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The Effect of ICT on Tax Revenue Mobilization: A Global Perspective

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Abstract

This paper examines the effect of information and communication technologies (ICT) on tax revenue mobilization (TRM) in 98 countries over the period 2008–2020. Using a multidimensional ICT index from UNCTAD and employing both fixed-effects OLS and System-GMM estimators, the study provides consistent evidence that ICT significantly enhances tax revenue mobilization. The findings remain robust when alternative ICT proxies and disaggregated tax indicators are used, and when endogeneity is addressed through Lewbel's heteroskedasticity-based IV–2SLS estimator. The analysis further reveals that ICT influences tax performance not only directly but also indirectly through institutional quality and financial development, as shown by formal mediation tests. These results underscore the critical role of digitalization in strengthening fiscal capacity. Policy implications suggest that expanding digital infrastructure, accelerating the dematerialization of tax procedures, and improving institutional effectiveness are essential for enhancing tax revenue performance.

Keywords: ICT, Tax Revenue Mobilization (TRM), Digitalization, OLS, System-GMM, Mediation Mechanisms.

1. Introduction

Domestic revenue mobilization has become a central pillar of development policy debates, particularly in low- and middle-income countries facing chronic fiscal constraints, rising development needs, and persistent vulnerabilities. Despite decades of reforms, tax performance in developing countries remains structurally weak. On average, tax revenues account for barely 11% of GDP, compared with nearly 20% in advanced economies (Okunogbe & Santoro, 2022). This gap is of profound consequence: achieving at least 15% of GDP in tax revenues is widely recognized as a minimum threshold for building capable states and financing the Sustainable Development Goals (Benitez et al., 2023). Weak tax systems undermine governments' ability to stabilize debt, invest in climate adaptation, strengthen public services, and reduce dependence on external financing.

The COVID-19 pandemic further exacerbated these vulnerabilities. According to the IMF (2023), developing countries experienced sharp declines in tax revenues due to widespread informality, limited administrative capacity, narrow tax bases composed largely of micro and small enterprises, and structural weaknesses in digitalization and automation. The temporary revenue shock reflected both domestic fragilities and the global economic contraction (Citaristi, 2022). Nevertheless, fiscal revenues rebounded in most countries in 2021–2022, returning to pre-pandemic levels as economic activity normalized (Aslam et al., 2022). Importantly, the crisis accelerated the digital transformation of tax administrations, which increasingly relied on information and communication technologies (ICTs) to expand taxpayer services, automate procedures, and enhance administrative monitoring (Mengistu & Nose, 2023; Mascagni et al., 2023; IMF Fiscal Monitor, 2025; Brun et al., 2020).

Digitalization has therefore become a cornerstone of modern fiscal governance. Over the past two decades, ICT has transformed tax administration worldwide. Electronic invoicing (e-invoicing) is now widely implemented in emerging and advanced economies, enabling real-time data reporting, automated audit trails, and reductions in tax evasion (Barreix et al., 2018; Pomeranz & Vila-Belda, 2023). Recent evidence demonstrates that e-invoicing reforms substantially reduce VAT gaps in developing economies (De Paola & Santoro, 2025). Parallel reforms include the integration of biometric identification, interoperability of administrative databases, and automated verification systems, increasingly adopted in countries such as India, Brazil, China, and Rwanda (Shahin & Zheng, 2018, 2020; World Bank GovTech Update, 2025). ICT diffusion, mobile telephony, internet connectivity, broadband, and digital identity systems have thus become foundational to digital public finance infrastructures (UNCTAD, 2022; OECD Digital Government Index, 2023).

These transformations resonate with long-standing theoretical debates. A pessimistic perspective emphasizes the challenges posed by informality, governance deficits, weak enforcement capacity, and institutional fragility, which may attenuate the benefits of taxation and ICT adoption alike (Brun & Chambas, 2014; Elgin, 2013; Moore et al., 2023). Conversely, an optimistic view highlights the potential of taxation to promote job creation, reduce inequalities, strengthen productivity, and foster digitally enabled economic ecosystems particularly when supported by robust ICT systems that reduce compliance costs, expand tax bases, and enhance transparency (Losch et al., 2012; Brun et al., 2020; Bahl & Bird, 2022). Empirical studies increasingly suggest that ICT strengthens tax performance by improving information quality, administrative efficiency, third-party reporting, and monitoring capacity (Nkoa & Song, 2022; Kwon, 2025; Osei & Martínez, 2025). However, results remain heterogeneous across countries, technologies, and institutional contexts (Del Gaudio et al., 2020; Alm & Soled, 2023; Yilmaz & Duran, 2024).

The broader literature on tax revenue mobilization can be grouped into three streams: the construction of tax performance measures (Timmons, 2010; Kumar et al., 2016); the consequences of taxation for growth, structural transformation, and state capacity (Easterly & Rebelo, 1993; Prichard et al., 2018); and the determinants of tax revenue, including GDP per capita, trade openness, FDI, natural resources, inflation, and urbanization (Asongu et al., 2021; Drummond et al., 2012; Fenochietto & Pessino, 2013). More recent contributions emphasize the importance of institutional quality, public–private partnerships, and digital public finance infrastructures (Vlachaki, 2015; Nkoa & Song, 2022; Ndulu, 2022; Lierse & Seelkopf, 2023; World Bank GovTech Report, 2024).

Despite significant progress, important gaps persist. First, most existing studies rely on single ICT proxies (mobile phones or internet penetration), which do not capture today's multidimensional digital ecosystems. Second, available evidence is geographically fragmented, limiting cross-country generalization. Third, although institutions and financial systems are widely cited as mechanisms through which ICT affects tax capacity, very few studies formally quantify these channels or evaluate their relative importance. Fourth, recent assessments highlight that the theoretical foundations linking digitalization to fiscal capacity remain insufficiently articulated and empirically underdeveloped (Alm & Soled, 2023; Prichard, 2023; Chen & Prichard, 2025). Fifth, endogeneity arising from reverse causality and omitted variables continues to undermine identification in many empirical studies.

This study contributes to filling these gaps in five ways. First, it constructs a multidimensional ICT index combining mobile penetration, internet usage, broadband subscriptions, and fixed-line connectivity. Second, it uses a broad panel of 98 countries from 2008 to 2020, covering both

the expansion of digital tax systems and the post-COVID acceleration of digital reforms. Third, it disaggregates tax revenue into direct, indirect, and non-resource components to reveal heterogeneous effects. Fourth, it introduces a formal mediation framework to quantify the institutional (regulatory quality, government effectiveness, control of corruption, voice and accountability) and financial (financial development) channels through which ICT affects tax mobilization. Fifth, it adopts a robust econometric approach combining fixed-effects OLS, System-GMM with Windmeijer correction, and Lewbel's heteroskedasticity-based IV-2SLS to address endogeneity, dynamic panel bias, and weak instruments.

Together, these contributions refine the measurement of ICT, broaden empirical coverage, provide insights into differentiated fiscal effects, and clarify the institutional and financial pathways through which digitalization strengthens tax capacity. The study makes an incremental but meaningful contribution to contemporary debates on digital taxation, fiscal modernization, and development financing. The positioning departs from Brun et al. (2020) in terms of analytical techniques, sample and periodicity.

The remainder of the paper is organized as follows. Section 2 presents the theoretical foundations and the related empirical literature. Section 3 describes the data, variables, and empirical strategy. Section 4 reports the main results and robustness checks. Section 5 examines the transmission mechanisms. Section 6 concludes and discusses policy implications and future research directions.

2. Literature review

2.1. Determinants of tax revenue mobilization

The literature has examined a wide range of determinants of tax revenue mobilization over the past decade, highlighting economic, demographic, institutional, and structural factors. Several studies including Addison and Levin (2011), Adedokun (2018), Castro and Camarillo (2014), Epaphra and Massawe (2017), Gnangnon and Brun (2018), Mawejje (2019), and Ramli and Andriani (2013), provide evidence that tax performance is shaped by both macroeconomic fundamentals and country-specific characteristics.

Economic growth is among the most widely recognized predictors of tax capacity. Sen (2007) argues that higher economic activity increases corporate profitability and market transactions, thereby strengthening tax bases such as VAT, excise taxes, and corporate income tax. Relatedly, Ofori and Asongu (2021), Gnangnon (2021), and Elgin (2013) emphasize that income levels expand taxable resources and improve governments' ability to levy and collect taxes. Inflation is another key macroeconomic variable, although its effect is ambiguous. While Saibu (2013) finds that inflation erodes the real value of tax revenues through the Olivera Tanzi effect, other evidence suggests that moderate inflation can increase nominal tax receipts when prices rise within controllable thresholds (Arif & Rawat, 2018; Wijaya & Prayer, 2022).

Structural variables also play a critical role. Castro and Camarillo (2014) show that industrial expansion, civil rights, and import taxation significantly boost tax revenues in OECD countries. However, tax revenues tend to decline with greater trade openness due to tariff reductions and dismantling of trade barriers (Baunsgaard & Keen, 2010). International evidence further indicates that foreign direct investment (FDI) contributes positively to tax performance through increased production, formalization, and employment (Amoh & Adaom, 2017; Chilima, 2005; Adé et al., 2018).

Demographic and human-capital factors are also highlighted in the literature. Population growth increases demand for goods and services, thus expanding the potential tax base (Gnangnon & Brun, 2018; Awashthi et al., 2020). Human capital improves citizens' understanding of tax obligations and contributes to higher specialization and productivity, which in turn positively affect tax mobilization (Chilima, 2005; Castro & Camarillo, 2014; Rodriguez, 2018). Complementary institutional factors such as democracy (Ehrhart, 2009), tax compliance (Tsaurai, 2021), and administrative capacity also emerge as significant predictors of tax performance.

In parallel, the role of digitalization has received increasing attention. ICT development in Africa and beyond has expanded significantly over the last two decades (Nkoa & Song, 2022), with growing evidence that digital technologies enhance tax compliance, transparency, and administrative efficiency. Mobile money, for instance, has been shown to significantly increase both direct and indirect tax revenues in countries where it is widespread (Apeti & Adoh, 2023). Other structural determinants such as international trade (Gropp et al., 1999; Khattry & Rao, 2002; Agbeyegbe et al., 2006) and the limited taxability of agricultural value added (Khattry & Rao, 2002; Brun et al., 2015) remain central to understanding cross-country variations in fiscal capacity.

