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Towards efforts to enhance tax revenue mobilisation in Africa: Exploring the interaction between industrialisation and digital infrastructure

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Abstract

Motivated by the momentous rise in the new economy, the implementation of the African Continental Free Trade Area agreement, and the expected rebound of foreign direct investment to Africa from 2022, this study examines the joint effects of industrialisation and digital infrastructure on resource mobilisation in Africa. To this end, we mine data for 42 African countries for the analysis. The results, which are based on the system GMM estimator show that although unconditionally both industrialisation and digital infrastructure enhance (i) goods and services tax (GST), and (ii) profits, corporate and income tax (PCIT) mobilisation efforts in Africa, the effects of the former is rather remarkable in the presence of the latter. Particularly, we find that although all our digital infrastructure dynamics 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, there has been a long-standing problem in African countries, notably: *inequality*, *informality*, *debt burden*, and *aid dependency*. Currently, Africa has entered into a period where resources have become crucial than ever. First, as the Organisation for Economic Co-operation and Development (OECD) (2020, 2019), the World Bank (2020, 2019) and the United Nations (2015) reckon, adequate resources are needed to fund policies and strategies underpinning 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 narrative above boils down to the effectiveness of the African tax system in generating the needed resources to fund projects essential for resilient growth trajectories (De Paepe & Dickinson 2014, Mascagni et al. 2014; Piancastelli & Thirlwall 2021; IMF 2018). Indeed, the unable nature 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 system thus remains a key objective. However, information gleaned from the 2020edition of the OECD Revenue Statistics indicates that, compared to other continents, Africa reports low tax revenue mobilisation effort. 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 & Higgins, 2018; OECD, 2014b).

[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%.

Aside from the contribution of aid[2] to Africa's development course, there are two key contemporary development tendencies in Africa— the momentous rise in (i) information and communication technology (ICT) adoption[3] and (ii) economic integration, evidenced by the African Continental Free Trade Area (AfCFTA) that can be leveraged to improve the continent's tax revenue generation efforts. 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 & Asongu, 2021; Asongu &Nwachukwu, 2018). Besides, the new economy can also be leveraged to broaden the tax net, 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 digital infrastructure in driving the SSA's industrialisation agenda and the enhancement of tax revenue generation effort is on the cards.

For instance, industrialisation presents opportunities for accelerating Africa's efforts aimed at reducing informality and precarious employment, which as Gupta (2007), and Teera and Hudson (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 digital infrastructure interacts with industrialisation to promote 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 digital infrastructure are missing in the extant scholarship.

[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.

These two voids in the literature are the motivation for this study. Accordingly, we test two hypotheses. First, we test whether unconditionally, both digital infrastructure (composed of ICT access, ICT usage and ICT skills) and industrialisation spur GST and PCIT revenue mobilisation in Africa. Second, we test whether digital infrastructure amplify the effect of industrialisation on GST and PCIT revenue mobilisation in Africa.

Our contribution is based on data for 42 African countries and the dynamic system GMM estimator. First, we find that although unconditionally both industrialisation and digital infrastructure enhance GST, and (ii) PCIT mobilisation efforts in Africa, the effect of the former is rather notable in the presence of the latter. Second, we find that while all our digital infrastructure dynamics amplifies the effect of industrialisation on GST, only ICT usage and ICT skills matter for PCIT. Third, the study unveils some critical ICT thresholds for complementary policies. The contributions we make could prove valuable for aiding African leaders generate adequate resources needed for accelerating COVID-19 recovery as well as social and economic overheads. It 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 digital infrastructure. 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 background and empirical literature review

2.1 Theoretical linkages between digital infrastructure, industrialisation and tax revenue

The Technology Acceptance Model (TAM) predicts that when economic agents are offered new technologies, several factors influence their choice as to when and how they use it (Davis, 1989). This implicitly points to the role of the digital infrastructure in enhancing work performance. In another breath, the model indicates that a good tax administration should consider the ability to pay, the convenience of fulfilling such obligations, and the cost to tax administrators for levying taxes. It is in this regard that digital infrastructure can play a role in enhancing revenue administration by aiding tax authorities to achieve better compliance of taxes, detect fraud and build systems that limits opportunities for tax system corruption (McCluskey & Huang, 2019). In the remit of industrialisation, also, the TAM can be viewed as a channel through which technologies improve the efficiency and the performance of

firms. By extension, such efficiency engenders favourable industrialisation outcomes from which tax revenue is derived.

