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DIGITAL TRANSFORMATION OF TAX SYSTEMS AND ITS IMPACT ON TAX REVENUE: EVIDENCE FROM GHANA AND THE GAMBIA

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Abstract

The digital transformation of tax administration has emerged as a central policy instrument for enhancing domestic revenue mobilisation in developing economies. This study examines the revenue impact of four tax digitalisation reforms in Ghana and The Gambia, two West African economies that have each invested substantially in digital tax administration over the past decade. Ghana deployed the Integrated Tax Application and Processing System (ITaPS) in 2019 and the Integrated Customs Management System (ICUMS) in 2020. The Gambia introduced GamTaxNet in 2018 and ASYCUDA World in 2022. Employing annual data spanning 2006 to 2024, this study estimates the effect of each reform on per-capita tax revenue using country-specific ARDL time-series models, controlling for GDP per capita and trade per capita.

The central empirical test is whether digital reforms improved the efficiency with which GDP per capita is converted into tax revenue per capita, tested through an interaction term between the reform dummy and GDP per capita. All interaction coefficients are positive. Ghana's ITaPS ($\gamma_1 = +0.211$, $p < 0.01$) and ICUMS ($\gamma_1 = +0.121$, $p < 0.05$) are statistically significant, as is The Gambia's ASYCUDA World ($\gamma_1 = +0.545$, $p < 0.01$), confirming that each reform raised the rate at which GDP per capita is converted into tax revenue. The findings provide systematic econometric evidence that digital tax administration reforms can materially expand revenue mobilisation in low-income West African economies.

Keywords: Digital tax administration, tax revenue mobilisation, ARDL bounds testing, Ghana, The Gambia, Sub-Saharan Africa, ITaPS, ICUMS, ASYCUDA World, GamTaxNet.

Introduction

Tax administration remains a fundamental pillar of fiscal sustainability and economic governance in low-income and developing economies. The capacity of state institutions to mobilise revenue has long been recognised as a determinant of fiscal space, public investment, and long-term development outcomes. In Sub-Saharan Africa, the average tax-to-GDP ratio of approximately 15% falls well below the 20% threshold widely regarded as the minimum required for adequate provision of public goods (IMF, 2011). Both Ghana, averaging 14.1% over 2006–2024, and The Gambia, averaging 10.5%, operate at or below this threshold. The revenue shortfall reflects not merely statutory tax design but also structural deficiencies in tax compliance and administrative enforcement gaps that digital technology has increasingly been identified as a means to address.

The digitalisation of tax administration operates through multiple reinforcing mechanisms. Electronic invoice systems reduce the scope for revenue under-declaration by establishing verifiable transaction records automatically transmitted to tax authorities. Digital filing and payment platforms lower compliance costs, thereby reducing the friction that discourages timely and accurate reporting. Customs digitalisation enhances transparency at the border, constraining the misvaluation and misclassification of imports that represent a persistent source of trade tax leakage. The empirical evidence from developing country contexts is instructive: electronic fiscal devices increased VAT compliance by 48% in Ethiopia (Mascagni, Mengistu & Woldeyes, 2021), while computerised VAT invoices accounted for over 10% of cumulative VAT revenue within five years of introduction in China (Fan, Liu, Qian & Wen, 2018). The extent to which analogous effects are realisable in West African contexts and under what institutional conditions remains an open empirical question. Ghana and The Gambia are particularly instructive comparators: they share the same regional trade framework yet occupy distinct positions on the income and institutional development spectrum. Ghana is a lower-middle-income economy with a comparatively diversified tax base and an extended history of administrative modernisation; The Gambia is a low-income economy structurally dependent on trade taxes and characterised by more constrained administrative capacity. Assessing whether digital reform delivers measurable revenue gains under both configurations informs the generalisability of the digital tax administration paradigm across Sub-Saharan Africa.

This study provides the first systematic econometric assessment of the revenue impact of digital tax administration reforms in Ghana and The Gambia over the period 2006–2024. The two countries constitute a well-suited comparative pair: both operate within the ECOWAS common tariff framework and have pursued analogous administrative modernisation trajectories yet pursued digital tax reform in different sequences and with different channel emphases. Ghana prioritised domestic tax administration digitalisation (ITaPS, 2019) before upgrading its customs platform (ICUMS, 2020); The Gambia undertook domestic tax system modernisation (GamTaxNet, 2018) preceding its migration to an integrated customs management system (ASYCUDA World, 2022). This differential sequencing creates a natural comparative structure for identifying the revenue effects of domestic and customs digitalisation separately, and for assessing whether these effects are sensitive to the structural characteristics of the host economy.

Research Goal

The primary objective of this study is to estimate the revenue impact of specific digital tax administration reforms on per capita tax revenue in Ghana and The Gambia over the period 2006–2024. It assesses whether reforms improved the efficiency with which GDP per capita is converted into tax revenue. A complementary objective is to evaluate whether reforms raised the share of GDP mobilised as tax, using supporting GDP-ratio models as corroborating evidence. The study is motivated by three factors: the persistent gap between actual and potential revenue in both countries; the scale of recent public investment in digital tax infrastructure; and the scarcity of rigorous time-series evidence on individually named reforms in the West African context. The use of country-specific ARDL time-series models anchored to precisely dated reform events enables identification of the revenue effect of specific systems within their institutional contexts, an objective that aggregate cross-country approaches are unable to achieve.

Research Question

Did the digitalisation of tax administration increase tax revenue per capita in Ghana and The Gambia, and did it improve the efficiency with which GDP per capita is converted into tax revenue?

Hypotheses

H1: Tax digitalisation reforms increase tax revenue per capita in Ghana and The Gambia, controlling for macroeconomic conditions.

H2: The revenue impact of tax digitalisation differs by tax channel, with domestic reforms producing larger effects on domestic tax revenue per capita and customs reforms producing larger effects on trade tax revenue per capita.

