – 10, a key finding from this study is that all our ICT dynamics are relevant moderators for amplifying the effect of industrialisation on GST revenue generation in Africa. The uniqueness of our results is that ICT access is key for boosting GST revenue mobilisation though modest effects are also evident for broadening ICT usage and ICT skills. The favourable effects of all our ICT indicators call for further scrutiny in terms of the extent to which policymakers should enhance each of these ICTs, which we shed light on by way of threshold analysis in the subsequent sections.

For our controls, we find that irrespective of the type of GST model specification, the lag of GST is remarkable and statistically significant in driving current GST mobilisation efforts. Additionally, we find that foreign aid suppresses GST mobilisation efforts in Africa.

This result is in line with Morrissey (2015) and Thornton (2014) who find strong empirical evidence to suggest that foreign aid is used as a substitute for domestic tax mobilisation efforts in the developing world. Despite modest effects, both FDI and economic growth proved GST revenue mobilisation-enhancing. For instance, the results in Column 8 show that, for every 1% increase in FDI and economic growth in Africa, GST rises by 0.06% and 0.13%, respectively. Particularly, the result on the former provides sheer optimism regarding the implementation of the AfCFTA agreement. Indeed, the rise in innovation characteristic of economic integration of this kind provides easier avenues for tax administrators to generate resources to fund developmental projects. This is in line with Obeng *et al.* (2021) who argue that FDI can boost productivity in the receiving economies, with the attendant benefits being a rise in (i) global value chain participation, (ii) domestic commercialisation, and (iii) tax revenue generation. The GST revenue generation-inducing effect of economic growth centres on empirical evidence by Ofori *et al.* (2021b) that rising economic development signifies the growing commercialisation, labour market participation, and capacity of the populace to spend and thus, the ability of tax authorities to generate resources domestically. Moreover, as expected, vulnerable employment proved harmful to GST mobilisation in Africa. This evidence amplifies the call for industrialisation in Africa, which can aid the resolve on the part of decision makers to transform the highly informal nature of Africa to at least the formalised informal sector. Finally, we find evidence that government effectiveness is highly effective for boosting GST revenue mobilisation. This is intuitive as quality governance is relevant for easing the burden of the private sector. Particularly, effective governance is relevant for building institutions that fight corruption in general and especially in the tax administration through tax system reforms and lower tax compliance costs (Gaalya 2015).

4.2.1 GMM results on the effects of industrialisation and ICTs on PCIT mobilisation

The following findings in Table 5 reveal the linkages between industrialisation and ICTs on PCIT generation in Africa. Concerning objective 1, first, we provide strong empirical evidence irrespective of model specification type to show that industrialisation is remarkable in inducing PCIT revenue mobilisation in Africa. For instance, the result in Column 2 shows that, for every 1% increase in industrialisation, PCIT increases by 0.298%. This is plausible since as compared to informal activities, companies keep records of their commercial activities, making it easier to tax. Additionally, evidence shows that tax evasion/non-

compliance in the industrial sector is low as compared to the agricultural sector, which is predominant in Africa (Akitoby 2018).

Second, the results unveil that only ICT usage and ICT skills matter for PCIT revenue mobilisation in Africa. We report unconditional effects of 0.083% (Column 5), and 0.067% (Column 6), respectively. These findings also make economic sense as the employment/adoption of ICTs in the industrial value chain can realistically yield favourable PCIT revenue generation impacts. In line with this evidence is the relevance of ICT skills, which is also crucial for determining the extent to which ICTs are employed in industrial activities. These findings also point to the plausible game-changing impact of the AfCFTA in spurring Africa's low revenue generation. In conformity to the results on the unconditional effects of ICTs on PCIT revenue generation, we find that only the (i) industrialisation-ICT usage, and (ii) industrialisation-ICT skills pathways, are keys for PCIT revenue performance in Africa. We, thus, find evidence for our second objective. Following Equation (5), we compute the net effects from the interaction between industrialisation and ICT usage on the one hand, and industrialisation and ICT skills on the other hand. Regarding the first interaction, we report a net effect of 0.4859 on PCIT revenue (Column 9). This is computed as:

$\frac{\partial(PCIT)}{\partial(indus)} = 0.6436 + (-0.0253 \times 6.234) = 0.4859$, where 0.6436 is the unconditional effect of industrialisation, -0.0253 is the indirect effect of industrialisation, and 6.234 is the average value for ICT usage as apparent in Table 1.

Similarly, we find a net effect of 0.1411 on PCIT revenue mobilisation for the industrialisation and ICT skills interaction (Column 10). This is also computed as:

$\frac{\partial(PCIT)}{\partial(indus)} = 2.9026 + (-0.0661 \times 41.778) = 0.1411$, where 2.9026 is the direct effect of industrialisation, -0.0661 is the indirect effect of industrialisation, and 41.778 is the average value for ICT usage.