Overall, the literature suggests that ICT is not merely an additional determinant but a potential *transformational factor* that interacts with economic, institutional, and structural conditions. It is therefore essential to examine not only the effect of ICT on tax revenues but also the channels through which digitalization shapes tax systems.

2.2. How does ICT affect tax revenue?

In this part, we outline, without being exhaustive, the two primary ways that ICT influences tax revenues. We begin with the premise that indirect mechanisms can be used to establish the relationship between ICT and tax revenues.

2.2.1. Institutional Quality Mechanism

ICT strengthens tax revenue partly by improving institutional quality, understood as the governance structures, enforcement capabilities, and transparency mechanisms that shape taxpayer behaviour. As argued by Morrell and Tuck (2014), effective tax governance relies on tools that limit evasion and avoidance. ICT enhances these tools by enabling digital identification, electronic transaction records, and automated audit trails, which increase the capacity of tax administrations to detect irregularities and sanction non-compliance (Bas, 2017).

However, empirical evidence shows that ICT is not a sufficient condition for higher tax revenue when governance is weak. Mallick (2021) demonstrates that ICT adoption may fail to improve revenue outcomes if taxpayers can bypass digital systems through cash-based or offline transactions. This aligns with the broader insight that technology affects tax systems only insofar as institutional complements transparency, accountability, and rule-based administration are present.

ICT also raises administrative integrity and procedural transparency by streamlining tax processes. E-filing and e-payment platforms reduce compliance costs and processing delays,

while increasing the accuracy of declarations (Umar & Masud, 2020). In border taxation, ICT strengthens customs administration through automated valuation, risk profiling, and verification procedures, thereby improving revenue performance (Gnangnon & Brun, 2018). E-government infrastructures shaped by globalisation and the diffusion of ICTs further promote transparency and rule compliance (Bouna Bat, 2017; Uyar et al., 2021).

The literature consistently documents the benefits of ICT-enabled governance reforms. Digital reporting and streamlined procedures reduce leakage and enhance compliance (Tjen & Evans, 2017; Sidani et al., 2014; Night & Bananuka, 2020). ICT investments improve access to tax information, reduce paperwork, and strengthen administrative efficiency (Decman & Stare, 2010). At the macro level, societies with stronger technological infrastructures benefit more from digital reforms (Barker, 2003; Norris, 2001; Singh et al., 2007; Nam, 2018).

Empirical studies confirm a positive association between ICT penetration and tax revenue: internet use, broadband access, personal computers, and mobile phone adoption significantly increase countries' revenue performance (Koyuncu et al., 2016). At the micro level, ICT deployment reduces tax evasion by widening the taxpayer net and enhancing traceability of transactions (Oseni, 2016). ICT systems also help governments cross-check private assets, public procurement, and fiscal transactions, enabling fraud detection and reducing leakages (Mallick, 2021). Conversely, weak governance reduces ICT effectiveness by creating spaces for corruption and informal practices (Johnson et al., 2021).

Taken together, this evidence shows that ICT enhances tax mobilisation primarily through improved institutional quality, by increasing transparency, strengthening enforcement credibility, reducing evasion incentives, and improving the overall integrity of tax administration.

2.2.2. Financial development mechanism

Beyond the institutional and administrative channels discussed earlier, ICT also strengthens tax mobilisation through a financial development mechanism. This channel is not merely an extension of financial inclusion, but a broader transformation of the entire financial ecosystem payments, intermediation, savings, credit allocation, and financial integrity enabled by digital technologies. Articulating this mechanism is essential given the reviewer's observation and aligns with the recent empirical literature in development economics and public finance.

First, ICT catalyses financial inclusion by expanding access to formal financial services through mobile money, digital wallets, fintech applications, and agent banking. These technologies reduce spatial, informational, and administrative barriers that traditionally exclude households and SMEs from banks. Evidence from Sub-Saharan Africa (Suri & Jack, 2016; Aron, 2018) shows that digital finance significantly increases account ownership, the use of formal savings instruments, and the frequency of electronic transactions. By increasing the share of economic

activity that passes through the formal financial system, ICT broadens the tax base and makes taxable economic activities more visible to tax authorities.

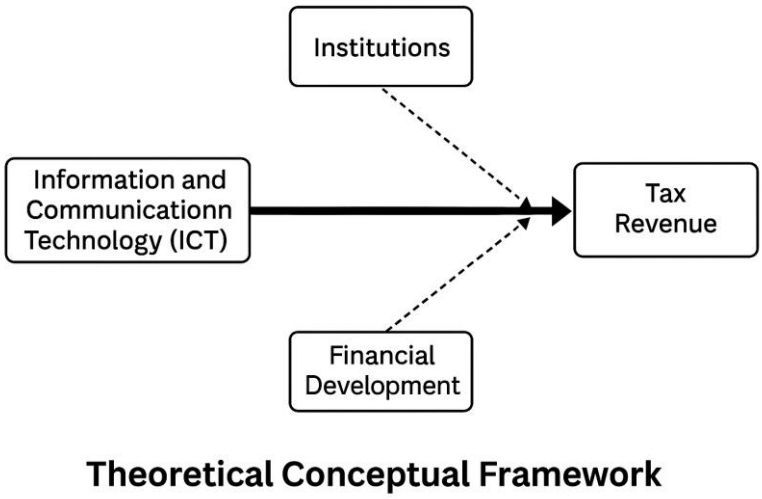
Second, ICT enhances transaction traceability, a central feature of modern tax systems. Digital payments generate electronic records, reduce cash-based transactions, and create auditable trails (Ozili, 2020; IMF, 2022). This mitigates opportunities for tax evasion, reduces information asymmetries between taxpayers and tax administrations, and increases the probability of detection for non-compliance. Empirical work by Gupta et al. (2022) and UNECA (2021) demonstrates that increased digital payment penetration correlates strongly with higher VAT compliance, greater revenue efficiency, and reduced leakages.

Third, ICT deepens financial intermediation efficiency. By improving credit scoring, digital identification (e-IDs), biometric verification, and mobile-based lending algorithms, ICT reduces screening costs, lowers collateral requirements, and expands access to credit (Asongu & Odhiambo, 2020; BIS, 2019). A more efficient financial system boosts investment, stimulates firm growth, and increases taxable income and profits. Moreover, the expansion of credit to SMEs enhances their visibility, formalisation, and interaction with revenue authorities, indirectly improving compliance.

Fourth, digital financial infrastructures support automated tax administration. E-filing, e-payment, and real-time reporting systems rely heavily on an integrated digital financial environment. The OECD (2022) shows that digital tax platforms reduce compliance costs, increase filing accuracy, and help tax administrations match financial data with reported income. In many developing countries, ICT-enabled financial ecosystems allow governments to integrate bank data, mobile money flows, and fintech transactions into taxpayer profiling and risk-based audits, dramatically improving enforcement capacity.

Finally, ICT fosters formalisation of the informal sector, a key determinant of domestic revenue mobilisation. Digital platforms encourage micro-enterprises and informal traders to adopt electronic payments, register for mobile banking, and integrate into digital marketplaces. This transition increases their visibility to tax authorities (UNCTAD, 2020; GSMA, 2021), reduces informality rents, and enables tax administrations to expand their reach to economic actors previously outside the tax net. The theoretical links discussed in this section are summarized in Figure 1, which outlines the direct and indirect channels connecting ICT to tax revenue mobilization.

Figure 1. Theoretical and Conceptual Framework Linking ICT to Tax Revenue Mobilization



Source: Authors

3. Data and empirical strategy

3.1. Data

Unbalanced data from 98 countries over the period 2008–2020 are used in this study, with the final sample size and time coverage determined by data availability. All variables originate from established secondary sources. The descriptive statistics (Table 1) show limited dispersion across observations, which is expected in cross-country macro datasets, and even small variations in ICT indicators or tax outcomes can generate meaningful explanatory power. The correlation matrix (Table 2) indicates relatively low pairwise correlations among the key variables, suggesting that multicollinearity among the explanatory variables is not a concern for model estimation. In addition, the correlation between ICT and tax revenue mobilization (TRM) remains moderate below 50% which supports the empirical relevance of exploring this relationship through econometric analysis rather than simple bivariate associations. Figure A1 illustrates the global association between ICT and tax income, while Figure A2 displays the sub-regional patterns of this relationship, highlighting heterogeneity across geographic blocs.

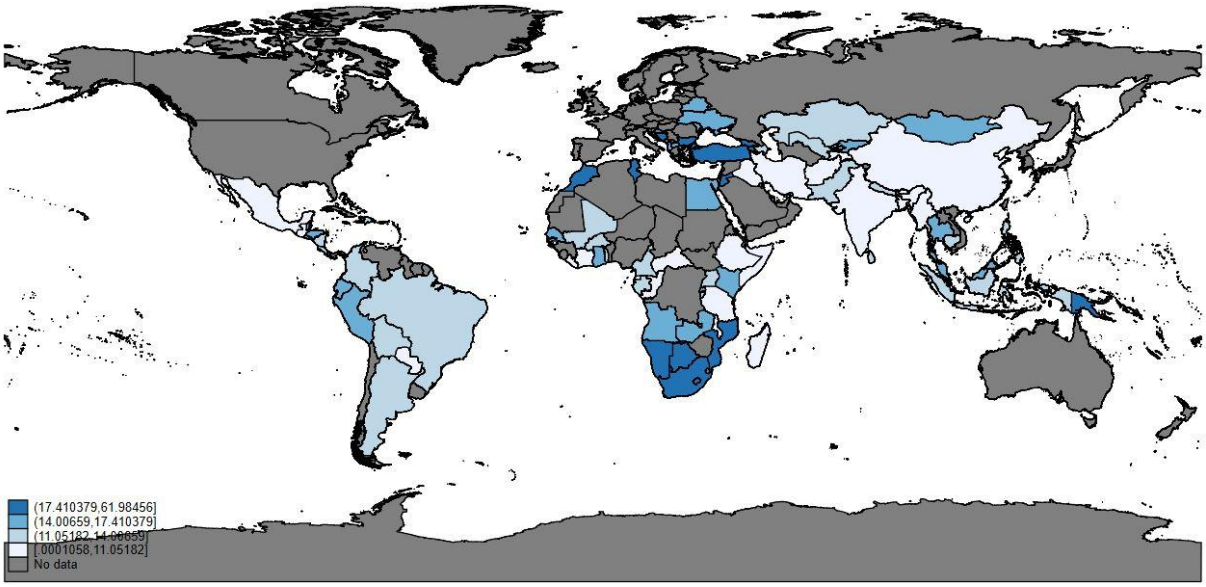
3.1.1 Depandent variable

Following Apeti and Edoh (2023), our main dependent variable is Tax Revenue Mobilization (TRM), sourced from the UNU-WIDER Government Revenue Dataset (GRD). In line with GRD conventions, we use the aggregate measure of non-resource tax revenue, explicitly excluding resource-related revenues and social contributions. This choice reflects the fact that resource-based revenues follow specific economic and political dynamics such as commodity price cycles and extractive-industry fiscal regimes that are not directly related to the mechanisms through which ICT influences domestic tax capacity.