Scientific Contribution

The existing literature on digital tax administration in Africa is characterised predominantly by single-country studies and descriptive analyses. This study contributes to the field by combining a rigorous time-series econometric methodology, the ARDL bounds testing framework, with a two-country comparative design to produce causal estimates of the revenue impact of named, time-stamped digital reforms. The interaction term specification, which tests whether reforms improved the efficiency with which GDP per capita is converted into per-capita tax revenue, constitutes a novel efficiency test not previously applied to tax digitalisation in West Africa at the country level. Supporting GDP-ratio models complement the primary per-capita specification by assessing whether reforms additionally raised the proportion of GDP mobilised as tax revenue. Critically, the use of country-specific binary reform dummies anchored to precisely dated system-level implementation events address a well-documented identification problem inherent in panel approaches that rely on continuous digitalisation indices. The United Nations E-Government Development Index (EGDI) for The Gambia exhibits variation of fewer than 0.05 points across the entire 2006–2024 study period, rendering it unsuitable as a continuous treatment variable. By grounding identification in institutional reform events, this study produces estimates that are interpretable in terms of specific administrative interventions and directly actionable for revenue policy.

Scientific Results

The primary empirical finding is that all interaction coefficients γ_1 (Reform Dummy × GDP per capita) are positive, indicating that each reform improved the rate at which GDP per capita is converted into tax revenue per capita. For Ghana, ITaPS yields $\gamma_1 = +0.211$ ($p < 0.01$) and ICUMS yields $\gamma_1 = +0.121$ ($p < 0.05$), both statistically significant. For The Gambia, ASYCUDA World produces the strongest effect at $\gamma_1 = +0.545$ ($p < 0.01$), while GamTaxNet

yields a positive but statistically insignificant coefficient of $\gamma_1 = +0.063$ ($p = 0.169$). The net reform effect, evaluated at observed post-reform GDP per capita levels, is positive for all significant models. Supporting GDP-ratio models provide directional corroborating evidence for the domestic channel reforms in Ghana.

Structure of the Thesis

Chapter 1 presents the institutional context, encompassing the reform histories of Ghana-RA and Gambia-RA, the relevant legal frameworks, administrative structures, and the specific digital systems deployed during the study period. Chapter 2 reviews the theoretical and empirical literature on fiscal capacity, third-party information reporting, tax compliance behaviour, and digital tax administration in developing country settings. Chapter 3 describes the data sources and variable construction methodology and presents descriptive statistics and revenue trend analysis. Chapter 4 sets out the ARDL bounds testing methodology, model specification, identification strategy, and limitations of the empirical design. Chapter 5 presents the full set of empirical results, comprising unit root tests, primary per-capita ARDL models, channel decomposition models, and supporting GDP-ratio specifications. Chapter 6 provides a summary of principal findings, contextualises the results within the broader literature, and draws policy implications for Ghana-RA, Gambia-RA, and ECOWAS member states. The thesis is approximately 12,000 words in length and draws on 39 sources.

Chapter 1: Institutional Context and Country Background

1.1 Ghana Revenue Authority (Ghana-RA)

The Ghana Revenue Authority (Ghana-RA) was established in 2009 through the institutional consolidation of three pre-existing departments: the Customs, Excise, and Preventive Service (CEPS); the Internal Revenue Service (IRS); and the Value Added Tax Service (VATS). This integration constituted the first unified revenue administration in Ghana's fiscal history, superseding a fragmented multi-agency architecture that had generated substantial compliance gaps and systemic revenue leakage. Prior to consolidation, taxpayers were required to engage with distinct administrative entities across different tax categories; the establishment of Ghana-RA centralised the governance of all principal tax types under a single institutional mandate.

Notwithstanding institutional consolidation, Ghana-RA's operational processes remained substantially manual until the late 2010s. Taxpayer registration, return filing, and revenue remittance continued to require physical engagement or paper-based submissions, generating significant compliance friction and creating discretionary interactions susceptible to corruption and under-reporting. The compliance burden was particularly acute for small and medium-sized enterprises (SMEs), a structurally important segment of Ghana's non-extractive economy that historically contributed a disproportionately modest share of direct tax revenue. IMF (2011) estimates that compliance costs equivalent to 10–15% of tax liability is prevalent in manual administrative systems across Sub-Saharan Africa and that such environments are systematically associated with under-reporting of firm turnover. Ghana-RA's subsequent strategic planning explicitly identified information technology infrastructure modernisation as the primary mechanism for narrowing the compliance gap.

Two principal digital reforms reshaped Ghana-RA's operational architecture during the study period. The first was the Integrated Tax Application and Processing System (ITaPS), introduced in 2019. ITaPS constitutes a comprehensive electronic services platform enabling taxpayer registration, return filing, revenue remittance, and issuance of tax clearance certificates through digital channels, with mobile-money payment integration incorporated from the initial deployment phase. The system replaced a fragmented legacy infrastructure and established a unified taxpayer account accessible across all functional divisions of Ghana-RA. A substantive

extension of ITaPS is the electronic VAT (e-VAT) system mandating Electronic Fiscal Devices (EFDs) for VAT-registered businesses introduced in October 2022. The EFD mandate requires VAT-registered firms to issue machine-generated receipts whose transaction data are automatically transmitted to Ghana-RA in real time, closing the compliance verification loop at the point of sale and materially constraining the feasibility of sales underdeclaration. By October 2023, Ghana-RA recorded over 40,000 registered EFD terminals, though coverage gaps persisted among smaller registered enterprises.

The second major reform was the Integrated Customs Management System (ICUMS), which became operational on 1 June 2020, superseding the GCNet/West Blue customs architecture that had governed Ghanaian border administration since 2003. ICUMS constitutes a customised deployment of the UNIPASS platform, providing a unified single-window environment for import and export declarations, tariff classification, risk management, and electronic payment processing. Implementation was phased, with full operational integration achieved over the 2020–2022 period. In empirical analysis, the ICUMS reform dummy activates from 2020, one year after the ITaPS dummy (which activates from 2019), enabling partial channel-level separability between domestic and trade tax models. In total-tax specifications, however, the near-simultaneous deployment of both reforms limits identification to their combined revenue effect, a limitation discussed in Chapter 4. The near-simultaneous deployment reflects a deliberate strategic decision to modernise both the domestic and trade tax channels within a single reform cycle, consistent with 2019 IMF Extended Credit Facility conditionalities requiring enhanced revenue administration as part of Ghana's fiscal consolidation programme (IMF, 2024). The complementarity between ITaPS and ICUMS — specifically the shared taxpayer registration database and the cross-referencing of import declarations with domestic tax accounts — implies that the combined revenue effect estimated in total-tax models may understate the individual contribution of each system in isolation.