Table 5: GMM results on the effects of industrialization and ICTs on PCIT mobilisation (Dependent variable: PCIT)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PCITT (lag)	0.8931***	0.9003***	0.8522***	0.8754***	0.8872***	0.9264***	0.6712***	0.7966***	0.8133***	0.9056***
	(0.0201)	(0.0176)	(0.0273)	(0.0239)	(0.0210)	(0.0088)	(0.0443)	(0.0302)	(0.0287)	(0.0392)
FDI	0.0069	0.0341	0.0050	0.0189	0.0033	0.0018	0.1960***	0.1536***	0.0831**	0.0416
	(0.0208)	(0.0275)	(0.0241)	(0.0263)	(0.0200)	(0.0189)	(0.0640)	(0.0386)	(0.0337)	(0.0430)
Economic growth	0.0632***	0.0800***	0.0896**	0.0579**	0.0783***	0.0299**	0.2384***	0.2331***	0.1314***	0.0709
	(0.0187)	(0.0244)	(0.0365)	(0.0239)	(0.0166)	(0.0114)	(0.0867)	(0.0706)	(0.0299)	(0.0821)
Vulnerable Employment	-0.0169**	-0.0121	-0.0474**	-0.0158*	-0.0003	0.0470***	-0.0030	-0.0179	0.0073	-0.1867***
	(0.0063)	(0.0091)	(0.0234)	(0.0079)	(0.0085)	(0.0076)	(0.0668)	(0.0253)	(0.0206)	(0.0391)
Foreign aid	-0.0289**	-0.0048	-0.0312	-0.0314	-0.0149	0.0013	-0.0478	-0.0106	-0.0335	-0.2081**
	(0.0132)	(0.0140)	(0.0359)	(0.0216)	(0.0179)	(0.0174)	(0.0867)	(0.0418)	(0.0311)	(0.0798)
Government effectiveness	0.4164	0.2088	0.6437	0.6235***	0.3796	0.5778***	0.5193	-0.1274	0.5753	-1.5897
	(0.2659)	(0.3451)	(0.4852)	(0.2222)	(0.3054)	(0.2054)	(1.7421)	(0.8587)	(0.6961)	(2.0385)
Inflation	0.0042	0.0180	0.0224	0.0041	0.0041	0.0546***	0.2036***	0.0250	0.0132	0.0685***
	(0.0089)	(0.0114)	(0.0148)	(0.0100)	(0.0094)	(0.0026)	(0.0571)	(0.0213)	(0.0168)	(0.0099)
Industrialization		0.2986**					2.6607***	0.8957*	0.6436***	2.9016***
		(0.1379)					(0.9473)	(0.4757)	(0.2015)	(0.6510)
ICT diffusion			-0.0215				0.2381			
			(0.0312)				(0.1550)			
ICT access				0.0032				0.0363		
				(0.0059)				(0.0610)		
ICT usage					0.0839***				0.3845**	
					(0.0122)				(0.1477)	
ICT skills						0.0679***				0.5284***
						(0.0083)				(0.1046)
industrialization ×ICT diffusion							-0.0190			
							(0.0156)			
industrialization ×ICT access								-0.0010		
								(0.0057)		
industrialization ×ICT usage									-0.0253*	
									(0.0129)	
Industrialization× ICT skills										-0.0661***
										(0.0092)
Constant	2.5678***	-1.5368	6.2870*	2.6350***	0.6317	-5.2643***	-26.6849**	-9.2586*	-6.4663**	-9.0581
	(0.5994)	(1.8593)	(3.2185)	(0.8819)	(0.8211)	(0.6868)	(12.7366)	(5.0542)	(2.6022)	(6.1981)
Net effect	na	na	na	na	na	na	na	na	0.4859	0.1411
Joint Significance Test Statistic	na	na	na	na	na	na	na	na	3.85*	51.24***
Joint Significance P-Value	na	na	na	na	na	na	na	na	0.057	0.000
ICT Thresholds	na	na	na	na	na	na	na	na	15.1976	7.9939
Observations	758	692	660	742	758	439	607	680	692	403
Countries	40	38	40	40	40	39	38	38	38	37
Instruments	30	30	30	30	30	30	30	30	30	30
Wald statistic	3561***	10101***	4398***	4125***	1956***	1.717e+06***	262***	7580***	1095***	1.254e+06***
Wald P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hansen P-Value	0.432	0.314	0.416	0.592	0.371	0.138	0.284	0.287	0.314	0.584
AR(1)	0.001	0.001	0.001	0.000	0.000	0.001	0.002	0.001	0.001	0.002
AR(2)	0.393	0.308	0.393	0.392	0.378	0.485	0.317	0.313	0.313	0.536

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

The uniqueness of these findings is that though industrialisation enhances PCIT revenue mobilisation in Africa, additional favourable effects are attained with the greater ICT usage and ICT skills. Our results suggest that broadening the use of ICTs in the industrial and service sectors, which constitute the bedrock of PCIT in Africa, can boost decision makers' resolve of improving revenue mobilisation in Africa. This means that boosting PCIT revenue generation in Africa will also rest on how policymakers diffuse ICTs in the public and civil services. These findings also suggest that the extent to which firms or companies employ ICTs in their value chains could prove crucial for revenue generation, particularly, considering the projected rise in FDI inflow to Africa from 2022 (UNCTAD 2021).