In the light of the above, the intuition for the study is built on the argument that although industrialisation can enhance tax revenue mobilisation efforts (Asongu et al., 2021), digital infrastructure greases the process of industrialisation (Asongu & 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

In this section, we present a survey of prior studies interrogating the effects of industrialisation or digital infrastructure on tax revenue mobilisation. For instance, Mallick (2021) uses time-series data spanning 1990-2018 for India and finds evidence from the autoregressive distributed lag (ARDL) estimation technique to show that digital infrastructure does not have a significant positive effect on overall tax revenue collection. The result, however, suggest possible in the presence of governance quality, digital infrastructure improves tax revenue performance. Employing an unbalanced panel of 157 countries for the period 1998-2013, 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) although 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 countries. 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. From the pioneering works of Gupta (2007), Ghura (1998), Tanzi (1992), Lotz and Morss (1970), Bahl (1971), Chelliah *et al*. (1975), and Morrissey (2015), we gather that factors such as political stability, corruption, accountability, trade liberalisation, foreign aid, and economic development influence tax revenue generation in the developing world. Empirical evidence in Garcia and von Haldenwang (2016) also indicates that political regimes have implications 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 in developing countries, the agricultural sector hampers tax revenue mobilisation efforts as it is informal and records of activities are not usually kept.

Further, there is the evidence that 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 a more recent contribution by Ofori et al.(2022, 2018) and Terefe and Teera (2018), we gather that key macroeconomic instability in the form of exchange rate volatility and inflation are harmful to tax revenue generation efforts.

2.4 The ICT-industrialisation-tax revenue relationship

While sceptics contend that digital infrastructure can be disastrous to resource mobilisation efforts in the developing economies if not properly applied by taxpayers and administrators[5]

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

(Akitoby 2018), there is also the argument that it can provide real opportunities for broadening the tax net, addressing tax evasion, and tax system corruption (McCluskey & Huang, 2019). Despite the consensus that the developing countries failed to adapt to the industrial revolution, the story is quite different from the current wave of the digital revolution (Asongu & Ofori 2021a; Andrès et al. 2017; Asongu, 2013). Indeed, in a continent where informal activities are widespread and formal activities are generally analogue-based, the new economy can prove crucial for (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.

Additionally, considering efforts on the part of African leaders in improving the institutional fabric of Africa[6], and the implementation of the AfCFTA, policies aimed at developing the continent's industrial base and digital infrastructure, could prove relevant for resource mobilisation efforts. Indeed, the graphical relationships between industrialisation, digital infrastructure and our tax indicators (i.e., GST and PCIT) as apparent in Figure 1 and Figure A.1, shows that these gains are plausible.

[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)