1.2 Gambia Revenue Authority (Gambia-RA)

The Gambia Revenue Authority (Gambia-RA) was established in 2004 through the merger of the Department of Customs and Excise and the Domestic Tax Department. Gambia-RA operates within a substantially smaller and more open economy than its Ghanaian counterpart: The Gambia has a population of approximately 2.7 million and a GDP of

approximately USD 2.4 billion in 2024, compared to Ghana's population exceeding 34 million and GDP of approximately USD 82 billion. This structural disparity is fiscally significant: the high degree of economic openness renders The Gambia far more dependent on trade taxation, which accounts for an average of 24% of total revenue compared to 14% for Ghana. Consequently, reforms that enhance the efficiency of customs administration carry a proportionally greater impact on The Gambia's aggregate revenue envelope.

Domestic tax administration in The Gambia was conducted through GamTaxNet during the study period. This platform underwent a major functional upgrade in 2018, enhancing electronic VAT filing capabilities, taxpayer registration infrastructure, and integrated compliance monitoring. The 2018 GamTaxNet upgrade constitutes the basis for the domestic reform dummy in the Gambian models (d_gamtaxnet, year ≥ 2018). The resulting post-reform observation window of seven years (2018–2024) is the longest among the reform dummies in this study, affording comparatively greater statistical power for estimating the domestic channel effect.

For customs administration, Gambia-RA migrated from ASYCUDA++ to ASYCUDA World, a web-based customs management system developed by UNCTAD, in July 2022, with mandatory full implementation achieved by 2023. ASYCUDA World is of particular strategic importance for The Gambia given the country's established function as a regional re-export corridor to Senegal and the Casamance sub-region; enhanced transit cargo tracking addresses a historically significant source of customs revenue leakage arising from the misdeclaration of transit shipments. The ASYCUDA World reform dummy activates from 2022 in the empirical analysis. UNCTAD (2024) reports a 23% increase in customs revenue in the year following the launch of ASYCUDA World.

In 2023, Gambia-RA additionally deployed a National Single Window (NSW) system, integrating customs procedures, certificates of origin, and port community operations into a unified platform. Given its position at the terminal boundary of the study window, the NSW is not separately modelled in this analysis. The sequential character of The Gambia's reform programme — domestic platform first (GamTaxNet), followed by customs modernisation (ASYCUDA World), and subsequently by trade facilitation infrastructure (NSW) — reflects a deliberate incremental capacity-building strategy, consistent with the IMF's (2023) recommended sequencing for small revenue administrations operating under constrained IT

capacity. The principal constraint on identification for The Gambia is the limited post-reform observation window for ASYCUDA World comprising only three annual observations (2022, 2023, and 2024) within the study period, which substantially reduces the statistical precision of the customs channel estimates, as acknowledged in Chapter 4.

Reform Timeline

Country	Tool	Implemented	Dummy ≥	Channel
Ghana	ITaPS (domestic e-services)	2019	2019	Domestic taxes
Ghana	ICUMS (customs platform)	2020	2020	Trade/customs
The Gambia	GamTaxNet	2018	2018	Domestic taxes
The Gambia	ASYCUDA World	2022	2022	Customs/trade

Table 1: Reform timeline. Source: Ghana Revenue Authority; Gambia Revenue Authority institutional documentation.

1.3 Tax Systems and ECOWAS Framework

Both countries maintain dual-track tax systems encompassing domestic taxation and international trade taxation. Domestic tax categories comprise personal income tax, corporate income tax, value added tax, and excise duties. Trade tax revenues are derived primarily from customs import duties and, in Ghana's case, historically from export levies.

Both countries are members of the Economic Community of West African States (ECOWAS), which administers a Common External Tariff (CET) applicable across all fifteen member states. Regional tariff harmonisation under the ECOWAS framework carries important implications for the identification strategy of this study: because import duty rates are administratively prescribed at the regional level, within-country variation in customs revenue is attributable primarily to administrative efficiency rather than to tariff policy changes, rendering investments in digital customs management directly comparable across member states and policy-relevant for the wider ECOWAS community. The CET delineates five tariff bands: 0% for essential social goods, 5% for raw materials and capital goods, 10% for intermediate goods, 20% for final consumer goods, and 35% for goods warranting special protection.

Details of the legal framework and individual tax rates for both countries are provided in Appendix A. The institutional and fiscal characteristics described in this chapter — the reform sequences, the structural dependence on trade taxation in The Gambia, and the near-simultaneous deployment of ITaPS and ICUMS in Ghana, directly inform the theoretical channels and empirical design developed in the following chapters.

Chapter 2: Literature Review

The theoretical foundation of this study is the concept of fiscal capacity — the institutional capacity of the state to mobilise revenues from its own economy. Besley and Persson (2013) demonstrate that fiscal capacity is not reducible to statutory tax rates but is determined critically by the quality of administrative institutions, legal enforcement mechanisms, and the political will to invest in taxation infrastructure. In their framework, states confronting greater developmental imperatives invest more intensively in fiscal capacity because the expected returns to such investment are higher. Digital tax administration systems constitute, within this framework, direct investments in fiscal capacity: they reduce the administrative cost of tax collection, expand the information sets available to revenue authorities, and enhance the credibility of enforcement.

Among the mechanisms through which digital systems augment revenue, third-party information reporting is theoretically and empirically the most significant. Gordon and Li (2009) demonstrate that revenue authorities in developing economies face fundamental informational constraints in taxing informal sector activity, arising from the absence of independently verifiable transaction records. Digital tax systems address this constraint by generating verifiable third-party data flows. Kleven, Kreiner and Saez (2016) establish that third-party reporting is the single most powerful determinant of tax compliance, and that its revenue effect is stronger in more formally structured, higher-income economies — a heterogeneity this study tests directly through the interaction term (Reform Dummy × GDP per capita).