4.3 Further discussion of results and Policy implications through threshold estimation

Concerning indirect tax (i.e., GST) revenue mobilisation in Africa, our variables of interest, industrialisation and ICTs are crucial (see Table 4). For direct taxes (i.e., PCIT), however, it is industrialisation and the ICT components of usage and skills that proved relevant (see Table 5). Considering the favourable effect of industrialisation on both GST and PCIT mobilisation, the AfCFTA presents policymakers interested in Africa's development agenda real opportunities for addressing Africa's hydra-headed problems of informality, unemployment, debt burden and low tax revenue generation. The results suggest that efforts aimed at improving Africa's intra- and inter-regional trade, forward and backward linkages, and the easing of the cost of doing business could prove momentous in sustaining and reaping direct investment dividends of which resource generation is key. Greater resource mobilisation benefits could even be envisaged if this is accompanied by efforts to reduce tax compliance cost, which as Akitoby (2018) and Koyuncu *et al.* (2016) indicate, can be realised with ICT adoption.

Linked to the above is our result on the remarkable effects of ICTs in resource generation. The optimism with ICTs is that their adoption has risen remarkably in Africa since 2003 (Africa Development Bank 2018; Lufumpa *et al.* 2017). In locations like Africa where informality and institutions are generally weak, ICT diffusion can promote effective governance and accountability. For instance, in Africa where information regarding the tax systems is hard to come by, ICT diffusion can aid transparency and efficiency as it reduces the marginal cost of raising a dollar of resources through the tax system while enhancing effective information dissemination. Tax authorities can also leverage the power of ICTs to aid revenue collection and compliance by mitigating tax complexity and dismantling hideouts

for tax evaders. Also germane is the power of ICTs in exposing corrupt tax authorities who try to overestimate/underestimate tax revenue reports.

While the evidence we provide regarding objectives 1 and 2 can trigger policy actions, we provide further evidence by computing thresholds at which improving industrialisation by means of ICTs is no longer necessary and sufficient to enhance GST and PCIT revenue mobilisation. First, with the absolute coefficient of the joint effect of industrialisation and ICT diffusion on GST being 0.0476 (see Column 7 of Table 4) and that of the direct effect being 0.2850, a threshold of 5.987 index is obtained. This is calculated as:

Threshold ICT diffusion index (Column 7) = 0.2850/0.0476 = 5.987 (index)

Hence, above the established threshold of 5.987, ICT diffusion should be complemented with other policy measures in order to boost GST revenue generation efforts. Following similar computations, ICT thresholds concerning usage, access, and skills are computed. The results provide ICT maximum levels that when attained should be complemented with other policy initiatives in order to maintain a positive effect on GST revenue mobilisation

Threshold for ICT access (Column 8) = 0.1235/0.0106 = 11.651 (per 100 people)
Threshold for ICT usage (Column 9) = 0.1634/0.0137 = 11.927 (% of population)
Threshold for ICT skills (Column 10) = 0.1142/0.0126 = 9.064 (% of gross)

Similarly, we compute the ICT thresholds regarding PCIT revenue generation efforts in Table 5. For ICT thresholds regarding PCIT revenue mobilisation, we report threshold values of 15.217 (% of the population) and 7.994 (% of gross) for the ICT access and ICT skills pathways, respectively. These thresholds are computed as:

Threshold for ICT usage (Column 9) = 0.3850/0.0253=15.217 (% of population)
Threshold for ICT skills (Column 10) = 0.5284/0.0661=7.994 (% of gross)

Comparatively, our ICT thresholds in Tables 4 and 5 for complementary policies are more apparent in Table 4 relative to Table 5. This is economically intuitive as coverage for generating GST in Africa is wider compared to PCIT. Additionally, these computed thresholds fall within the minimum and maximum values of respective ICT variables as apparent in Table 1, signifying that such thresholds make economic sense and are achievable.

In other words, the computed ICT thresholds have economic meaning and policy relevance because they are situated within their respective statistical ranges disclosed in the summary statistics.

5.0 Conclusion, policy recommendations and future research directions

This study contributes to the debate on the need for African countries to boost tax revenue mobilisation efforts. While marginal and partial effects are imperative, we go a step further to inform policy actions by computing ICT thresholds for complementary policies. To this end, we draw on data spanning 1996 – 2020 for 42 African countries for the analysis. We provide evidence robust to several specifications from the GMM results to show that although unconditionally, both industrialisation and ICT diffusion enhance GST and PCIT revenue mobilisation in Africa, the effects of the former are rather remarkable in the presence of ICT adoption. First, considering direct taxes (PCIT), we provide robust evidence to show that only ICT usage and skills form significant synergies with industrialisation on resource generation efforts. Second, regarding indirect taxes (GST), all our ICT dynamics (i.e., ICT diffusion in general, ICT access, ICT usage, and ICT skills) are essential instruments for amplifying the effect of industrialisation on tax revenue mobilisation efforts.