The GRD provides substantial advantages over alternative tax datasets such as the OECD Revenue Statistics or the World Revenue Longitudinal Database (WoRLD). In particular, it uniquely distinguishes between resource and non-resource revenues using detailed information from IMF Article IV reports, which improves cross-country comparability and measurement reliability, especially for developing economies (Prichard, 2016). For these reasons, and to ensure that our dependent variable captures genuine domestic tax mobilisation, we rely on the GRD definition of tax revenue excluding natural-resource taxes and social contributions.

To illustrate the evolution of TRM over the sample period, Figure 2 presents a global overview of tax revenue mobilization from 2008 to 2020, highlighting general trends and cross-country heterogeneity.

Figure 2. Global overview of tax revenue mobilization over the period 2008-2020



Source: Authors

3.1.2. Independent variable

The main variable of interest in this study is the UNCTAD ICT composite index, which constitutes our baseline indicator of digital readiness by capturing multiple dimensions of technological development, including connectivity, digital access, and the diffusion of digital infrastructure. To assess the robustness of our results, we complement this composite index with four alternative ICT proxies commonly used in the literature. These include: internet penetration, measured by the number of active internet subscriptions per 100 inhabitants over the previous three months; mobile phone penetration, based on the number of active prepaid and postpaid mobile subscriptions per 100 inhabitants; fixed-line penetration, measured through fixed telephone subscriptions per 100 inhabitants, reflecting access to the Public Switched Telephone Network (PSTN); and fixed broadband subscriptions per 100 inhabitants, which proxy access to high-speed optical fiber networks (Annafari & Bohlin, 2014; Nakamura, 2015; Foster, 2018; Ongo & Song, 2022; Wiranatakusuma & Zakaria, 2024). The last three indicators include only subscriptions providing voice communication and exclude data-only devices such as USB modems, data cards, telemetry services, or private mobile radio systems. While the UNCTAD ICT index serves as the core explanatory variable, these four alternative measures are used exclusively for robustness checks to verify whether the ICT–tax revenue nexus persists across different facets of digital infrastructure.

3.1.3. Control variables

In order to estimate the tax revenue mobilization model in a robust manner and minimize omitted-variable bias, we rely on empirical evidence to select control variables recognized in the literature as key macroeconomic determinants of tax performance. Although data availability partly constrained our choices, the selection is also justified by the economic context of the study. Economic growth, proxied by real GDP per capita, is included because it reflects both the population's standard of living and the level of economic activity (Jemiluyi & Jeke, 2023). Higher income levels tend to expand the tax base and improve governments' ability to levy and collect taxes, as emphasized by Ofori & Asongu (2021), Gnangnon (2021), and Elgin (2013). Population dynamics, measured by the annual growth rate of the total population, are also considered since higher population growth may increase engagement in economic activities that generate taxable income (Gnangnon & Brun, 2018). Foreign direct investment (FDI), defined as the acquisition of at least 10% of a company's voting shares in a foreign economy, constitutes another important control variable. As recorded in the balance of payments, FDI comprises equity capital, reinvested earnings, and other long- and short-term capital flows. According to Tsaurai (2022), FDI reflects long-term investment relationships that reshape production structures, employment, and economic capacity, thereby influencing the tax base. Finally, we include inflation, measured through the consumer price index (CPI). Inflation may adversely affect tax revenues through the well-known Olivera–Tanzi effect (Tanzi, 1983; Muttaqin & Halim, 2020), whereby delays between tax assessment and tax collection reduce the real value of tax receipts. This inverse relationship is particularly relevant for tax categories where collection lags are more substantial.

3.2. Empirical strategies

This article's model was motivated by the works of Gnangnon (2020), Asongu et al. (2021) and Ongo and Song (2022). The choice of the model is due to the fact that traditional tax revenue mobilization (TRM) models have not explicitly taken into account the role of ICT. The modeling is based on a tax structure that would predict that the diffusion of ICT would induce improvements in the mobilization of tax revenues. The modified version of the model is specified as follows in Equation (1):

$$TRM_{it} = \alpha + \beta_1 TRM_{it-1} + \beta_2 ICT_{it} + \beta_3 X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \qquad (1)$$

Where TRM represents the tax revenue mobilization, ICT represents information and communication technology, X_{it} is the vector of control variables, represents the lagged form of deprivation, is an unobserved country-specific effect, is a time-specific effect, and is the error term.

We adopt a multi-stage econometric approach; to this end, we mobilize a number of estimating methods from the literature, including OLS absorbing multiple fixed effects levels and system GMMs. We start with the multiple fixed effects OLS developed by Correia (2016). This method allows to analyze the direct effect of ICT on the TRM by absorbing several levels of fixed effects. It is a generalization of the fixed effects model allowing the clustering of multidirectional errors. Error clustering is a technique to control heteroscedasticity and autocorrelation. In traditional fixed effects models, on the other hand, the clustering is unidirectional.

The empirical specification of the econometric model is as follows in Equation (2):

$$Y = Z\beta + D_1\alpha + D_2\gamma + \varepsilon \quad (2)$$

Where $D_1 \; et \; D_2$ are panel fixed effects but with different dimensions. D_1 captures region fixed effects, and D_2 captures income-group fixed effects, as reported in Table 3. Including both dimensions allows the model to control simultaneously for unobserved structural heterogeneity across regions and across income categories.

Since the preceding approach was incongruous in the setting of a dynamic model, our modeling might be hampered by the Nickel (1981) bias given the definition of equation (1). Their failure to consider the unobserved heterogeneity of some variables implies that our model may be endogenous and heteroscedastic (Baum et al., 2003). In accordance with Blundell and Bond (1998), we employ dynamic panel GMM estimations with the Windmeijer (2005) correction (S-GMM). This approach addresses the Nickell (1981) bias and controls for the endogeneity of the dependent variable and other explanatory variables. By using two instruments, the system GMM approach makes it possible to rectify these biases. By using double instrumentation, the system GMM technique accounts for these biases. The first involves using at least one variable that is time-lag (in level) to instrument the initial difference of the equation to be estimated, which removes unobservable, individual, and time-invariant properties. The second part of the instrumentation strategy uses lagged differences as instruments for the variables in levels, ensuring that the level equation is properly identified. To avoid the risk of over-identification resulting from an excessive number of instruments, we follow the procedure recommended by Roodman (2009), which reduces instrument proliferation when implementing System GMM. This strategy entails minimizing the instruments by having distinct moments for each lag (as opposed to one moment for each lag and each period)[1]. Hansen's J test for overidentification and Arellano and Bond's (1991) autocorrelation tests are

[1] We also use the 'collapse' option for the xtabond2 command in STATA

used to validate the instrumentation method. While the systemic GMM is strong in handling the endogeneity problems, it has a flaw in that it can produce too many instruments, which can lead to overfitting of endogenous variables, weaken Hansen's test of the instruments' joint validity, and produce biased estimates (Roodman, 2009). To mitigate this issue, we have included the collapse option in our GMM matrix to limit the proliferation of instruments.

Table1. Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
ICT index[2]	1090	.626	.116	.428	.9
Mobile phone[3]	1090	.261	.088	.158	.615
Fixed_telephone[4]	1090	.901	.022	.862	.963
Internet_users[5]	1090	.406	.198	.061	.888
Fixed_broadband[6]	1090	.175	.083	.086	.593
tax income[7]	1023	5.464	3.547	.596	17.128
tax exc sc[8]	1023	2.88	2.29	.025	13.38
tax inc sc[9]	1023	2.153	1.487	.268	8.044
Revenue inc[10]	1023	.408	.777	-.239	7.935
Revenue exc[11]	1023	23.152	12.572	1.983	161.209
Taxes inc	1023	22.848	12.482	1.983	161.209
Taxes exc	1023	15.797	8.959	1.908	60.946
Resourcetaxes[12]	1023	1.725	5.667	0	39.167
Resourcetaxes[13]	1023	4.966	3.335	.641	17.128
No rtax inc sc[14]	1023	13.809	7.774	1.908	60.946
No rtax exc sc[15]	1023	13.548	7.472	1.908	60.946
Direct inc sc inc rt[16]	1023	6.008	4.033	.641	17.793
Direct inc sc exc rt[17]	1023	5.341	3.741	.641	17.277
GDP prcapita[18]	1080	.022	.021	.003	.11
lnPopulation[19]	1081	.034	.059	0	.369
Inflation	1080	.025	.028	0	.142
FDI[20]	1081	.014	.056	-.018	.605