Pomeranz (2015) provides experimental evidence from Chile that the VAT possesses an intrinsic self-enforcement property: because the deductibility of input taxes depends on invoice documentation, the transactional paper trail created by VAT generates cross-verification incentives throughout production chains. Digital systems amplify this mechanism by automating the invoice-matching process and reducing the cost of cross-referencing buyer and seller records. Naritomi (2019) demonstrates in the Brazilian context that consumer-facing e-invoicing generated a 21% increase in reported revenues among targeted firms. These mechanisms are directly operative in Ghana's e-VAT/EFD programme and The Gambia's EFD rollout. The self-enforcement argument is further substantiated by Keen and Lockwood (2010), who document in a cross-country study that VAT adoption is systematically associated with sustained

improvements in revenue performance, particularly in economies investing in digital invoice infrastructure. A complementary behavioural dimension is identified by Luttmer and Singhal (2014), who demonstrate that tax morale — the intrinsic disposition to comply without coercive enforcement — is substantially higher when taxpayers perceive the system as equitable and administratively transparent; digital systems contribute to this perception by reducing discretionary official interactions and the associated corruption risks. Fjeldstad and Semboja (2001) similarly document from Tanzania that compliance willingness is closely conditioned on perceived fiscal reciprocity.

The broader empirical literature documents a growing body of evidence on the revenue effects of digital tax reform in developing country contexts. Fan, Liu, Qian and Wen (2018) exploit the staggered rollout of VAT computerisation in China to find that computerised invoicing raised VAT revenues by 17% among treated firms and accounted for 10.8% of cumulative VAT revenue over a five-year horizon. Okunogbe and Pouliquen (2022) report that the introduction of electronic filing in Zambia reduced compliance time by 40% and doubled tax payments among high-evasion-risk firms, while concurrently reducing informal payments to tax officials. Mascagni, Mengistu and Woldeyes (2021) provide experimental evidence from Ethiopia that electronic sales registration machines increased VAT compliance by at least 48%. In Peru, mandatory VAT e-invoicing was associated with a 5% increase in reported sales and commensurate improvements in VAT remittances within a year of implementation (Bellon et al., 2022). Andersen (2009) further demonstrates that e-government systems broadly reduce corruption by establishing auditable electronic records of interactions between taxpayers and revenue officials.

Directly relevant to the Ghana context, Dzansi, Jensen, Lagakos and Telli (2022) provide experimental evidence from local governments in Ghana that technology use materially improves property tax capacity. Their randomised evaluation finds that GIS-enabled tablet technology increases bill deliveries by 27% and tax collections by 103%, with revenue collectors responding by reallocating time toward households with the highest payment propensity. Critically, their census of all 216 Ghanaian districts reveals that most local governments lack technological support for property registration and tax collection, underscoring the broader

administrative capacity gap that national-level digital reforms such as ITaPS and ICUMS are designed to address.

The emerging literature on African tax digitalisation is directly pertinent to this study. Okunogbe and Santoro (2023), in a continent-wide review, conclude that IT-based tax reforms demonstrate revenue potential but that outcomes are highly sensitive to implementation quality, the degree of taxpayer digital connectivity, and the pre-existing administrative capacity of the revenue authority. Abubakari et al. (2024) documents the early experience of ITaPS in Ghana, finding that while the platform reduced compliance costs for registered taxpayers, its penetration of informal-sector compliance was limited in the initial years of operation. IMF (2023) reviews cross-country adoption of digital tax technologies and concludes that customs digitalisation tends to generate faster revenue gains than domestic tax digitalisation, attributable partly to the bottleneck character of border administration and partly to the higher exposure of the formal sector to customs enforcement. Dom, Custers, Davenport and Prichard (2022) conclude from a comprehensive review of African compliance innovation that reforms generating trust between taxpayers and revenue authorities through transparency, reduced corruption, and lower compliance costs produce more durable revenue gains than enforcement-centred approaches. Mann (2004) notes that semi-autonomous revenue authorities such as Ghana-RA and Gambia-RA are institutionally better positioned to pursue trust-based reform.

The semi-autonomous revenue authority (SARA) institutional model within which both Ghana-RA and Gambia-RA operate is relevant to the interpretation of reform effects. Taliercio (2004) finds that the SARA model is associated with superior compliance and collection outcomes relative to conventional finance ministry structures. However, Kidd and Crandall (2006) caution that SARA effectiveness is critically conditioned on adequate information technology infrastructure: institutional autonomy alone is insufficient to overcome the information asymmetries that underlie tax evasion.

The structural determinants of tax revenue in developing economies have been extensively investigated. Gupta (2007) identifies GDP per capita, trade openness, and agricultural sector share as the principal structural drivers of the tax-to-GDP ratio across developing countries. Crivelli and Gupta (2014) establish that institutional quality is independently associated with superior revenue performance. McNabb (2018) documents that

both Ghana and The Gambia mobilise below the levels predicted by their structural characteristics, indicating genuine scope for administrative improvement. Jensen (2022) provides a theoretical and empirical account of how the structural transition from self-employment to wage employment drives long-run increases in tax capacity, motivating the inclusion of GDP per capita and its interaction with reform dummies in the primary model specification. Le, Moreno-Dodson and Bayraktar (2012) decompose tax effort into structural and administrative components, finding that the administrative gap is largest in Sub-Saharan Africa — directly motivating the comparative design employed here. Slemrod (2019) argues that the most effective compliance instruments are those that alter the information environment rather than merely intensifying audit probability; electronic third-party reporting achieves this through structural means, and its effects are expected to manifest as permanent shifts in tax revenue per capita.

Synthesising the literature, three primary channels are identified through which digital tax administration reforms augment revenue mobilisation. The first is the information channel, through which digital systems generate independent third-party transaction data that constrain evasion. The second is the compliance-cost channel, through which lower filing and payment costs expand the population of compliant taxpayers. The third is the corruption-reduction channel, through which electronic processing reduces the frequency and discretionary character of taxpayer-official interactions that create bribery opportunities.

The expectation that these three channels operate with greater intensity at higher income levels, motivate the use of the interaction term (Reform Dummy × GDP per capita) as the primary efficiency test in this study. A positive coefficient on this term indicates that the reform improved the rate at which GDP per capita is converted into per-capita tax revenue, consistent with the information channel mechanism. The Gambia remains largely absent from the quantitative tax administration literature, with no published econometric study directly estimating the revenue effects of its digital reform programme. This gap reinforces the empirical contribution of the present study.