Finally, these ICT-industrialisation synergies rest on some maximum ICT thresholds for complementary policies, which are more apparent in terms of achieving GST mobilisation compared to PCIT. These ICT thresholds are actionable critical limits that should be taken into account by sampled countries when formulating policies that require a combination of industrialisation and ICT efforts to boost tax revenue mobilisation. Per the current 10% level of industrialisation in Africa, our thresholds provide optimism for decision makers who are interested in generating enough resources to accelerate COVID-19 recovery, and the achievement of the ambitious goals enshrined in the UN Agenda 2030 and Africa's Agenda 2063, especially as it pertains understanding what critical masses of ICT require complementary policies in order to boost the targeted outcomes. Our results also indicate that, with concerted efforts in the areas of industrialisation and ICT diffusion, policymakers in Africa can reduce the high aid dependency and the attendant debt sustainability concerns while generating resources necessary for effective participation in the AfCFTA.

We recommend that development partners such as the African Development Bank and the World Bank do not only channel resources to boost the continent's ICT skills, access, usage and digital tax filling platforms but should be aware that beyond some established ICT

thresholds, the attendant institutions should equally channel resources for complementary policies. Particularly, initial efforts at boosting ICT can yield real resource mobilisation dividends if technical, logistical and monetary support is provided to supplement African leader's efforts in improving ICT access, skills, and usage, especially in the hinterlands where lags in ICT adoption are most glaring. However, as ICT penetration intensifies, policymakers should equally be aware of which policy measures are required to maintain the positive synergy from the interaction between industrialisation and ICT dynamics on tax revenue mobilisation. Enhancing governance and financial development which can constitute some relevant complementary policy measures should be considered in future research, not least, because these propositions should withstand empirical scrutiny before being prescribed to policymakers.

Also, for policymakers to take full advantage of the AfCFTA and the projected rebound of FDI inflow to Africa from 2022 to spur industrialisation and revenue mobilisation efforts, we recommend that policymakers support the private sector to build capacity to deepen indigenous forward and backward linkages, and global value chain participation. Further, policymakers should also strive to employ/diffuse ICTs in the civil, public and private sectors to boost revenue generation as this can prove momentous in fighting corruption, tax non-compliance and the reduction in the cost of generating resources through the tax system. Finally, in line with the synergistic relationship between ICT diffusion and industrialisation, we recommend that African leaders develop the region's innovation/tech-hubs, which are essential in translating the industrialisation prospect to realistic national development and revenue generation avenues. The study leaves room for further studies. First, future studies can explore whether the synergistic relationship between industrialisation and ICT diffusion is essential for inclusive growth as well. Also, country-specific and regional studies can be undertaken to establish whether the findings in this study withstand empirical scrutiny when extended to the underlying contexts, contingent on alternative estimation approaches that are relevant to the attendant contexts.

Declaration of conflict of interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Africa Union. (2015). Agenda 2063: Framework document—The Africa We Want, available at: https://au.int/sites/default/files/documents/33126-doc-01_background_note.pdf

African Development Bank (2018). The Africa infrastructure development index, Statistics Department, available at: http://afdb.org (accessed 16 June 2021).

Agbeyegbe, T. D., Stotsky, J., & WoldeMariam, A. (2006). Trade liberalization, exchange rate changes, and tax revenue in Sub-Saharan Africa. *Journal of Asian Economics*, *17*(2), 261-284.

Ahmed, Q. M., & Muhammad, S. D. (2010). Determinant of tax buoyancy: empirical evidence from developing countries. *European Journal of Social Sciences*, *13*(3), 408-418.

Andrés, A. R., Amavilah, V., & Asongu, S. (2017). Linkages between Formal Institutions, ICT Adoption, and inclusive human development in sub-Saharan Africa. In *Catalyzing development through ICT adoption* (pp. 175-203). Springer, Cham.

Akitoby, B. (2018). Five country cases illustrate how best to improve tax collection. *Finance & Development*, *55*(1), 18-21.

Alavirad, A. (2004). "The Effect of Inflation on Government Revenue and Expenditure: The Case of the Islamic Republic of Iran". OPEC *Review,* 27(4), p. 331 – 341.

Andrés, A. R., Amavilah, V., & Asongu, S. (2017). Linkages between formal institutions, ICT adoption, and inclusive human development in sub-Saharan Africa. In *Catalyzing development through ICT adoption* (pp. 175-203). Springer, Cham.

Arellano, M., &Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, *68*(1), 29-51.

Asongu, S. A. (2013). How has mobile phone penetration stimulated financial development in Africa? *Journal of African Business*, *14*(1), 7-18.

Asongu, S. A., Adegboye, A., & Nnanna, J., (2021). Promoting female economic inclusion for tax performance in Sub-Saharan Africa. *Economic Analysis and Policy*, 69 (March), 159-170.

Asongu, S. A., & De Moor, L. (2017). Financial globalisation dynamic thresholds for financial development: evidence from Africa. *The European Journal of Development Research*, *29*(1), 192-212.

Asongu, S. A., & Odhiambo, N. M. (2020a). Remittances, the diffusion of information and industrialisation in Africa. *Contemporary Social Science*, 15(1), 98-117.

Asongu, S. A., & Odhiambo, N. M. (2020b). Inequality thresholds, governance and gender economic inclusion in sub-Saharan Africa. *International Review of Applied Economics*, *34*(1), 94-114.