Source : Authors

[2] Information and Communication Technology Index
[3] mobile phone subscriptions (per 100 people)
[4] fixed telephone subscriptions (per 100 people) refers to the sum of an active number of analog fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents, and fixed public pay phones.
[5] Use of the Internet
[6] Fixed broadband internet connection
[7] Tax on taxable income
[8] Tax excluding social contributions
[9] Tax including social contributions
[10] Revenue including social contributions
[11] Revenue excluding social contributions
[12] Resourcetaxes including social contributions
[13] Resourcetaxes excluding social contributions
[14] No resource taxes including social contributions
[15] No resource taxes excluding social contributions
[16] Direct including social contributions
[17] Direct excluding social contributions
[18] GDP per capita is gross domestic product (constant 2010 U.S. dol-lars) divided by midyear population.
[19] Population density (people per sq. km of land area).
[20] Foreign direct investment

Table 2. Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) Income tax	1.000																	
(2) rev_inc_sc	0.413	1.000																
	(0.000)																	
(3) rev_ex_sc	0.404	0.938	1.000															
	(0.000)	(0.000)																
(4) tax_inc_sc	0.609	0.740	0.551	1.000														
	(0.000)	(0.000)	(0.000)															
(5) tax_ex_sc	0.741	0.633	0.564	0.915	1.000													
	(0.000)	(0.000)	(0.000)	(0.000)														
(6) nrtax_inc_sc	0.458	0.621	0.407	0.975	0.873	1.000												
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)													
(7) nrtax_ex_sc	0.608	0.507	0.414	0.883	0.968	0.908	1.000											
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)												
(8) direct_inc_sc	0.705	0.730	0.527	0.901	0.754	0.846	0.669	1.000										
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)											
(9) direct_inc_sc	0.588	0.649	0.427	0.884	0.723	0.892	0.710	0.965	1.000									
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)										
(10) ICT index	0.390	0.478	0.331	0.583	0.496	0.564	0.462	0.636	0.696	1.000								
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)									
(11)	0.249	0.474	0.348	0.485	0.393	0.520	0.417	0.497	0.556	0.748	1.000							

Internet_user																		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)								
(12) Fixed telephone	0.258	0.467	0.321	0.573	0.469	0.563	0.437	0.568	0.614	0.690	0.688	1.000						
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)							
(13) Mobile cellular	0.160	0.332	0.260	0.319	0.280	0.373	0.328	0.296	0.342	0.513	0.669	0.443	1.000					
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
(14) Fixed broadband	0.255	0.420	0.259	0.540	0.427	0.509	0.371	0.573	0.639	0.743	0.694	0.787	0.460	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
(15) GDP per capita	0.270	0.335	0.338	0.237	0.221	0.083	0.048	0.393	0.422	0.519	0.552	0.541	0.319	0.538	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.148)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
(16) lnPopulation	-0.020	0.002	-0.005	0.011	0.011	0.012	0.015	0.009	0.014	0.310	0.010	-0.025	-0.062	-0.062	-0.040	1.000		
	(0.505)	(0.941)	(0.875)	(0.725)	(0.732)	(0.728)	(0.653)	(0.770)	(0.668)	(0.000)	(0.732)	(0.411)	(0.042)	(0.044)	(0.181)			
(17) Inflation	-0.052	-0.081	-0.077	-0.045	-0.051	-0.060	-0.064	-0.037	-0.042	-0.093	-0.106	-0.063	-0.077	-0.072	-0.076	-0.016	1.000	
	(0.087)	(0.010)	(0.015)	(0.142)	(0.096)	(0.068)	(0.053)	(0.235)	(0.203)	(0.002)	(0.000)	(0.039)	(0.011)	(0.019)	(0.012)	(0.605)		
(18) FDI	0.069	0.121	0.117	0.140	0.177	0.130	0.159	0.069	0.054	-0.049	-0.006	0.063	0.021	-0.002	-0.026	-0.088	-0.020	1.000
	(0.024)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.028)	(0.100)	(0.107)	(0.832)	(0.040)	(0.492)	(0.942)	(0.397)	(0.004)	(0.506)	

$p < 0.10$; $p < 0.05$; $p < 0.01$

Source : Authors

4. Results and discussions

This section presents and analyses the empirical findings of the study. We begin by examining the baseline results obtained from the linear specification, focusing on the association between ICT diffusion and tax revenue mobilisation. We then assess the robustness of these results using alternative estimators, inference corrections and specification checks. In a second stage, we explore the potential mechanisms through which ICT may influence tax revenues, with particular attention to institutional quality and financial development.

4.1. Basic results

The linear model shows that ICT diffusion captured through internet use, mobile-phone penetration, landline subscriptions and optical-fiber availability is positively and significantly associated with tax revenue mobilisation (Table 3). Because the ICT index is bounded between 0 and 1, the estimated coefficient should not be interpreted as the effect of a literal one-unit change. A more meaningful interpretation is obtained by considering marginal variations in ICT diffusion. In Columns (1) and (5), the coefficient of approximately 0.091- 0.093 implies that a 0.10 (10-percentage-point) increase in the ICT index is associated with an increase of roughly 0.0091 to 0.0093 units in tax revenue, holding other factors constant. The magnitude and significance of the coefficient remain stable when using bootstrapped standard errors (Column 6) and Jackknife corrections (Column 7), although as expected their standard errors are slightly larger. These results are fully consistent with modernization theory, according to which technological diffusion enhances administrative efficiency, strengthens public-sector capabilities, and improves governments' ability to mobilise domestic revenues (Dlodlo, 2009). ICT expansion facilitates record-keeping, reduces transaction opacity and increases enforcement capacity, all of which contribute to higher tax compliance and improved revenue performance.

To be clearer, the modernization theory is predicated on the notion that societies are transformed and developed through processes of innovation and adaptation to new technologies, and offers a relevant framework for understanding the impact of ICTs on the mobilization of tax revenues. According to this theory, technological development plays a crucial role in improving institutions and administrative practices, and ICT can thus be seen as a lever for modernizing tax systems. In this perspective, the use of ICT in tax management makes it possible to optimize tax collection, reduce administrative costs and increase the efficiency of tax administrations. For example, the automation of tax declaration and payment processes facilitates collection by making these procedures simpler, faster and more accessible for taxpayers. In addition, digital tools allow for better traceability of transactions and easier detection of tax fraud, including tax losses related to tax evasion. In addition, digitalization helps to strengthen transparency and trust between citizens and the State, which can encourage greater compliance with tax obligations. Finally, with the help of ICT, tax administrations can collect accurate data on taxpayers, allowing better targeting of collection efforts and the implementation of appropriate tax policies. Thus, according to the theory of modernization, ICT

is an essential means to increase the efficiency of the tax system and, consequently, improve the mobilization of tax revenues in a context. A related issue concerns the role of informality in shaping tax performance. Although informality plays a central role in determining revenue outcomes, incorporating direct measures of informality into the empirical analysis is not feasible in the present cross-country setting. Existing informality indicators such as the Medina and Schneider shadow economy estimates or employment-based informality proxies are not consistently available across countries and years for our sample. They also differ in methodology and measurement precision, which would considerably reduce sample size and compromise comparability. To mitigate potential omitted-variable bias arising from unobserved informality, the empirical strategy includes governance and financial development variables that partially reflect channels through which informality affects revenue mobilisation, such as transparency, transaction traceability and formalisation incentives. Nevertheless, the absence of harmonised cross-country informality data remains a limitation of the macro-level approach, and future research could exploit country-specific digitalisation programmes or administrative tax microdata to more directly examine the ICT–informality–revenue nexus.

Table 3. OLS absorbing multiple fixed effects levels, Bootstrap and Jackknife

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			REGHDFE			Bootstrap	Jackknife
VARIABLES				**TMR**			
ICT index	**0.0910*** **	**0.0820*** **	**0.0963*** **	**0.0958*** **	**0.0930*** **	**0.0930*** **	**0.0930*** **
	(0.00865)	**(0.00826)**	**(0.00743)**	**(0.00740)**	**(0.00732)**	**(0.00725)**	**(0.00740)**
GDP per capita		0.063***	0.999***	1.003***	1.058***	1.058***	1.058***
		(0.147)	(0.142)	(0.141)	(0.137)	(0.138)	(0.140)
lnPopulation			-0.00232***	-0.00225***	-0.00178***	-0.00178***	-0.00178***
			(0.000540)	(0.000543)	(0.000629)	(0.000625)	(0.000638)
Inflation				-0.568*	-0.606*	-0.606	-0.606
				(0.292)	(0.322)	(0.792)	(0.596)
FDI					4.621**	4.621**	4.621**
					(1.974)	(1.945)	(2.020)
Constant	0.0219***	0.0198***	0.0572***	0.0561***	0.0457***	0.0457***	0.0457***
	(0.00507)	(0.00493)	(0.0107)	(0.0107)	(0.0129)	(0.0124)	(0.0131)
Icome groups fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1090	1090	1090	1094	1070	1070	1070
R-squared	0.244	0.280	0.289	0.290	0.305	0.305	0.305

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors

With respect to the control variables, the results show heterogeneous effects on tax revenue mobilization (TRM). GDP per capita exerts a positive and significant impact, increasing TRM by 0.063 units, a result consistent with Elgin (2013), who argues that higher income levels facilitate tax mobilization. Rising real income per capita reflects greater economic sophistication, stronger institutional capacity, and increased demand for public services factors that tend to expand

the tax base and reinforce government revenues, as similarly documented by Crivelli and Gupta (2014). In contrast, population growth exhibits a negative effect on TRM, reducing revenues by 0.00232 units. This finding contrasts with Gnangnon and Brun (2018), who contend that larger populations are more likely to engage in tax-generating activities. One possible explanation is that rapid demographic expansion in many developing economies is often accompanied by growing informality, insufficient urban planning, and pressures on administrative capacity, which may weaken effective tax collection despite theoretical expectations.

Regarding foreign direct investment (FDI), several mechanisms support a positive link with tax revenues. Nguyen et al. (2022) show that FDI inflows stimulate employment creation, thereby expanding personal income tax bases. Rodrik (1998) emphasizes that FDI enhances linkages, networking, and technological spillovers between domestic and foreign firms, which can foster formal sector development. In line with this reasoning, Camara (2023) finds that FDI inflows positively and significantly improve tax revenues a result confirmed in our own estimations, where FDI contributes meaningfully to strengthening TRM.