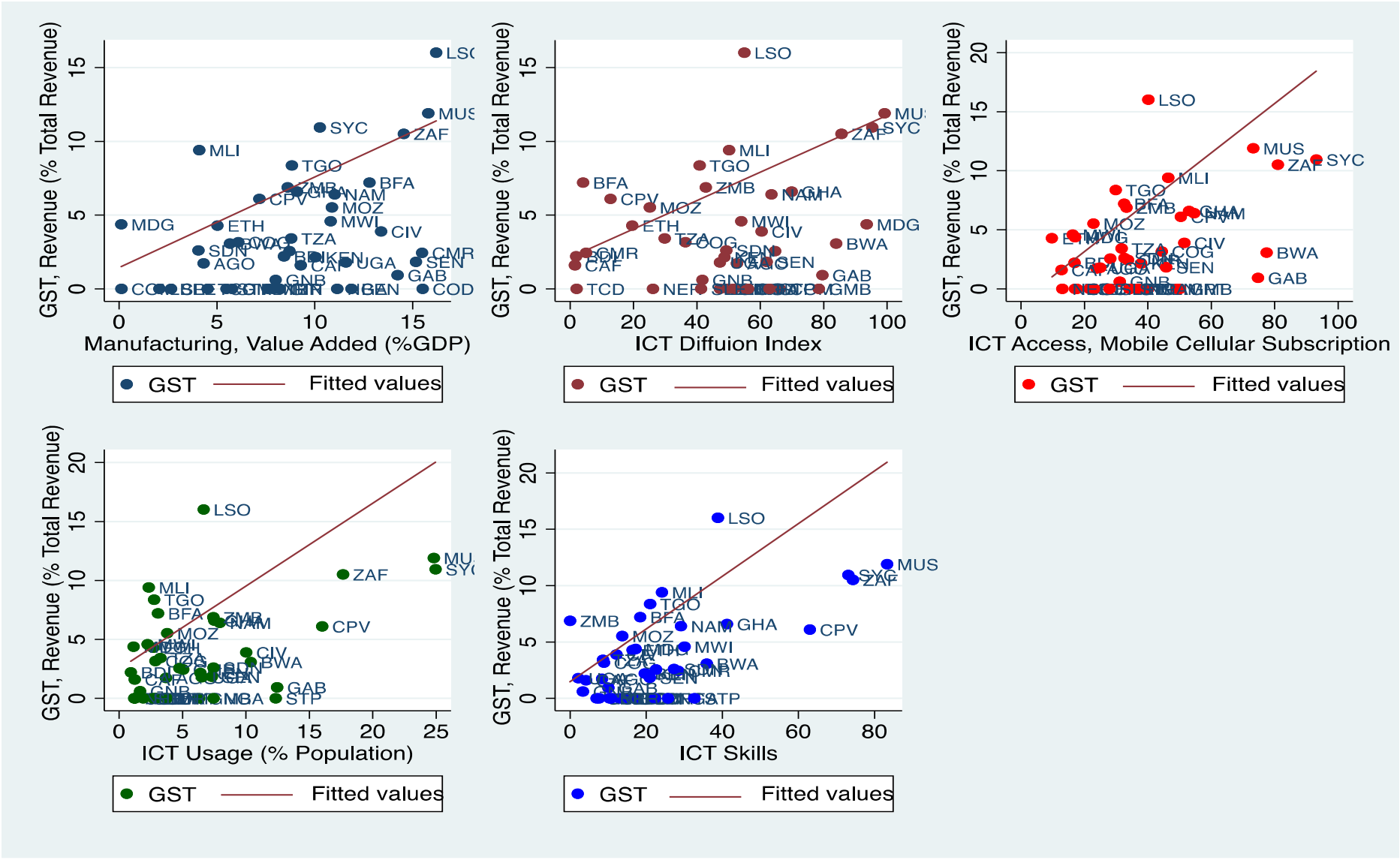

Figure 1: Within Country PCIT, ICT Diffusion and Industrialisation Nexuses In Africa, 1996 – 2020

3.0 Data and methodology

3.1 Data and variable justification

The study employs a panel dataset spanning 1996-2020 for42African countries [7] for the analysis. Two main tax revenue indicators, namely, GST and PCIT, are used as outcome variables. Both GST and PCIT are sourced from the World Development Indicators (WDI) and the UNU-WIDER Government Revenue Dataset (World Bank, 2021; ICTD/UNU-WIDER, 2021). The variables of interest in this study are digital infrastructure, proxied by ICT diffusion index (including its key sub-components of access, usage and skills) and industrialisation. While we proxy the latter by manufacturing value-addition 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 digital infrastructure from the African Infrastructure Knowledge Program (Africa Development Bank, 2018; Lufumpaet al. 2017).

Our attention 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 to take into account the (i) nature of the economies under consideration and (ii) mitigation of omitted variable bias. These variables are economic development, vulnerable employment, foreign aid, inflation, foreign direct

[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.

investment(FDI) and government effectiveness. The literature is divided on the implication of FDI for revenue generation efforts in developing countries (Hunady & Orviska, 2014). While in one breath, the literature indicates that FDI enhances tax revenue efforts (Ahmed &Muhammad 2010; Agbeyegbe et al., 2006), a section also reports a suppressing effect due to tax exemption and offshore practices (Zucman, 2015). Also, we consider economic development as it presents opportunities for labour market participation in a continent where unemployment is high, and thus the growing capacity of tax authorities to levy and collect taxes (see, Ofori et al., 2022; 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, breeds tax non-compliance, tax system corruption, and the high marginal cost of levying taxes (Gammage et al., 2020; Chaudhry & Munir, 2010; Emran & 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 mobilisation (Morrissey &Torrance, 2015; Morrissey, 2015; Thornton, 2014). On the other hand, evidence also shows that due to repayment conditions attached to aid, it can induce revenue generation efforts (Benedek et al., 2014; Cordella & 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 currencies), it can also prove deleterious to tax revenue mobilisation efforts through macroeconomic instability (Ofori et al., 2018). Finally, we control for government effectiveness so as 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 & Kraay, 2017; Kaufmann et al., 2010). The description of the variables is provided in Table 1.