Bahl, R. W. (1971). A regression approach to tax effort and tax ratio analysis. *Staff Papers*, *18*(3), 570-612.

Benedek, D., Crivelli, E., Gupta, S., &Muthoora, P. (2014). Foreign aid and revenue: Still a crowding-out effect? *FinanzArchiv/public finance analysis*, *70*(1), 67-96.

Brafu-Insaidoo, W. G., & Obeng, C. K. (2012). Import Liberalisation and Import Tariff Yield in Ghana: Estimating Tariff Buoyancy and Elasticity. *American Journal of Economics* 2 (2), 20-25.

Brun, J. F., Chambas, G., Tapsoba, J., &Wandaogo, A. A. (2020). Are ICT's boosting tax revenues? Evidence from developing countries. https://hal.uca.fr/hal-02979897

Chaudhry, I. S., & Munir, F. (2010). Determinants of Low Tax Revenue in Pakistan. *Pakistan Journal of Social Sciences (PJSS)*, *30*(2), 439-452

Chelliah, RJ, Baas, HJ, & Kelly, MR (1975). Tax ratios and tax effort in developing countries, 1969-71. *Staff papers*, *22* (1), 187-205.

Chelliah, RJ (1971). Trends in taxation in developing countries. *Staff Papers*, *18* (2), 254-331.

Cody D. (2018). Creating Fiscal Space. Finance and Development, 55(4), 23-28

Cordella, T., &Ulku, H. (2007). Grants vs. Loans. *IMF Staff Papers*, *54*(1), 139-162.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of Information technology. *MIS Quarterly*, 13(3), 319-340.

De Paepe, G, & Dickinson, B. (2014). Tax revenues as a motor for sustainable development. *The Organisation of Economic Co-operation and Development Development Cooperation report*: 91-97.

Emran, M. S., & Stiglitz, J. E. (2005). On selective indirect tax reform in developing countries. *Journal of Public Economics*, *89*(4), 599-623.

Feltenstein, A., &Tanzi, V. (1992). Tax Policy and Trade Liberalization: An Application to Mexico. *IMF Working Papers*, *1992*(108).

Fosu, A. K., &Abass, A. F. (2019). Domestic credit and export diversification: Africa from a global perspective. *Journal of African Business*, *20*(2), 160-179.

Gaalya, M. S. (2015). Trade liberalization and tax revenue performance in Uganda. *Modern Economy*, *6*(2), 228-244.

Gammage, S., Sultana, N., &Glinski, A. (2020). Reducing Vulnerable Employment: Is there a Role for Reproductive Health, Social Protection, and Labor Market Policy? *Feminist Economics*, *26*(1), 121-153.

Garcia, M. M., & Von Haldenwang, C. (2016). Do democracies tax more? Political regime type and taxation. *Journal of International Development*, *28*(4), 485-506.

Ghura, M. D. (1998). *Tax revenue in Sub-Saharan Africa: Effects of economic policies and corruption*. International Monetary Fund.

Gupta, A. S. (2007). Determinants of tax revenue efforts in developing countries. *IMF Working Papers*, *2007*(184).

Hunady, J., &Orviska, M. (2014). Determinants of foreign direct investment in EU countries do corporate taxes really matter? *Procedia Economics and Finance*, *12*, 243-250.

ICTD/UNU-WIDER. (2021). Government Revenue Dataset. Available at https://www.wider.unu.edu/project/government-revenue-dataset

IMF (2018). *"IMF Annual Report 2018: Building a Shared Future"*. Washington DC. https://www.imfconnect.org/content/dam/imf/SpringAnnual%20Meetings/AM18/Public%20Documents/IMF%202018%20Annual%20Report.pdf

IMF (2011). Revenue Mobilisation in Developing Countries. *Fiscal Affairs Division of the IMF*, Washington DC.

Kaufmann, D., and Kraay A. (2017). *Worldwide Governance Indicators*. Washington, D.C.

Kaufmann, D., Kraay, A., &Mastruzzi, M. (2010). The worldwide governance indicators:

Methodology and analytical issues. *World Bank policy research working paper*, (5430).
Koyuncu, C., Yilmaz, R., &Ünver, M. (2016). Does ICT penetration enhance tax revenue?: Panel Evidence. *Anadolu ÜniversitesiSosyalBilimlerDergisi*, *16*(Özel Sayı), 71-80.
Lotz, J. R., &Morss, E. R. (1970). A theory of tax level determinants for developing countries. *Economic Development and cultural change*, *18*(3), 328-341.
Lufumpa, C. L., Letsara, N., &Saidi, S. (2017). Infrastructure Development Index. *Infrastructure in Africa: Lessons for Future Development*, 25.
Lustig, N., Jellema, J., &Pabon, V. M. (2019). *Leaving No One Behind: Can Tax-Funded Transfer Programs Provide Income Floors in Sub-Saharan Africa?* (No. 85). Tulane University, Department of Economics.
Lustig, N., & Higgins, S., (2018). "The CEQ Assessment: Measuring the Impact of Fiscal Policy on Inequality and Poverty." *Chapter 1 In Commitment to Equity Handbook.*
Estimating the Impact of Fiscal Policy on Inequality and Poverty, edited by N. Lustig. Brookings Institution Press and CEQ Institute, Tulane University.
Mallick, H. (2021). Do governance quality and ICT infrastructure influence the tax revenue mobilisation? An empirical analysis for India. *Economic Change and Restructuring*, *54*(2), 371-415.
Mascagni, G., Moore, M., &McCluskey, R. (2014). Tax Revenue Mobilisation In Developing Countries: Issues and Challenges. *European Union* (Belgium).
McCluskey, W., & Huang, C. Y. (2019). The role of ICT in property tax administration: Lessons from Tanzania. *CMI Brief*, *2019*(06).
Morrissey, O. (2015). Aid and government fiscal behaviour: Assessing recent evidence. *World Development*, *69*, 98-105.
Morrissey, O., & Torrance, S. (2015). Aid and taxation. In *Handbook on the economics of foreign aid*. Edward Elgar Publishing.
Obeng, K. C., Yeltulme Mwinlaaru, P., & Kwesi Ofori, I. (2021). Global Value Chain Participation and Inclusive Growth in Sub-Saharan Africa. *Isaac, Global Value Chain Participation and Inclusive Growth in Sub-Saharan Africa (May 15, 2021)*.
OECD (2020), Mobilising Tax Revenues To Finance The Health System in Côte d'Ivoire, OECD, Paris. Retrieved from: www.oecd.org/tax/tax-policy/mobilising-tax-revenues-to-finance-the-health-system-in-cote-ivoire.htm
OECD (2019). Tax Revenue Trends in the OECD Countries. Revenue Statistics 2019
OECD, (2014a). "Domestic Revenue Mobilization in Fragile States. OECD Publishing, 2, rue André-Pascal. Paris. CEDEX 16
OECD (2014b). Tax Revenue Mobilisation In Developing Countries: Issues And Challenges.
Ofori, I. K., Obeng, C. K., & Mwinlaaru, P. Y. (2021). Effect of exchange rate volatility on tax revenue performance in Sub-Saharan Africa.
Ofori, I., & Asongu, S. (2021). ICT Diffusion, Foreign Direct Investment and Inclusive Growth in Sub-Saharan Africa. *ICT Diffusion, Foreign Direct Investment and Inclusive Growth in Sub-Saharan Africa (May 13, 2021)*.
Ofori, I., Obeng, C. K., &Armah, M. K. (2018). Exchange rate volatility and tax revenue: Evidence from Ghana. *Cogent Economics & Finance*, *6*(1), 1537822.
Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM

in Stata. *The Stata Journal*, *9*(1), 86-136.

Taiwo, F. H. (2018). An empirical investigation of the determinants of value added tax (VAT) in Southwestern Nigeria. *International Journal of Advances in Agriculture Sciences*.

Tanzi, V. (1992). Theory and policy: a comment on Dixit and current tax theory. *Staff Papers*, *39*(4), 957-966.

Teera, J. M., & Hudson, J. (2004). Tax performance: a comparative study. *Journal of international development*, *16*(6), 785-802.

Tchamyou, V. S. (2019). The role of information sharing in modulating the effect of financial access on inequality. *Journal of African Business*, *20*(3), 317-338.

Tchamyou, V. S., & Asongu, S. A., (2017). Information Sharing and Financial Sector Development in Africa, *Journal of African Business,* 18(7), 24-49.

Tchamyou, V.S., Asongu, S.A. & Odhiambo, N.M. (2019a). The Role of ICT in Modulating the Effect of Education and Lifelong Learning on Income Inequality and Economic Growth in Africa, *African Development Review*, 31(3), 261-274.

Tchamyou, V. S., Erreygers, G., & Cassimon, D. (2019b). Inequality, ICT and financial access in Africa. *Technological Forecasting and Social Change*, *139*, 169-184.

Thornton, J. (2014). Does foreign aid reduce tax revenue? Further evidence. *Applied Economics*, *46*(4), 359-373.

UNCTAD. (2021). Global Trade Update. February 2021.Geneva: United Nations Commission On Trade and Development.

World Bank. (2021). World Development Indicators. April 2021. *Washington, DC:* World Bank.

World Bank (2019). Mobilizing Tax Resources to Boost Growth and Prosperity in Sub-Saharan Africa.*https://www.worldbank.org/en/results/2019/09/09/mobilizing-tax-resources-to-boost-growth-and-prosperity-in-sub-Saharan-Africa*

Zucman, G. (2015). The Hidden Wealth of Nations: The Scourge of Tax Havens, *Chicago: University of Chicago Press.*