4.2. Controlling the endogeneity problem with the Sys-GMM method

To address potential endogeneity arising from reverse causality, omitted variables, and the dynamic structure of tax revenue mobilisation, we estimate a System-GMM model following Blundell and Bond (1998). This estimator combines equations in levels and first differences while using internal instruments constructed from suitable lags of the dependent and explanatory variables. Consistent with the recommendations in Roodman (2009), we restrict the lag depth and employ the *collapse* option to limit instrument proliferation and prevent overfitting. As a result, the number of instruments remains well below the number of countries, reducing the risk of weak identification and improving the reliability of the Hansen test.

The validity of the model is evaluated using the Arellano–Bond tests for serial correlation and the Hansen test of over-identifying restrictions. The AR(1) statistic confirms the expected first-order autocorrelation in differenced residuals, while the AR(2) test is insignificant, indicating the absence of second-order serial correlation and supporting the validity of the moment conditions. The Hansen p-values fall within acceptable ranges, suggesting that the reduced instrument set is jointly valid and uncorrelated with the error term. Together, these diagnostics support the internal consistency of our System-GMM specification.

Across specifications reported in Table 4, ICT maintains a positive and statistically significant effect on tax revenue mobilisation. Although the magnitudes differ depending on the instrument structure, the sign and significance remain stable, reinforcing the interpretation that ICT expansion enhances countries' capacity to mobilise non-resource tax revenues. This result aligns with the broader literature (Gnangnon, 2021; Ongo & Song, 2022), yet our findings extend previous work by leveraging a multidimensional ICT index and a global sample. The evidence suggests that ICT adoption strengthens tax administration by improving information flows, broadening the taxable base, and enhancing enforcement capacity through digital traceability.

Overall, the System-GMM results confirm that the positive association between ICT and tax revenue mobilisation is robust to endogeneity concerns, while the refined diagnostic analysis strengthens confidence in the empirical identification strategy.

Table 4. Controls for endogeneity problem with Sys-GMMs

	(1)	(2)	(3)	(4)	(5)
	SYS-GMM				
Variables	TMR				
L.TMR	**0.615*** **	**0.710*** **	**0.448*** **	**0.446*** **	**0.597*** **
	(0.0650)	**(0.00884)**	**(0.00974)**	**(0.0101)**	**(0.0491)**
ICT index	2.371***	0.0173***	0.00805**	0.00792**	0.0167**
	(0.764)	(0.00209)	(0.00340)	(0.00332)	(0.00719)
GDP Per capita		0.0634**	0.689***	0.713***	0.377***
		(0.0257)	(0.0852)	(0.0873)	(0.133)
lnPopulation			0.00865***	0.00866***	0.00352
			(0.00156)	(0.00163)	(0.00227)
Inflation				0.269***	1.829***
				(0.0652)	(0.430)
FDI					3.108**
					(1.412)
Constant	1.212***	0.00907***	-0.119***	-0.119***	-0.0460
	(0.248)	(0.000891)	(0.0245)	(0.0259)	(0.0354)
Time Effects	Yes	Yes	Yes	Yes	Yes
Observations	985	985	985	985	964
Number of groups	98	98	98	98	98
Instruments	24	52	52	52	30
AR(1)	0.0331	0.0119	0.0145	0.0144	0.0224
AR (2)	0.791	0.772	0.858	0.924	0.874
Hansen P-value	0.486	0.169	0.298	0.371	0.243

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Sources: Authors

The effects of population growth and GDP per capita on tax revenue mobilization diverge sharply: while higher income levels support stronger tax collection, rapid demographic expansion appears to weaken it. In theory, population growth should contribute to a larger urbanized tax base, as rural–urban migration brings new workers seeking employment, housing, education, and health services. Such dynamics would normally favor a broader taxable economy and improved administrative reach. However, in many developing countries, fast population growth often coincides with rising informality, insufficient urban planning, and limited administrative capacity, which can undermine the effectiveness of tax collection despite the expanding population.

Conversely, increases in real GDP per capita reflect greater economic and institutional sophistication, higher productivity, and growing demand for public services. These factors tend to widen the tax base and strengthen the government's ability to levy and collect taxes—a relationship consistent with Crivelli and Gupta (2014). Regarding foreign direct investment (FDI), the literature suggests several mechanisms through which it can enhance tax revenues. Nguyen

et al. (2022) show that FDI inflows stimulate employment creation and expand income tax bases. Rodrik (1998) highlights the role of FDI in fostering linkages, networking, and technological spillovers between domestic and foreign firms, which encourages formal sector expansion. In line with these findings, Camara (2023) reports a positive and significant effect of FDI on tax revenues, a result that is also confirmed in our estimations.

4.2. Robustness analysis

This section provides a set of complementary robustness checks designed to assess the stability, magnitude, and economic relevance of the relationship between ICT and tax revenue mobilisation. In addition to confirming the statistical significance of the baseline results, these exercises help clarify *how different dimensions of ICT adoption matter*, *which tax components respond most strongly*, and *why effects vary across income groups, periods, and technologies*. The robustness analysis therefore contributes not only to empirical credibility but also to the interpretation of the mechanisms through which digitalisation affects fiscal performance.

4.2.1. Alternative measures of the ICT index

The robustness of our findings is further confirmed when replacing the composite ICT index with its individual components mobile cellular penetration, internet usage, fixed telephony and fixed broadband subscriptions as reported in Table 5. Across all specifications, each measure retains a positive and statistically significant effect on tax revenue mobilisation, although the magnitude of the coefficients varies in ways that reveal important mechanisms at play. Notably, mobile cellular adoption consistently produces one of the strongest elasticities: with a coefficient of approximately 0.0147 in the controlled specification, a 10-percentage-point increase in mobile penetration is associated with a 0.147-unit rise in tax revenues, underscoring the central role of mobile technologies in extending digital payments, mobile money services and taxpayer identification in contexts where formal banking and broadband infrastructure remain limited. In parallel, internet usage and broadband connectivity also exert significant and economically meaningful effects. Internet penetration, with coefficients between 0.0025 and 0.0045, facilitates e-filing, online declarations and the digitalization of tax services, while broadband subscriptions whose coefficients range from 0.0063 to 0.0092 strengthen the administrative backbone of tax authorities through improved data exchange, audit capacity and real-time monitoring systems. Fixed telephony, although exhibiting relatively smaller effects, remains positively associated with tax mobilisation, reflecting broader structural development and historical communication infrastructure. Taken together, these differentiated magnitudes not only confirm that our baseline estimates are not an artefact of index construction, but also reveal that the most critical segment of the digital adoption curve differs across countries: mobile technologies yield the largest marginal gains in lower-income economies transitioning away from cash-based systems, whereas internet and broadband infrastructures play a more decisive role in more advanced administrative environments. This nuanced pattern highlights the multiplicity of digital channels through which ICT enhances fiscal capacity and reinforces the robustness of our core result.

Table 5. System GMM Estimates Using Alternative ICT Indicators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	SYS-GMM									
VARIABLES	TMR									
L.TMR	0.615***	0.597***	0.859***	0.906***	0.812***	0.829***	0.852***	0.822***	0.865***	0.765***
	(0.0650)	(0.0491)	(0.0143)	(0.00741)	(0.0166)	(0.0161)	(0.0239)	(0.0148)	(0.0204)	(0.00982)
ICT index	**2.371*** **	**0.0167** **								
	(0.764)	**(0.00719)**								
Mobile cellular			**0.974*** **	**0.0147*** **						
			(0.349)	**(0.00462)**						
Fixed telephone					**0.0236*** **	**0.0119*** **				
					(0.00312)	**(0.00359)**				
Internet							**0.00455*** **	**0.00247*** **		
							(0.00108)	**(0.000820)**		
Fixed broadband									**0.00910*** **	**0.00640** **
									(0.00328)	**(0.00250)**
Control variable	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Constant	1.212***	-0.0460	0.706***	-0.00238***	0.793***	-0.0332***	0.00601***	-0.0424***	0.00708***	-0.0290**
	(0.248)	(0.0354)	(0.0742)	(0.000829)	(0.108)	(0.00943)	(0.000993)	(0.0141)	(0.00107)	(0.0121)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	985	964	1033	1032	981	1034	1035	1035	1030	1031
Number of groups	98	98	131	130	98	130	130	130	124	123
Instruments	24	30	47	51	39	52	28	37	28	37
AR(1)	0.00331	0.00224	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)	0.791	0.874	0.720	0.471	0.707	0.834	0.767	0.765	0.571	0.796
Hansen P-value	0.486	0.243	0.0476	0.103	0.118	0.292	0.337	0.633	0.154	0.430

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

Source: Authors

4.2.2. Alternative measures for tax revenue mobilization

To further assess whether ICT affects different components of the tax system in distinct ways, Table 6 re-estimates the baseline model using alternative measures of tax revenue mobilisation, including direct taxes, indirect taxes, non-resource revenues and other subcomponents of the ICTD-GRD dataset. The results reveal important compositional differences. ICT exerts a consistently positive and significant effect across all tax categories, but the magnitudes indicate that direct taxes particularly corporate and personal income taxes respond more strongly to digitalisation than indirect taxes. This pattern is intuitive: direct taxation relies heavily on accurate income reporting, third-party information and audit capacity, all of which are strengthened by digital tools such as e-invoicing, digital bookkeeping, electronic taxpayer identification, and automated cross-checking systems. In many developing economies, limited financial development and the weak integration of third parties (e.g., banks, payment providers) traditionally constrain administrative capacity (Kleven et al., 2016). ICT mitigates these constraints by increasing the visibility of financial flows, enabling real-time exchange of invoice and transaction data, and reducing opportunities for under-reporting and leakage.

Indirect taxes, by contrast, already constitute the largest share of total revenues in most developing countries, and their collection mechanisms (e.g., VAT) are structurally easier to administer. As a result, improvements from ICT adoption tend to be more incremental. The stronger elasticities observed for direct tax components therefore suggest that digitalisation delivers its largest marginal gains where baseline enforcement capacity is weakest—namely in income taxation. This interpretation also explains why low-income and lower-middle-income countries experience particularly large returns from ICT expansion: modest improvements in digital infrastructure can meaningfully raise the traceability of transactions in economic environments that rely heavily on informal exchanges and cash-based systems.