Table 1: Definitions and sources of variables

Variables	Descriptions	Sources
Dependent variables		
Goods and service tax	A value-added tax levied on most goods and services sold for domestic consumption, which 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/ UNU-WIDER
Profit, income and corporate tax	Tax levied on actual net income, on profits of corporation and gains (% revenue)	WDI/ UNU-WIDER
Variables of interest		
Industrialization	Manufacturing, value added (% GDP)	WDI
ICT Diffusion	A 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; and ICT is Information and Communication Technology.
Source: Authors' construct, 2022

3.2 Estimation strategy

The theoretical foundation of the study is anchored in the argument that digital infrastructure and industrialisation are growth, employment and revenue mobilisation enhancers (McCluskey &Huang, 2019; Davis, 1989). That said, we turn attention to the empirical rigour of the study, which begins with a test of the bivariate relationships between the outcome

variables (i.e., GST, PCIT),our digital infrastructure dynamics, and industrialisation. We specify our bivariate models as apparent in Equations (1) and (2):

$$tax_{it} = \lambda_0 + \delta_1 ict_{it-1} + \mathcal{I}_i + \mu_t + \varepsilon_{it} \quad (1)$$

$$tax_{it} = \lambda_0 + \delta_1 indus_{it-1} + \mathcal{I}_i + \mu_t + \varepsilon_{it} \quad (2)$$

In the next step, we specify a tax model, which depends on our set of control and key variables as seen in Equation (3).

$$tax_{it} = \lambda_0 + \delta_1 tax_{it-1} + \beta_1 ict_{it} + \beta_2 indus_{it} + \beta_3 gov_{it} + \beta_4 aid_{it} + \beta_5 gdpg_{it} + \beta_6 inf_{it} + \beta_7 vul_{it} + \beta_8 fdi_{it} + \beta_9 (ict_{it} \times indus_{it}) + \mathcal{I}_i + \mu_t + \varepsilon_{it} \quad (3)$$

A conspicuous empirical concern regarding the estimation of Equation (3) 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$tax_{it-\tau}$ dependson $\varepsilon_{it-\tau}$, 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 technique is seen in (Ofori & Grechyna, 2021; Ofori et al. 2022a,b; Tchamyou, 2019; Asongu & Nwawchukwu, 2018). First, the sampled country (i.e., N) 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 GMM technique is satisfied. Second, the panel dataset also reveals cross-country variation which is accounted for in the estimation (Asongu & Odhiambo, 2020b; Ofori et al. 2022c; Tchamyou & Asongu, 2017). Consequently, we follow the Arellano and Bover (1995) approach by transforming Equation (3) into Equations (4) and (5) to capture the level and first difference, which encapsulate the dynamic system GMM estimation method.

$$tax_{it} = \lambda_0 + \delta_1 tax_{it-1} + \beta_1 indus_{it} + \beta_2 ict_{it} + \sum_1^6 \theta_k V_{kit-\tau} + \mathcal{I}_i + \mu_t + \varepsilon_{it} \quad (4)$$

$$tax_{it} - tax_{it-\tau} = \delta_1 (tax_{it-\tau} - tax_{it-2\tau}) + \beta_1 (indus_{it} - indus_{it-\tau}) + \beta_2 (ict_{it} - ict_{it-\tau}) + \sum_1^6 \theta_k (V_{kit-\tau} - V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \quad (5)$$

Next, to capture the hypothesised joint effect of industrialization and ICT diffusion on tax mobilisation efforts, Equation (5) is modified to obtained Equation (6).

$$tax_{it} - tax_{it-\tau} = \delta_1(tax_{it-\tau} - tax_{it-2\tau}) + \beta_1(indus_{it} - indus_{it-\tau}) + \beta_2(ict_{it} - ict_{it-\tau}) + \beta_3(ict_{it} \times indus_{it} - ict_{it-\tau} \times indus_{it-\tau}) + \sum_1^6 \theta_k(V_{kit-\tau} - V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \quad (6)$$