The ARDL bounds testing framework, developed by Pesaran, Shin and Smith (2001), is specifically designed to accommodate cointegration among variables of mixed integration order I(0) and I(1). Narayan (2005) provides small-sample critical values appropriate to the T = 19 observation constraint per country. Gupta (2007) and McNabb (2018) both employ variants of

this framework to estimate the structural determinants of tax effort in developing countries. This study extends that estimation tradition by introducing precisely dated reform dummies and an interaction term that allows the income-to-revenue relationship to shift at the point of reform implementation.

Chapter 3: Data and Descriptive Analysis

3.1 Data Sources and Variable Construction

Annual data for Ghana and The Gambia are compiled for the period 2006 to 2024, yielding 19 observations per country and 38 country-year observations in total. Tax revenue data are sourced from the OECD/African Union Revenue Statistics for Africa, which provides disaggregated revenue by category on a basis consistent with international fiscal reporting standards. Macroeconomic control variables, including GDP per capita (constant 2015 USD), GDP growth (annual percentage), trade openness (exports plus imports as a share of GDP), and inflation (annual CPI percentage change), are obtained from the World Bank World Development Indicators (WDI). Digital governance indicators are sourced from the United Nations E-Government Survey (UNDESA), published biennially and linearly interpolated to annual frequency.

Reform event dummies are constructed as binary indicator variables equal to zero in all years preceding the reform implementation date and equal to one from the reform year onward. Implementation dates are drawn from official documentation published by the Ghana Revenue Authority and the Gambia Revenue Authority. Four reform dummies are constructed in total: ITaPS (Ghana, activating from 2019), ICUMS (Ghana, activating from 2020), GamTaxNet (The Gambia, activating from 2018), and ASYCUDA World (The Gambia, activating from 2022). The identification strategy underpinning these dummies is discussed in full in Chapter 4.

The United Nations E-Government Development Index (EGDI) was considered as a background control variable to capture general improvements in digital governance capacity. However, The Gambia's EGDI series exhibits variation of fewer than 0.05 points across the entire 2006–2024 study period, which is insufficient to identify as a driver of revenue changes measured in hundreds of USD per capita. EGDI is accordingly excluded from the primary estimation models; identification rests instead on the named reform dummies as discussed in Chapter 4.

The primary dependent variables are tax revenue per capita (USD per person), computed as (Tax Revenue in USD millions × 1,000,000) / Population across three channels: total tax, domestic taxes (personal income tax, VAT, and excise duties), and trade taxes (customs duties and export taxes). Population is derived algebraically from GDP divided by GDP per capita. Per-

capita normalisation is adopted as the primary specification because it enables the interaction term (Reform Dummy × GDP per capita) to test directly whether reforms improved the efficiency with which GDP per capita is converted into tax revenue per capita.

Tax-to-GDP ratios are constructed as secondary dependent variables for the supporting GDP-ratio specifications. Controls in the primary per-capita models are GDP per capita and trade per capita (trade openness × GDP per capita), with a COVID-19 dummy (2020) as an additional fixed control. Controls in the supporting GDP-ratio models comprise trade openness and the log of the nominal exchange rate. The log nominal exchange rate is included because all per-capita and GDP measures are denominated in current US dollars, rendering exchange rate movements a direct source of variation in the dependent variables that is independent of tax administration quality and must be controlled to avoid confounding the reform estimates.

3.2 Descriptive Statistics

Variable	Ghana Mean	Ghana SD	Ghana Min	Ghana Max	Gambia Mean	Gambia SD	Gambia Min	Gambia Max
Total Tax PC (USD)	255.04	73.17	124.61	360.04	75.94	11.65	56.26	105.52
Domestic Tax PC (USD)	144.37	44.97	67.68	219.89	37.28	9.28	20.98	56.31
Trade Tax PC (USD)	34.95	6.30	21.81	43.41	18.06	2.56	13.23	23.28
Total Tax/GDP (%)	14.13	1.16	11.42	16.47	10.45	1.12	8.54	12.11
GDP per Capita (USD)	1,812	518	906	2,445	728	93	568	883
GDP Growth (%)	5.82	3.12	0.51	14.05	3.53	3.76	−8.13	7.23
Inflation (%)	15.26	8.08	7.14	38.11	6.91	3.35	2.06	16.97
Trade Openness (% GDP)	70.72	8.14	60.76	93.17	46.64	7.27	38.11	64.81
EGDI (0–1)	0.448	0.140	0.275	0.632	0.255	0.033	0.212	0.309

Table 2: Country-level descriptive statistics, 2006–2024 (N = 19 per country). Source: OECD Revenue Statistics; World Bank WDI; UN EGDI.[1]

The country-level comparison reveals pronounced structural differences. Ghana's mean total tax per capita (USD 255.04) is more than three times The Gambia's (USD 75.94). Ghana's mean tax-to-GDP ratio of 14.13% remains marginally below the SSA benchmark of 15%, while The Gambia's mean of 10.45% represents a more substantial shortfall. The Gambia's greater structural dependence on trade taxation implies that customs digitalisation affects a proportionally larger share of its total revenue base. Ghana exhibits higher mean GDP growth (5.82% versus 3.53%) and substantially higher mean inflation (15.26% versus 6.91%), with the severe inflationary episode of 2022–2023 (peak 38.1%) reflecting the fiscal stress that preceded Ghana's 2023 IMF Programme engagement. Exchange rate movements are of particular relevance as a control variable for Ghana: the Ghanaian cedi depreciated by approximately 80% against the US dollar in 2022 alone, materially reducing USD-denominated per-capita tax figures even as local-currency revenues maintained growth, an effect that accounts for the visible decline in Ghana's total tax per capita during 2022–2023 notwithstanding the structural revenue improvements attributable to ITaPS and ICUMS. For The Gambia, nominal exchange rate depreciation has been comparatively moderate (approximately 7% per annum on average), consistent with a more stable fiscal position and lower debt-to-GDP ratio. The EGDI variable shows a substantial gap between Ghana (mean EGDI 0.448) and The Gambia (mean EGDI 0.255), reflecting divergent trajectories in digital infrastructure investment and e-government development.