Finally, these results remain stable when using alternative definitions of fiscal capacity drawn from the ICTD-GRD database, including measures that exclude natural-resource revenues. Given that non-resource taxation is the most reliable and policy-relevant foundation for long-term fiscal sustainability, finding that the ICT coefficient remains positive and significant across all variants underscores the robustness of the relationship. Taken together, the evidence shows that ICT not only boosts aggregate tax revenues but also reshapes the composition of fiscal capacity, with the strongest effects materialising in tax categories that depend most critically on information availability, reporting accuracy and administrative oversight.

Table 6. System GMM Estimates Using Alternative measures of tax revenue mobilization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Including social contributions				Excluding social contributions			
VARIABLES	Revenue	Tax	Non-Ressource Tax	Direct tax	Revenue	Tax	Non-Ressource Tax	Direct tax
L. Revenue	0.996***							
	(0.00333)							
L. Taxes		0.765***						
		(0.0390)						
L. Non-ressource Tax			0.756***					
			(0.0473)					
L. Direct tax				0.893***				
				(0.0317)				
L. Revenue					0.497***			
					(0.0322)			
L. Tax						0.547***		
						(0.0356)		
L. Non-ressource Tax							0.707***	
							(0.0416)	
L. Direct tax								0.902***
								(0.0271)
ICT index	0.0190***	0.00490***	0.00514***	0.0525***	0.00819***	0.00784***	0.00349**	0.0401***
	(0.00502)	(0.00183)	(0.00148)	(0.00828)	(0.00223)	(0.00194)	(0.00135)	(0.00879)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0462***	-0.00958	-0.00732	0.0290	0.0279***	-0.0170**	-0.00460	0.0175
	(0.0163)	(0.00651)	(0.00517)	(0.0280)	(0.00869)	(0.00802)	(0.00519)	(0.0244)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1023	1013	1003	959	1090	1006	976	891
Number of groups	103	103	96	96	102	103	96	95
Instruments	30	36	30	42	41	38	22	42
AR(1)	0.0965	0.000	0.000	0.000	0.0043	0.000	0.000	0.000
AR(2)	0.396	0.225	0.338	0.911	0.295	0.144	0.250	0.876
Hansen P-value	0.135	0.187	0.123	0.267	0.154	0.0238	0.338	0.351

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source : Authors

4.2.3. Alternative control of endogeneity by the IV-2SLS technique of Lewbel (2012)

To further address endogeneity concerns and complement the dynamic identification provided by System-GMM, we estimate an alternative specification using Lewbel's (2012) heteroskedasticity-based IV–2SLS method. This estimator is particularly valuable when valid external instruments are unavailable or difficult to justify theoretically a common challenge in empirical fiscal studies where ICT adoption and tax performance interact through multiple simultaneous channels. Lewbel's technique exploits the presence of heteroskedasticity in the

data to generate internally constructed instruments that satisfy orthogonality conditions without relying on traditional exclusion restrictions. Preliminary tests confirm that our dataset exhibits the heteroskedastic structure required for this identification strategy, making the method suitable for our context.

The underlying intuition is that ICT diffusion and tax revenue mobilisation may be jointly determined by broader institutional or structural factors. By constructing instruments from the covariance between the regressors and the heteroskedastic component of the error term, Lewbel's estimator isolates exogenous variation in ICT that is not driven by these latent factors. In addition, we follow Baum and Lewbel's (2019) recommendation to include internal lagged instruments where relevant; accordingly, the lag of natural resource rents is incorporated as an auxiliary instrument. This hybrid specification helps strengthen identification while maintaining theoretical consistency.

The results reported in Table 7 show that the ICT variable remains positive and statistically significant across all specifications, regardless of the ICT proxy used. The magnitudes are generally close to those obtained under System-GMM, confirming that the ICT–revenue relationship is not driven by dynamic feedback or omitted-variable bias. Importantly, diagnostic tests support the reliability of the Lewbel-IV estimates: the Cragg-Donald and Kleibergen-Paap statistics exceed the Stock–Yogo critical values, indicating strong instruments, while Hansen and Sargan tests confirm over-identification validity with p-values comfortably above conventional thresholds. Taken together, these diagnostics demonstrate that the heteroskedasticity-generated instruments are both relevant and exogenous.

Beyond statistical robustness, the Lewbel results also provide additional substantive insights. They indicate that part of ICT's fiscal effect operates through structural channels correlated with economic volatility and institutional heterogeneity precisely the type of unobserved factors addressed by Lewbel's identification approach. This suggests that digitalisation enhances tax mobilisation not only through compliance and administrative improvements but also by stabilising the informational environment in economies characterised by fluctuating production structures or reliance on natural-resource revenues. The convergence between the IV-2SLS and GMM estimates therefore strengthens confidence in the causal interpretation of our findings: ICT expansion robustly improves tax revenue mobilisation across a wide range of identification strategies.

Table 7. Alternative control of endogeneity with IV-2SLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	IV-2SLS-Lewbel, (2012)									
VARIABLES	TMR									
ICT index	0.0984***	0.101***								
	(0.00876)	(0.00768)								
Mobile cellular			0.0942***	0.0757***						
			(0.0154)	(0.0155)						
Fixed telephone					0.0776***	0.0536***				
					(0.0102)	(0.0106)				
Internet user							0.0397***	0.0354***		
							(0.00382)	(0.00385)		
Fixed Broadband									0.0635***	0.0306*
									(0.0178)	(0.0184)
Control Variables	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Constant	0.0155***	0.0389***	0.0417***	0.0227***	0.0411***	0.0152**	0.0356***	0.0291***	0.0420***	0.0168**
	(0.00451)	(0.0103)	(0.00347)	(0.00648)	(0.00349)	(0.00720)	(0.00324)	(0.00591)	(0.00430)	(0.00791)
Observations	917	894	1094	1020	1021	1024	1028	1026	1053	1016
R-squared	0.255	0.322	0.158	0.218	0.160	0.213	0.181	0.216	0.143	0.201
10% maximal IV size	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15% maximal IV size	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20% maximal IV size	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
Hanse J test p-value	0.383	0.594	0.894	0.700	0.382	0.361	0.790	0.464	0.677	0.820
Kleibergen-Paap rk LM P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap rk LM statistic	268.5	241.2	1069	1032	484.7	458.7	787.0	733.7	278.4	280.4

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Authors

4.2.4. ICT–Tax Revenue Elasticities Across Income Categories

To further examine whether the relationship between ICT and tax revenue mobilisation varies across different development levels, we conduct a sensitivity analysis based on income groups. This exercise is particularly relevant given the asymmetries highlighted in the literature: the marginal return of digitalisation tends to be higher in countries where administrative capacity, financial development, and ICT infrastructure are still evolving. For this purpose, the sample is disaggregated into four categories low-income, lower-middle-income, upper-middle-income, and high-income economies following the World Bank classification. The results presented in Table 8 reveal a clear magnitude asymmetry across income groups. Although the ICT coefficient

remains positive in all groups, its size differs substantially. The strongest effects are observed in lower-middle-income economies, where a marginal improvement in ICT adoption yields disproportionately large gains in tax revenue mobilisation. This is consistent with the idea that these countries are situated at a "critical elasticity point" of the digital adoption curve: small increases in mobile and internet penetration can dramatically improve taxpayer identification, reduce cash-based transactions, and strengthen compliance monitoring in environments where the shift from informal to formal economic activity is still underway.

In contrast, low-income economies display smaller coefficients due to structural constraints such as limited digital infrastructure, lower internet penetration, and weaker administrative systems, which prevent ICT investments from translating directly into fiscal gains. Meanwhile, upper-middle-income and high-income economies continue to benefit from ICT, but their marginal effects are lower because they are already equipped with more mature digital tax systems, stronger institutional governance, and deeper financial markets. In these contexts, ICT contributes more to efficiency gains and administrative refinement rather than to transformative expansion of the tax base. Overall, the sensitivity test confirms that while the positive effect of ICT on tax mobilisation is universal, the intensity and nature of this effect are heterogeneous, reflecting differences in economic structure, governance capacity, and stage of digital development. These findings underscore the need for income-specific tax digitalisation strategies, as policy priorities differ sharply between early-stage adopters and digitally advanced economies.

Table 8. Heterogeneous Effects of ICT on Tax Revenues Across Income Categories

	(1)	(2)	(3)	(4)
	IV-Lewbel, (2012)			
	Low income	Lower-Middle income	Upper-Middle income	High income
VARIABLES	TMR			
ICT index	**0.00362**	**0.0685*** **	**0.0268** **	**0.220*** **
	(0.0578)	**(0.00923)**	**(0.0130)**	**(0.0235)**
GDP per capita	-11.84*	3.712**	-2.744***	1.406***
	(6.062)	(1.591)	(0.670)	(0.155)
lnpopulation	0.00548*	-0.000624	0.00298***	0.00460**
	(0.00296)	(0.00106)	(0.00108)	(0.00200)
Inflation	-2.882**	-0.0416	4.281***	5.579
	(1.262)	(0.143)	(1.349)	(4.425)
FDI	14.62***	0.437	9.361**	1.046
	(3.056)	(2.304)	(3.815)	(3.505)
Region fixed effects	No	Yes	Yes	Yes
Constant	-0.0610	0.0339	0.00624	-0.191***
	(0.0474)	(0.0214)	(0.0157)	(0.0449)
Observations	133	284	356	121
R-squared	0.350	0.399	0.411	0.816
10% maximal IV size	19.93	19.93	19.93	19.93
15% maximal IV size	11.59	11.59	11.59	11.59
20% maximal IV size	8.75	8.75	8.75	8.75
Hansen J test p-value	0.491	0.932	0.838	0.913

Kleibergen-Paap rk LM P-value	0.000	0.000	0.000	0.000
Kleibergen-Paap rk LM statistic	42.97	42.91	57.79	57.40

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source : Authors

5. Analysis of transmission mechanisms

This sub-section evaluates the transmission mechanisms in the relationship between ICT and tax revenue mobilization. We study four main channels namely: Regulatory Quality (RQ), Voice and Accountability (Voice), Control of Corruption (CC), Government Effectiveness (GE) and Financial development (FD). It is thus illustrated in Figure 1 below.