Table A.1: Pairwise correlation matrix of variables, 1996 – 2020

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) PCIT	1												
(2) GST	0.713***	1											
(3) Industrialisation	0.161**	0.267***	1										
(4) FDI	-0.0673	-0.0187	-0.223***	1									
(5) Economic growth	-0.0656	-0.0890	-0.113*	0.148**	1								
(6) Vulnerable employment	-0.476***	-0.421***	-0.217***	0.0338	0.166**	1							
(7) Foreign aid	-0.284***	-0.195***	-0.162**	0.274***	0.000828	0.327***	1						
(8) Government effectiveness	0.471***	0.493***	0.250***	-0.0599	-0.0353	-0.775***	-0.313***	1					
(9) Inflation	0.0250	-0.121*	-0.138**	0.110*	0.0302	0.0546	0.205***	-0.0483	1				
(10) ICT diffusion	0.333***	0.254***	0.203***	0.0245	-0.125*	-0.621***	-0.379***	0.522***	0.134*	1			
(11) ICT access	0.382***	0.338***	0.0378	0.00173	-0.204***	-0.456***	-0.365***	0.380***	-0.238***	0.546***	1		
(12) ICT usage	0.305***	0.349***	0.0736	-0.00574	-0.191***	-0.532***	-0.219***	0.467***	-0.123*	0.457***	0.732***	1	
(13) ICT skills	0.451***	0.429***	0.124*	-0.00162	-0.175***	-0.834***	-0.347***	0.703***	-0.0591	0.612***	0.623***	0.670***	1

Table A.2: Bivariate results on the effects of industrialisation and ICT diffusion on PCIT

Variables	(1)	(3)	(4)	(5)	(6)
Industrialisation	0.2449**				
	(0.0970)				
ICT diffusion		0.1311***			
		(0.0191)			
ICT usage			0.4571***		
			(0.0373)		
ICT access				0.1254***	
				(0.0100)	
ICT skills					0.2632***
					(0.0215)
Constant	8.2406***	5.1234***	7.0543***	5.5374***	-0.2244
	(1.0772)	(1.0695)	(0.4680)	(0.6032)	(1.0410)
Observations	931	756	1,050	947	581
R-squared	0.0068	0.0586	0.1256	0.1421	0.2054
Adjusted R-squared	0.00574	0.0574	0.125	0.141	0.204
F-statistic	6.37**	46.93***	150.56***	156.58***	149.64***
P-Value	0.0118	0.0000	0.0000	0.0000	0.0000