3.3 Revenue Trends and Figure Overview

Figure 1 presents total tax revenue as a percentage of GDP for both countries over the full study period, with reform event dates marked by vertically dashed lines. Blue dashed lines indicate Ghana reforms; red dashed lines indicate Gambia reforms. Ghana's tax-to-GDP ratio fluctuated between approximately 11% and 16.5% over the study period, peaking at 16.5% in 2012 before declining to a trough of 11.4% in 2013, then recovering to a stable range of 13–15%

[1] All per-capita values in nominal USD. Ghana's GDP per capita (mean USD 1,812) is approximately 2.5 times Gambia's (mean USD 728).

from 2016 onward. The ratio remained broadly stable during the ITaPS and ICUMS deployment years (2019–2020), reflecting the dampening effect of exchange rate depreciation on USD-denominated revenues during this period. The Gambia's ratio fluctuated between approximately 8.5% and 12.1%, with no clear monotonic trend, ending the study period at 12.1% in 2024.

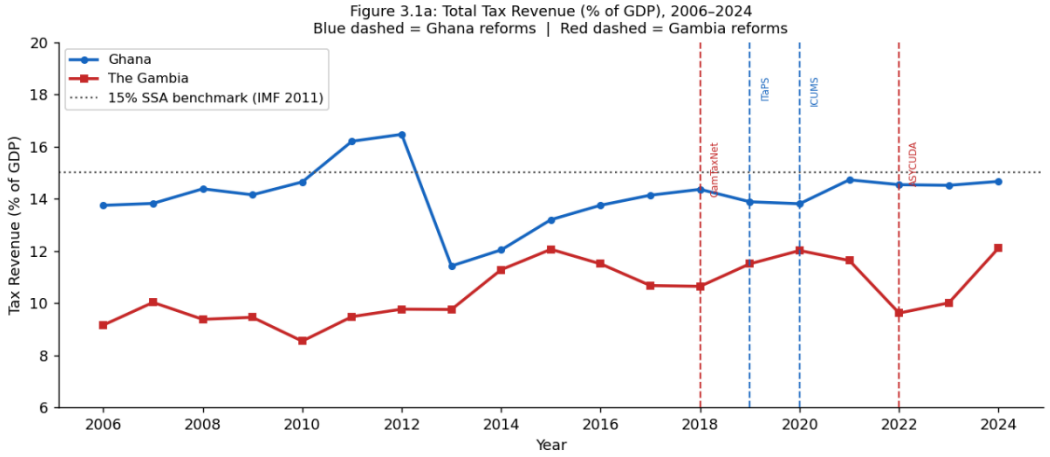

Figure 1: Total Tax Revenue (% of GDP), 2006–2024. Source: OECD Revenue Statistics; WDI.

Figure 2 presents tax revenue per capita (USD) across three channels — total, domestic, and trade — for both countries. Ghana's total tax per capita increased from approximately USD 125 in 2006 to a peak of approximately USD 360 in 2021, before contracting as the 2022–2023 exchange rate depreciation eroded USD-denominated values. The Gambia's total tax per capita exhibited more gradual growth, rising from approximately USD 56 in 2006 to approximately USD 106 by 2024, with a discernible acceleration from 2018 coinciding with the GamTaxNet upgrade and sustained revenue momentum following the introduction of ASYCUDA World.

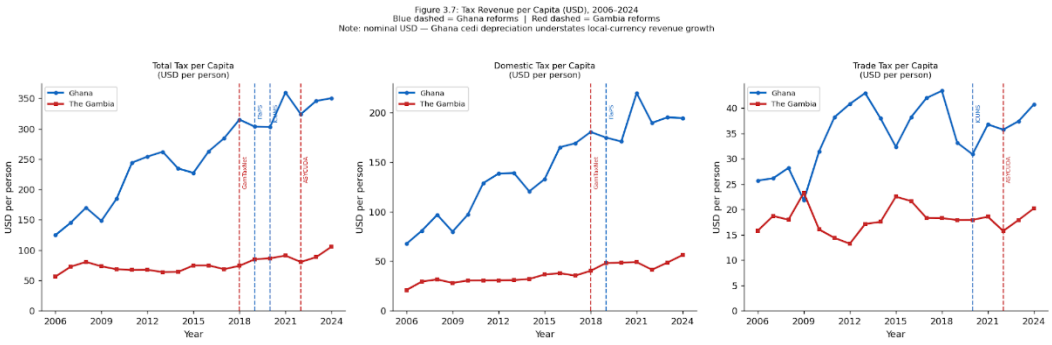

Figure 2: Tax Revenue per Capita (USD), 2006–2024 — Total (left), Domestic (centre), Trade (right). Source: OECD Revenue Statistics; WDI [2]

Figure 3 provides a simple before-and-after comparison of mean total tax per capita around each primary reform event.

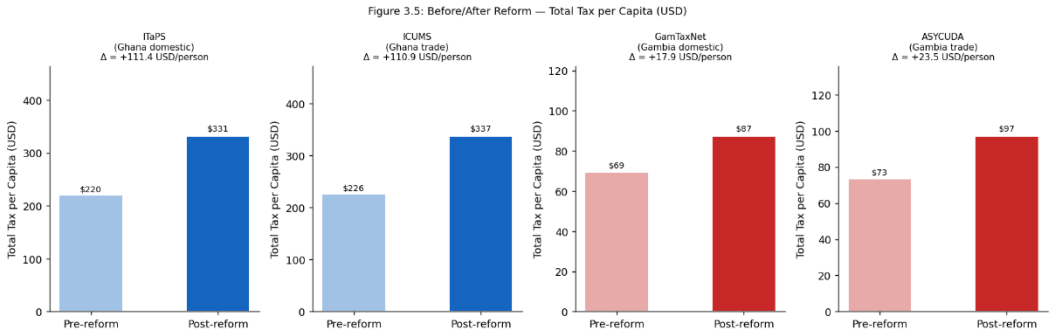

Figure 3: Pre- vs Post-Reform Mean Total Tax Revenue per Capita (USD). Bars show average before and after each reform dummy activation. Source: OECD Revenue Statistics; WDI.

[2] Ghana (blue) and The Gambia (red), 2006–2024. Dashed vertical lines: Ghana reforms in blue (ITaPS 2019; ICUMS, 2020), Gambia reforms in red (GamTaxNet, 2018; ASYCUDA World, 2022).