Two regression equations are subsequently estimated using this method, as follows in Equations (3) and (4):

$$Model\ 1: Med_{it} = a_1 + b_1 TIC_{it} + c_1' X_{it} + u_{it} \quad (3)$$

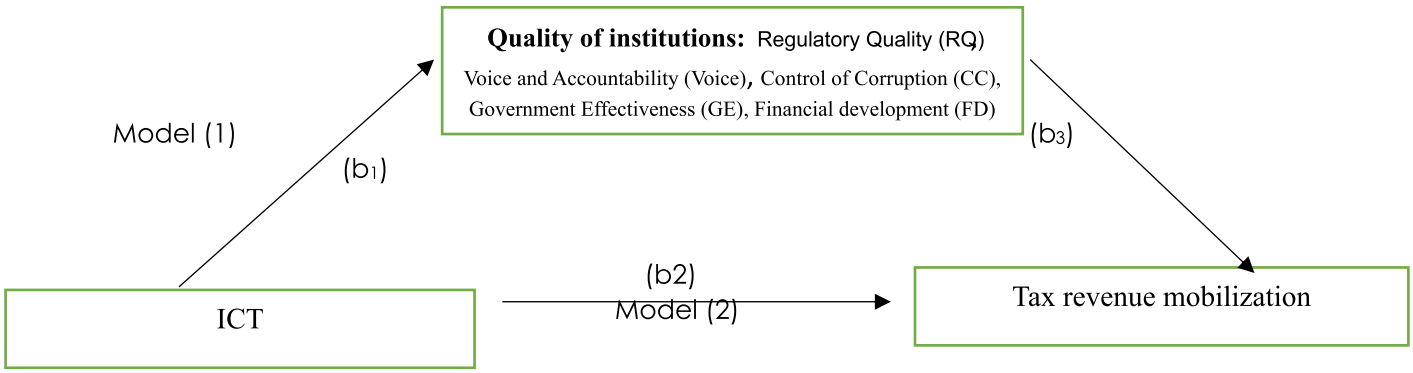
$$Model\ 2: TMR_{it} = a_2 + b_2 TIC_{it} + b_3 Med_{it} + c_2' X_{it} + v_{it} \quad (4)$$

Where Med_{it} represents the mediation variables (regulatory quality (rq), voice and accountability (voice), control of corruption (cc), government effectiveness (ge), Financial development (FD)). The two models mentioned above are used to derive the composition impact in the following way:

Figure 3. Modeling the mediating effects of ICT on the mobilization of tax revenue.

Indirect effect: $b_1 * b_3$; direct effect: b2 and total effect: $(b_1 * b_3) + b_2$.

Figure 3. Modeling of the mediation effect



Source: Authors

Table 9. Results of the analysis of transmission mechanisms

	(i) Mediator : Regulatory Quality		(ii) Mediator : Voice and Accountability		(iii) Mediator:Control of Corruption		(iv) Mediator : Government Effectiveness		(iv) Mediator : Financial development	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)	(5a)	(5b)
VARIABLES	RQ	TMR	Voice	TMR	CC	TMR	GE	TMR	FD	TMR
RQ		1.0301***								
		(0.177)								
ICT index	1.9928***	4.2847***	1.4355***	4.1404***	1.7990***	4.2683***	2.2534***	2.9953***	2.2539***	
	(0.088)	(0.517)	(0.122)	(0.441)	(0.101)	(0.453)	(0.072)	(0.570)	(0.075)	
Voice				1.1539***						
				(0.151)						
CC						1.4756***				
						(0.191)				
GE								1.7100***		
								(0.197)		
FD										1.8100***
										(0.199)
Constant	-0.8172***	3.2027***	-0.6851***	2.3392**	-0.9216***	2.0783*	-1.0031***	3.5830***		3.3835***
	(0.029)	(1.124)	(0.041)	(1.065)	(0.035)	(1.107)	(0.027)	(1.073)		(1.063)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Observations	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,071		1,071
Bootstrap replication	500	500	500	500	500	500	500	500		500

	coef	std.error	P-value	coef	std.error	P-value	coef	std.error	P-value	coef	std.error	P-value	coef	std.error	P-value
(A) Mediation tests															
Delta	2.053	0.359	0.000	1.656	0.251	0.000	2.655	0.381	0.000	3.853	0.463	0.000	2.623		0.000
Sobel	2.053	0.364	0.000	1.656	0.259	0.000	2.655	0.374	0.000	3.853	0.460	0.000	2.623		0.000
Monte Carlo	2.053	0.361	0.000	1.656	0.256	0.000	2.655	0.370	0.000	3.853	0.456	0.000	2.623		0.000
(A) Composition of the effect															
indirect effect (sobel)	2.053			1.656			2.655			3.853			2.623		
Direct effect	4.285			4.140			4.268			2.995			3.241		
Total effect	6.337			5.797			6.923			6.849			5.864		
% of the total effet mediated rowhead	32%			29%			38%			56%			44%		

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

Table 9 reveals a consistent pattern. First, ICT significantly improves all five mediators at the 1% level across columns (1a)–(5a), indicating that digitalisation strengthens governance structures, enhances regulatory capability, improves participation and oversight, reduces corruption, and deepens financial development. These effects reflect ICT's ability to restructure administrative processes, increase transparency, support digital reporting frameworks, and expand formal financial channels.

Second, all mediators significantly explain tax revenue mobilisation in columns (1b)–(5b). This demonstrates that ICT affects fiscal performance not only through technological efficiency but also through the institutional and financial ecosystem it helps reinforce. Based on the indirect effect estimates and the computed mediation shares, several important contributions emerge.

Regulatory Quality (32% mediated share) plays a substantial role in shaping the ICT–tax mobilisation link. ICT-driven improvements in regulatory clarity and enforcement make compliance easier, reduce administrative uncertainties and integrate firms more deeply into formal reporting structures. The 32% mediation share indicates that nearly one-third of ICT's fiscal impact operates through strengthened regulatory institutions. This result underscores how digitalisation facilitates rule enforcement, automated oversight and policy consistency.

Voice and Accountability (29%) contributes almost one-third of the total effect. ICT expands access to information, increases public scrutiny and enhances civic monitoring of fiscal governance. Better accountability reduces tax evasion pressures and induces stronger compliance. Although slightly smaller in magnitude than RQ's contribution, the 29% mediation share highlights the social and participatory dimension of ICT in fiscal performance particularly relevant in countries where ICT increases transparency and public engagement.

Control of Corruption (38%) emerges as one of the most powerful mediators. The indirect effect accounts for 38% of ICT's total impact on tax revenue mobilisation. Digitalisation dramatically reduces face-to-face interactions, limits opportunities for bribery, improves auditability and creates verifiable digital trails. These mechanisms reduce leakages and fraudulent practices. The large contribution of this channel shows that corruption reduction is a central path through which ICT enhances tax collection effectiveness.

Government Effectiveness (56%) is the strongest mediator in the entire system. More than half of ICT's effect on tax mobilisation stems from improvements in administrative capacity, service delivery, bureaucratic coordination and the overall performance of tax institutions. This substantial share reflects the central role of ICT in modern public sector management enhancing data integration, real-time information processing, automation, and overall governance efficiency. The magnitude of this mediation suggests that ICT reforms are particularly transformative when tax

administrations are able to absorb and operationalise new technologies within broader governance frameworks.

Finally, Financial Development (44%) represents a crucial structural channel. ICT significantly boosts financial development (Column 5a), and FD strongly increases tax revenue mobilisation (Column 5b). With 44% of ICT's total effect mediated through FD, the results reveal that the expansion of digital payments, e-banking, transaction formalisation and financial sector deepening is a major pathway through which digitalisation expands the effective tax base. ICT reduces informality, improves traceability of flows, increases the volume of reportable transactions and facilitates revenue mobilisation. This channel is particularly relevant in emerging economies where ICT accelerates the transition from cash-based to digital financial ecosystems.

Formal mediation tests Sobel, Delta and Monte Carlo confirm that indirect effects are statistically distinct from zero for all five mediators. Bootstrap confidence intervals further validate the robustness of these mediation patterns. The mediation structure therefore reveals that ICT's impact on fiscal capacity is multidimensional: it strengthens institutions, improves governance quality, reduces corruption, enhances administrative performance and facilitates financial deepening all of which jointly amplify the capacity of governments to mobilise tax revenue.

In sum, Table 9 shows that ICT does not enhance tax mobilisation through a single dominant channel. Instead, it operates through five mutually reinforcing institutional and financial mechanisms, with particularly strong effects from government effectiveness and financial development. These results highlight the need for policymakers to complement ICT investments with institutional reforms, governance improvements and financial sector modernisation to maximise the fiscal gains from digital transformation.

6. Conclusion, implications and future research directions

This study assessed the impact of information and communication technologies (ICTs) on tax revenue mobilization using a multidimensional approach and a global panel of countries over the period 2008–2022. Motivated by the dual challenge of unstable tax revenues exacerbated by the COVID-19 crisis and the rapid expansion of digital technologies, the paper combined theoretical insights with empirical evidence from fixed-effects OLS, System-GMM, and Lewbel's IV-2SLS estimators. Across all specifications, the results consistently show that higher ICT penetration through internet usage, mobile subscriptions, landlines, and broadband infrastructure significantly increases tax revenue mobilization at the global level. These findings confirm a robust and positive ICT tax nexus.

From a policy perspective, the results highlight the importance of strengthening digital public finance infrastructures. Policymakers should prioritize simple, stable, and transparent tax systems supported by digital identification, electronic filing, e-payments, and automatic information exchange. Digitalization can reduce tax evasion, expand the tax net, and improve administrative efficiency. Investing in ICT infrastructure, improving the digital skills of tax officials, and promoting taxpayer awareness are critical steps to enhancing compliance and trust in the tax system. Incentives that encourage businesses to adopt digital accounting and reporting tools can further reinforce these gains, especially in economies where informality remains pervasive.