Where, $\boldsymbol{tax_{it}}$is the tax revenue performance 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 (overall), ICT usage, ICT access and ICT skills. Also**,** $\boldsymbol{ict \times indus}$is the interaction term for our ICT dynamics 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 industrialisation, ICT diffusion, economic growth, FDI and government effectiveness to enhance 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 ICTs,an expression of the partial effect from Equation (6) is specified in Equation (7).

$$\frac{\partial(tax_{it})}{\partial(indus_{it})} = \beta_1 + \beta_9(\overline{ict_{it}}), \quad (7)$$

where,$\overline{ict_{it}}$ is the mean of our various ICT diffusion indicators (i.e., ICT diffusion (overall), ICT access, ICT usage and ICT 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. The data as presented in Table 2 show a mean PCIT 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, 2022

Also, the data reveal a mean GST 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, ICT access, and ICT 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 study 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 (including the subcomponents of access, usage, skills),industrialisation, and the outcome variable (i.e., GST and PCIT).

Table 3: Bivariate results on the effects of industrialisation and digital infrastructureon 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.

4.3 Presentation of Results

4.3.1 Effects of industrialisation and digital infrastructure on GST mobilisation

This section presents the findings on the conditional and unconditional effects of industrialisation and digital infrastructure on GST (see Table 4). Following the extant scholarship on the GMM approach (Asongu &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. First, per the AR(2) p-values, our estimates are free from second-order serial autocorrelation in the residuals. Second, there is strong evidence that the instruments used in the estimation are valid since all the Hansen p-values are statistically 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.

Table 4: GMM results for the effects of industrialisation and digital infrastructure 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*

On the first hypothesis of the paper, we provide evidence in Table 4 to show that industrialisation and digital infrastructure 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 industrialisation improves productivity, which signifies economic agents' growing access to goods and services 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 digital infrastructure (overall), ICT access, ICT usage and ICT skills for 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 channel for enhancing GST mobilisation in Africa. 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 of this study, we investigate the conditional effect of industrialisation on GST mobilisation. We find strong empirical evidence to show that although industrialisation promotes GST mobilisation in Africa, some additional gains are evident in the presence of ICTs. The uniqueness of our results is that all our ICT dynamics are effective moderators for the effect of industrialisation on GST mobilisation. Particularly, we find that ICT access is the most important channel for interacting with industrialisation to induce GST revenue mobilisation in Africa. In terms of the magnitudes, wee report a net effect 0.02 for the industrialisation and ICT access interaction, compared to 0.03, for that of the industrialisation-ICT usage pathway. These net effects are computed following Equations (7).

First, for the ICT diffusion and industrialisation interaction in Column 7, wecompute a net effect of 1.928, . This is calculated as:

$$\frac{\partial(GST)}{\partial(indus)} = 2.2618 + (-0.0476 \times 6.997) = 1.9287,$$

where 2.2618 is the unconditional effect of industrialisation; the conditional effect of industrialisationis -0.047, and 6.997 is the mean of ICT diffusion as apparent in Table 2.

We follow similar computations in deriving the net effects for the industrialisation-ICT usage, industrialisation-ICT access, and industrialisation-ICT skills interaction terms. These results are presented in respective terms as:

$\frac{\partial(GST)}{\partial(indus)} = 0.9215 + (-0.0106 \times 41.864) = 0.4777$, where 0.9215is 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 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 developing countries. Despite modest effects, the results suggest that both FDI and economic growth promote GST revenue mobilisation. For instance, the results in Column 8show that, for every 1% increase in FDI and economic growth, GST increases 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 can provide easier avenues for tax

administrators to generate resources to fund developmental projects. This is in line with Obeng et al. (2022) who argue that FDI can boost productivity in host economies, with the attendant benefits being a rise in (i) global value chain participation, (ii) domestic commercialisation, and (iii) tax revenue generation. Also, the GST revenue inducing effect of economic growth centres on empirical evidence by Ofori et al. (2018) 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).