Chapter 4: Methodology

4.1 Research Design

This study employs a two-country comparative time-series design. With N = 2 units, panel estimation is methodologically inappropriate: the identification of fixed effects in a panel regression requires meaningful cross-sectional variation that is not available with only two countries. Each country is accordingly treated as an independent time series of T = 19 annual observations, and country-specific ARDL models are estimated separately. The two countries are analysed as contrasting reform trajectories and compared on a descriptive basis; they are not pooled as statistically interchangeable units.

The study adopts a quantitative approach within a positive epistemological framework. The primary analytical paradigm is time-series cointegration analysis, which is appropriate when series may be non-stationary and a stable long-run equilibrium relationship between revenue and macroeconomic fundamentals is theoretically expected. The ARDL bounds testing framework of Pesaran, Shin and Smith (2001) is selected on three grounds: it accommodates regressors with mixed integration orders I(0) and I(1); it produces both short-run dynamic adjustment coefficients and long-run equilibrium estimates within a single specification; and it is specifically designed to perform reliably in small samples. Country-specific binary reform dummies anchored to precisely dated system-level implementation events are employed, following the methodology of the policy evaluation literature.[3]

4.2 Model Specification

The central model specification is motivated by the hypothesis that digitalisation improves the efficiency of tax collection: if administrative modernisation reduces compliance gaps, a given level of GDP per capita should generate systematically higher per-capita tax revenue in the post-reform period. The formal test of this efficiency improvement is whether the coefficient on the interaction term (Reform Dummy × GDP per capita) is positive, indicating that the reform shifted upward the rate at which GDP per capita is converted into tax revenue per capita.

[3] The EGDI is unsuitable as a continuous treatment variable for The Gambia, where it exhibits variation of fewer than 0.05 points across the entire 2006–2024 study period; see Section 3.1 for full discussion.

The general ARDL(p, q) per-capita model for each country and specification is:

$$tax\_pc(t) = \alpha + \Sigma\, \varphi_i \cdot tax\_pc(t\text{-}i) + \Sigma\, \beta_j \cdot X(t\text{-}j) + \gamma_1 \cdot [D(t) \times gdp\_pc(t)] + \gamma_2 \cdot D(t) + controls + \varepsilon(t)$$

where tax_pc is tax revenue per capita (USD); X includes GDP per capita and trade per capita as endogenous regressors, with lag orders *p* and *q* selected by BIC subject to a maximum of two lags — so tax_pc($t-i$) denotes the dependent variable lagged by i periods, and X($t-j$) denotes the regressors lagged by j periods — yielding an ARDL(2,1) specification throughout; exogenous regressors are fixed at one lag[4]; D is the binary reform step dummy; [D × gdp_pc] is the interaction term; controls include the COVID-19 dummy (2020); and $\varepsilon(t)$ is the error term. HAC (Newey-West) standard errors are applied throughout to correct for serial correlation and heteroskedasticity.

The parameter of central interest is γ_1, the coefficient on the interaction term. A positive and statistically significant γ_1 indicates that the reform increased the marginal contribution of GDP per capita to per-capita tax revenue, consistent with an improvement in revenue conversion efficiency. The level dummy coefficient γ_2 captures any discrete structural shift in the revenue trajectory at the reform activation date.

Supporting models replace per-capita revenue with tax-to-GDP ratios as dependent variables, employing trade openness and the log nominal exchange rate as controls. These GDP-ratio specifications are complementary to, rather than alternative to, the primary per-capita models: because they normalise revenue by the contemporaneous scale of the economy, they control for nominal income growth but may attenuate the estimated reform effect during periods of rapid GDP expansion. Reading the two specifications in conjunction provides a more complete characterisation of whether reform effects represent genuine improvements in administrative efficiency.

[4] Fixing exogenous regressors at one lag rather than selecting by BIC is a deliberate degrees-of-freedom conservation measure: with only T = 19 observations per country, estimating additional lag parameters for exogenous variables would rapidly exhaust available degrees of freedom and reduce the reliability of coefficient estimates. The sample size constraint and its implications for model parsimony are discussed in full in Section 4.4.

4.3 Reform Dummies and Identification

As established in Table 1, reform dummies are specified as country-specific binary step indicators activating from 2019 (ITaPS), 2020 (ICUMS), 2018 (GamTaxNet), and 2022 (ASYCUDA World). Although d_itaps and d_icums differ by one year, in total-tax models the one-year offset means estimates partially overlap and should be interpreted primarily as capturing the combined revenue effect of both reforms implemented in close temporal proximity, rather than the effect of either system in full isolation.

The identification strategy rests on three maintained assumptions:

I. absent the reform, revenue would have followed its pre-reform trend trajectory
II. no concurrent policy changes independently and materially shifted the revenue trajectory; and
III. the timing of reform implementation was not endogenously determined by anticipated near-term revenue growth.

Control dummies for COVID-19 (2020) are included to address known confounding events. Assumption (iii) is imperfect for Ghana's ITaPS, which coincided with an IMF Extended Credit Facility arrangement entered into in 2019 that included explicit revenue-raising conditionalities. It is accordingly not possible to fully separate the administrative revenue effect of ITaPS from the broader fiscal consolidation associated with the IMF Programme. This limitation is partially addressed by including GDP per capita and trade per capita as control.

4.4 Limitations

Four principal limitations are acknowledged. First, the T = 19 observation constraint per country restricts statistical power, particularly for reforms implemented near the terminal boundary of the study period. ASYCUDA World (The Gambia, 2022) yields only three post-reform observations (2022, 2023, and 2024), rendering the associated coefficient estimates preliminary in character and subject to revision as additional post-reform data accumulate. The Y-lag order is selected by BIC subject to a maximum of two lags, while endogenous regressors follow a fixed lag order of one, yielding an ARDL(2,1) specification throughout. Second, the near-simultaneous activation of ITaPS (2019) and ICUMS (2020) in Ghana precludes separate identification of their individual revenue effects in total-tax specifications. Third, the possibility

of endogenous reform adoption cannot be excluded in the absence of a valid instrumental variable. Fourth, with N = 2 countries, the results are not generalisable to the broader West African context without corroboration from additional comparative evidence.