Note: PCIT is Profits, Corporate and Income Taxes

Standard errors in parentheses

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

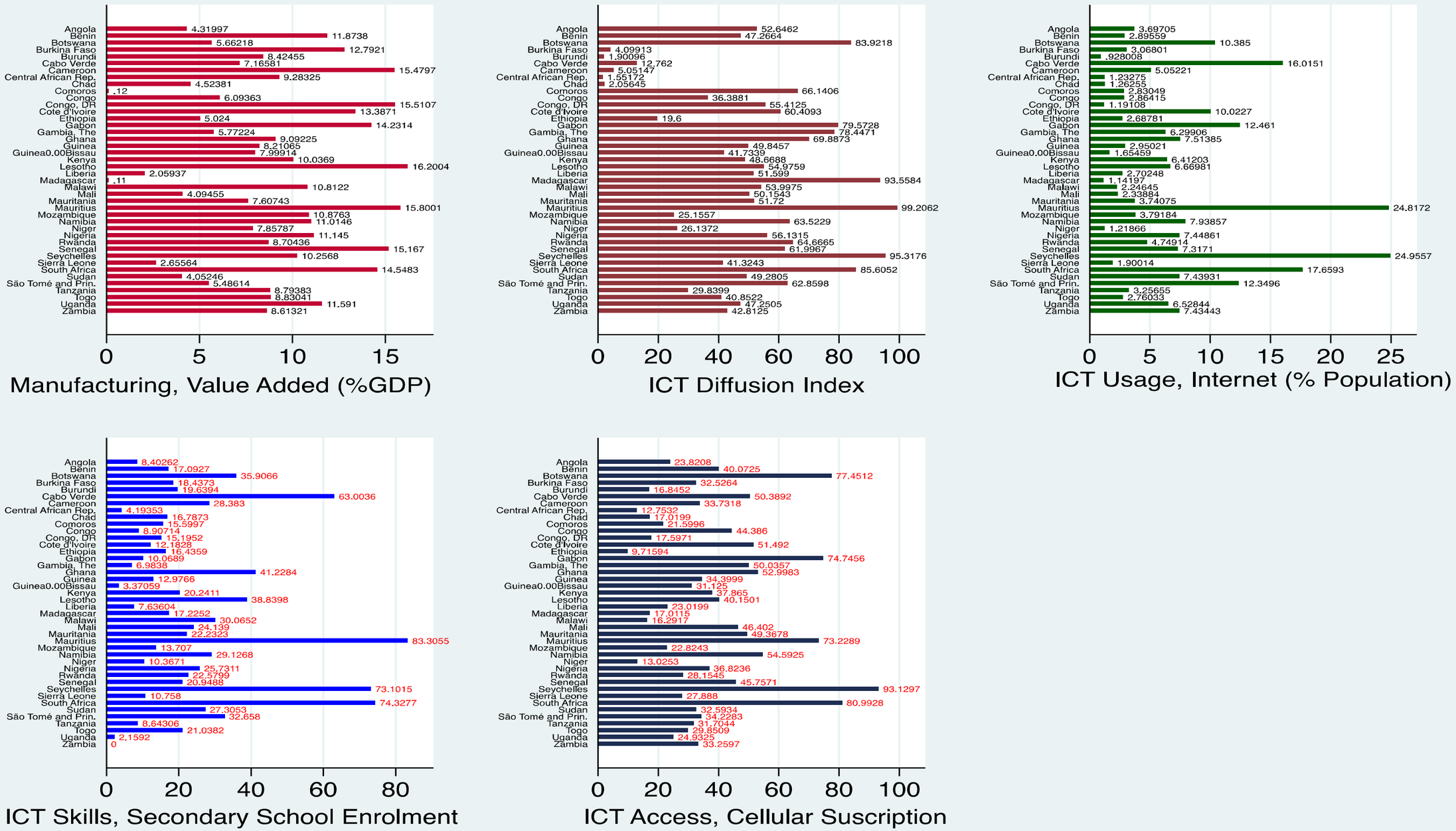

Figure A.1: Average Within Country Industrialisation and ICT Diffusion, Access, Usage, and Skills in Africa, 1996 – 2020

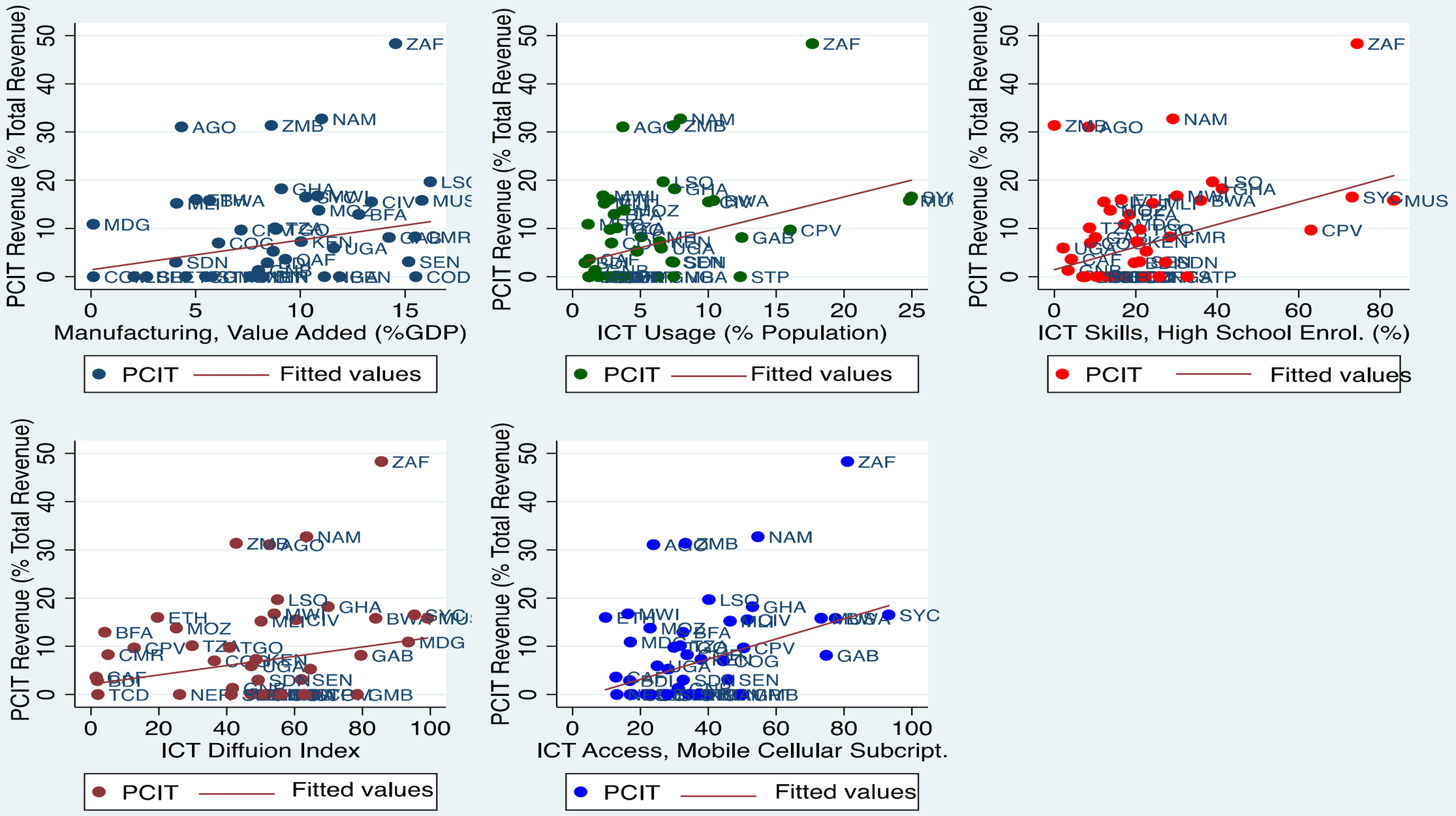

Figure A.2: Average Within Country Industrialisation and ICT Diffusion, Access, Usage, and Skills in Africa, 1996 – 2020