4.3.2Effects of industrialisation and digital infrastructure on PCIT mobilisation

The findings in Table 5 reveal the effects of industrialisation and digital infrastructure on PCIT generation in Africa. Concerning the first hypothesis of the study, we find that irrespective of the type of model specification, industrialisation is remarkable in inducing PCIT revenue mobilisation. 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 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.

Table 5: GMM results for the effects of industrialisation and digital infrastructure 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*

These findings also point to the plausible game-changing impact of the AfCFTA in boosting Africa's revenue generation efforts. 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 to affirm our second hypothesis. 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 2.

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 its indirect effect of industrialisation, and 41.778 is the average value for ICT usage.

The uniqueness of these findings is that although industrialisation enhances PCIT revenue mobilisation in Africa, additional gains can be attained with the enhancement of 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, we find that 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 are relevant (see Table 5). Considering the favourableeffect 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 are our results on the remarkable effects of ICTs in resource generation. The optimism with ICTs is that their adoption has risen remarkably in Africa since 2003 (Ofori & Asongu, 2021; Ofori et al., 2022d, 2021). In locations like Africa where informality and institutions are generally weak, ICT diffusion can promote effective governance and accountability. For instance, 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 hypotheses 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 of15.217 (% 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 the respective ICT variables as apparent in Table 2, 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 Concluding remarks and policy recommendations

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 – 2020for 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 digital infrastructure enhance GST and PCIT revenue mobilisation in Africa, the effects of the former are rather remarkable in the presence of the latter. First, considering direct taxes (PCIT), we show that only ICT usage and ICT skills interact with industrialisation to boost 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 interactive effects 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 to 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 Banks should not only channel resources to boost the continent's digital infrastructure, and digital tax filling platforms but should also be aware that beyond the 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, ICT skills, and ICT 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 interactive effect between industrialisation and our digital infrastructure dynamics.

Also, for policymakers to take full advantage of the AfCFTA and the predicted rebound of FDI inflow to Africa from 2022 to spur industrialisation and revenue mobilisation efforts, we recommend that policymakers support the private sector n building capacity. This

can go a long way to deepen indigenous forward and backward linkages, and global value chain participation. 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 positive interactive effect 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.

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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 for the effects of industrialisation and digital infrastructureon 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*