While the findings are robust, the study necessarily has limitations. First, although the ICT index captures multiple dimensions of digitalization, measurement constraints remain due to cross-country data availability. Second, the use of aggregated panel data does not fully account for country-specific tax reforms or the quality of digital implementation. Third, despite relying on System-GMM and heteroskedasticity-based instrumentation, some endogeneity concerns may persist because digitalization and tax capacity can reinforce each other. These limitations open scope for deeper analysis using more granular administrative data, micro-level digital footprints, and natural experiments where possible.

Future research could extend these insights in several directions. One avenue is to examine how ICT interacts with broader development objectives, including the Sustainable Development Goals (SDGs). Another is to explore heterogeneity across income groups, given that high-income and low-income countries may respond differently to digital reforms. In addition, assessing the sequencing of tax digitalization reforms, the role of political economy factors, and the interaction between ICT and innovation ecosystems would further enrich understanding of the digital fiscal relationship. Overall, this study contributes to the growing literature on digital public finance and provides a foundation for future work on how ICT can support more efficient, equitable, and sustainable revenue mobilization. When considering the above future research directions, an alternative threshold approach such as that adopted by Wang et al. (2024) should be considered,

not least, because the suggested approach could not be applied in the present study due to concerns related to conceptual alignment and econometric feasibility.

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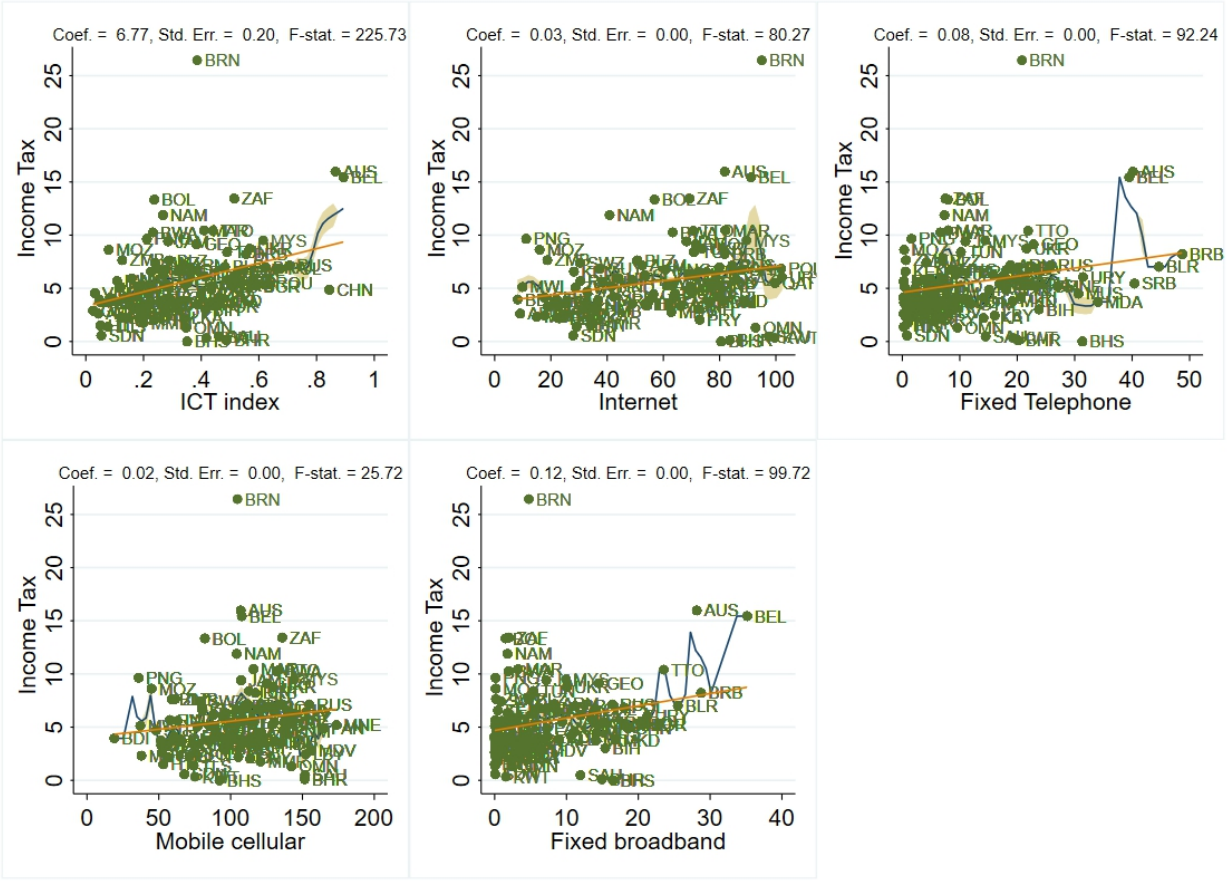
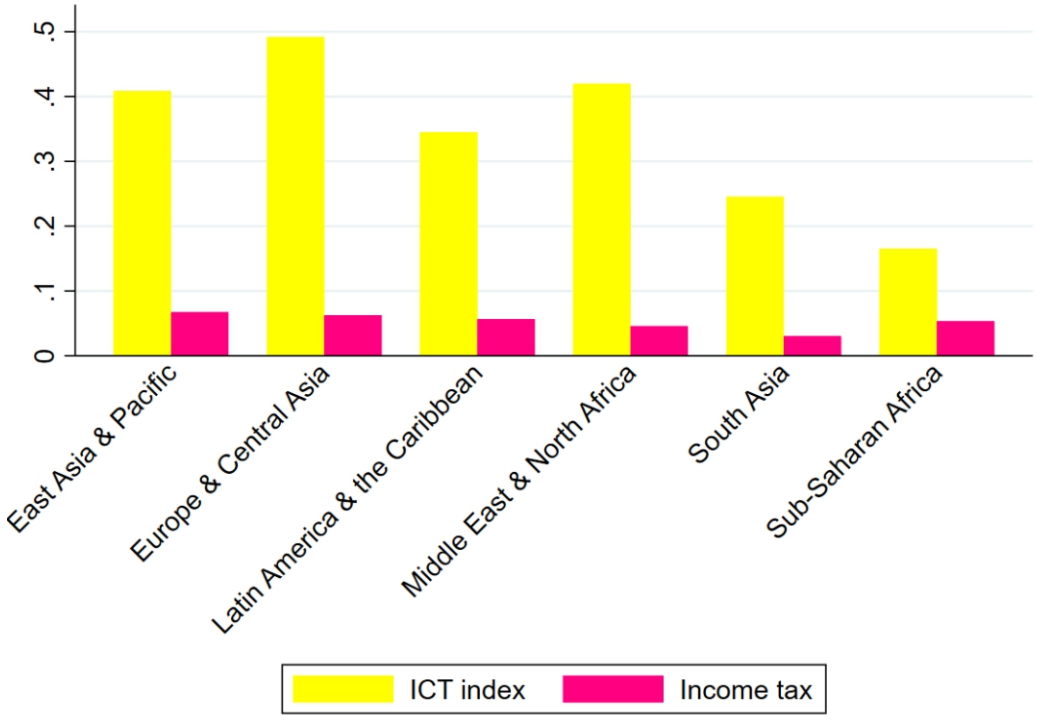
Appendices

Figure A1. Effect of ICT and tax income



Source : Authors

Figure A2. Sub-regional effects of ICT on tax income



Source : Authors

Data sources, and definitions

ICT Index (UNCTAD) is the main measure of digital readiness used in this study. It is a composite indicator developed by the United Nations Conference on Trade and Development (UNCTAD) that captures multiple dimensions of ICT development, including connectivity, access to digital infrastructure, technology diffusion, and the enabling institutional environment. The index aggregates several technological and infrastructural subcomponents into a unified scale, providing a comprehensive assessment of a country's overall digital capability.

Source: UNCTAD, various editions.

Tax income refers to the total revenue collected by the State from taxing individuals and firms. It includes personal income tax, corporate income tax, value-added tax (VAT), and other compulsory levies.

Source: UNU-WIDER Government Revenue Dataset (GRD), Version 2021.
https://doi.org/10.35188/UNU-WIDER/GRD-2021

Tax revenue (% of GDP) corresponds to non-resource tax revenue excluding social contributions, expressed as a percentage of GDP.

Source: UNU-WIDER GRD, Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021
Non-resource tax revenue including social contributions (% of GDP) includes total non-resource tax revenues plus mandatory social security contributions.

Source: UNU-WIDER GRD, Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021

Resource taxes (% of GDP) capture the share of tax revenue derived from natural-resource activities, particularly corporate taxation of extractive industries.

Source: UNU-WIDER GRD, Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021

Indirect taxes (% of GDP) represent the non-resource component of indirect taxation, including VAT, excise duties, and sales taxes.

Source: UNU-WIDER GRD, Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021
Fixed telephone subscriptions (per 100 people) indicate the number of active fixed telephone lines per 100 inhabitants, including analogue landlines, VoIP subscriptions, wireless local loop (WLL) lines, ISDN voice channels, and fixed public payphones.

Source: World Development Indicators (WDI)

GDP per capita is gross domestic product (constant 2010 US dollars) divided by the mid-year population, reflecting the average income level of the population.

Source: WDI

Population density measures the number of people living per square kilometre of land area.
Source: WDI
Inflation refers to the annual percentage change in the consumer price index (CPI), capturing changes in the cost of living.

Source: WDI

Foreign direct investment (FDI, % of GDP) refers to net inflows of investment intended to acquire at least 10% of the voting shares of a foreign firm. It includes equity capital, reinvested earnings, and other long- and short-term capital flows, divided by GDP.

Source: WDI

Internet penetration (per 100 people) represents the number of active internet subscriptions per 100 inhabitants in the last three months.

Source: WDI

Mobile phone subscriptions (per 100 people) include all active prepaid accounts used in the last three months and all postpaid subscriptions that allow voice communication.

Source: WDI

Fixed broadband subscriptions (per 100 people) measure the number of fixed high-speed broadband connections, including optical fiber.

Source: WDI