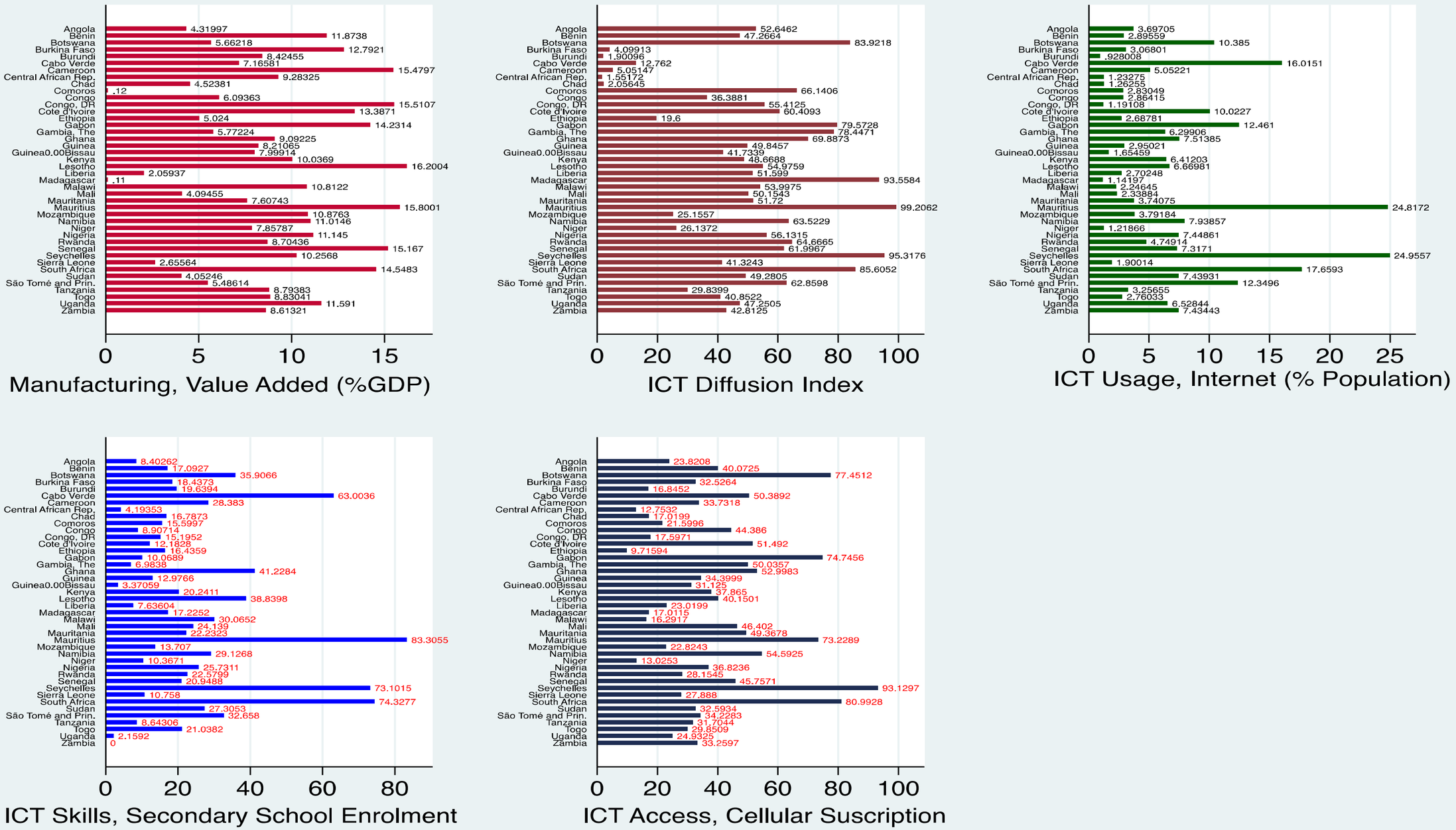

Figure A.1: Average In-country Industrialisation and ICT Diffusion, Access, Usage, and Skills in Africa, 1996 – 2020

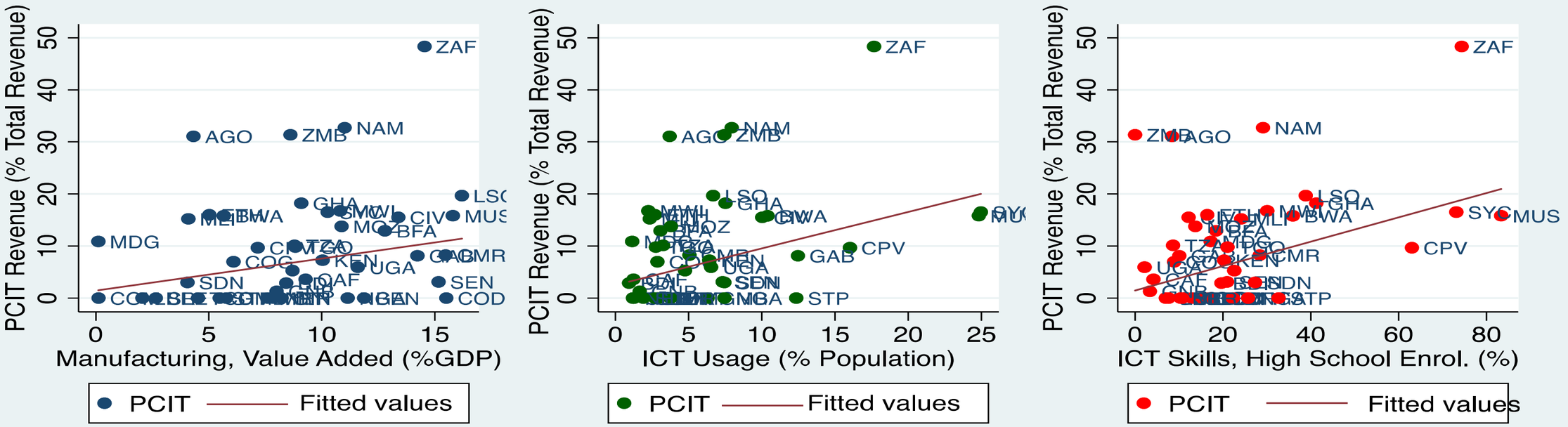

Figure A.2: Average In-country Industrialisation and ICT Diffusion, Access, Usage, and Skills in Africa, 1996 – 2020