Chapter 5: Empirical Results

5.1 Unit Root Tests

Prior to estimation, all variables are subjected to stationarity testing using the Augmented Dickey-Fuller (ADF) test with automatic lag selection governed by the Akaike Information Criterion (AIC), subject to a maximum of two lags. The results confirm a pattern of mixed integration orders: the majority of per-capita tax revenue series are integrated of order one I(1), while GDP growth and selected trade variables are I(0) for The Gambia. The full ADF results table, together with ARDL bounds test results, is reported in Appendix B (Table B.3). The presence of variables of mixed integration order confirms the appropriateness of the ARDL bounds testing approach over Johansen cointegration (which requires uniform I(1) integration) or OLS (which assumes uniform I(0) stationarity). Narayan (2005) small-sample critical values are applied throughout, reflecting the T = 19 observation constraint per country.

The Y-lag order in all ARDL models is selected by the Bayesian Information Criterion (BIC), subject to a maximum of two lags, yielding an ARDL(2,1) specification throughout. The bounds F-test results indicate that cointegration is confirmed in only one of eight primary models. The Gambia's domestic tax model (GamTaxNet) is the only model confirming a long-run cointegrating relationship (F = 5.139, exceeding the I(1) 5% upper critical value of 5.39). Ghana's trade tax model (ICUMS) yields an inconclusive result (F = 3.880). For the remaining models, F-statistics fall below the I(0) lower bound; the level dummy coefficients are therefore best interpreted as discrete structural breaks in the revenue trajectory at the reform activation date. The reform event identification strategy, rather than the cointegration framework, provides the primary basis for causal attribution in this study.

5.2 Primary ARDL Results — Total Tax per Capita

Estimation results for all primary models are presented in Table 4. The central parameter of interest is γ_1 — the interaction coefficient on Reform Dummy × GDP per capita — which captures whether each reform improved the efficiency with which GDP per capita is converted into per-capita tax revenue. The level dummy γ_2 captures any discrete shift in the revenue trajectory at the reform activation date; both parameters must be read together to characterise the full reform effect (see Appendix B, Table B.1 for full output).

Model	Dependent Variable	Channel	γ_1 (D×gdp_pc)	p	γ_2 (Dummy)	p	Adj. R^2	DW	N
M1-GH	Total Tax PC	Domestic (ITaPS)	+0.2114***	0.001	−481.0	0.002	0.926	1.967	17
M2-GH	Total Tax PC	Trade (ICUMS)	+0.1208**	0.037	−243.7	0.070	0.924	1.881	17
M1-GM	Total Tax PC	Domestic (GamTaxNet)	+0.0633 n.s.	0.169	−27.4	0.469	0.646	2.081	17
M2-GM	Total Tax PC	Trade (ASYCUDA)	+0.5449***	0.001	−462.3	0.001	0.724	2.214	17

Table 4: Primary ARDL results — total tax per capita.[5]

For Ghana, both reforms yield positive and statistically significant interaction terms. The ITaPS interaction coefficient (γ_1 = +0.2114, p = 0.001) indicates that ITaPS raised the GDP-elasticity of per-capita tax revenue: each additional USD of GDP per capita generates approximately USD 0.21 more in per-capita total tax revenue in the post-reform period relative to the pre-reform baseline. The ICUMS interaction coefficient (γ_1 = +0.121, p = 0.037) similarly confirms that ICUMS improved revenue conversion efficiency on the trade channel. For The Gambia, the ASYCUDA World interaction coefficient (γ_1 = +0.545, p = 0.001) is the largest across all primary models, consistent with the country's high structural dependence on trade taxation. The GamTaxNet interaction coefficient is positive (γ_1 = +0.063) but does not attain statistical significance (p = 0.169). The level dummies (γ_2) are negative across all models; this reflects the model's partitioning of the reform effect between the level shift and the income-dependent interaction term and does not imply revenue contraction. The net reform effect at any given GDP per capita level is computed as $\gamma_2 + \gamma_1 \times$ gdp_pc and is positive at all observed post-reform income levels for the significant models (Section 5.5). See Appendix B, Table B.1 for full regression output.

[5] Controls: GDP per capita, trade per capita, COVID-19 dummy. ARDL(2,1) specification. HAC standard errors. DW = Durbin-Watson statistic; values between 1.5 and 2.5 indicate no serious serial correlation. *** p<0.01, ** p<0.05, * p<0.1. Note: M1-GH and M2-GH total-tax estimates are near-identical because ITaPS (2019) and ICUMS (2020) were deployed in close temporal proximity and affect the same aggregate revenue base. Full output in Appendix B, Table B.1.

5.3 Channel Decomposition Models

Table 5 presents results when domestic and trade tax per capita are used as separate dependent variables, allowing us to test whether each reform had its strongest effect on the corresponding tax channel (H2).

Model	Dependent Variable	Reform	γ_1 (D×gdp_pc)	p	γ_2 (Dummy)	P (γ_2)	Adj. R^2
M3-GH	Domestic Tax PC	ITaPS	+0.1570**	0.022	−360.2	0.020	0.819
M4-GH	Trade Tax PC	ICUMS	+0.0074 n.s.	0.608	−25.7	0.449	0.348
M3-GM	Domestic Tax PC	GamTaxNet	+0.0682**	0.014	−37.8	0.037	0.768
M4-GM	Trade Tax PC	ASYCUDA	+0.0728**	0.031	−61.4	0.027	−0.882[6]

Table 5: Channel decomposition models. HAC standard errors. *** p<0.01, ** p<0.05, * p<0.1.

For Ghana, the domestic channel model (ITaPS) yields a positive and statistically significant interaction term ($\gamma_1 = +0.157$, $p < 0.05$), consistent with ITaPS's design as a domestic tax administration platform. The ICUMS interaction on the trade channel is positive but does not reach statistical significance ($\gamma_1 = +0.007$, $p = 0.608$), likely reflecting the near-simultaneous deployment of both reforms and the limited separability of their effects in the Ghana trade tax series. For The Gambia, GamTaxNet yields a positive and significant interaction coefficient on the domestic channel ($\gamma_1 = +0.068$, $p < 0.05$), and ASYCUDA World produces a positive and significant interaction on the trade channel ($\gamma_1 = +0.073$, $p < 0.05$), providing cleaner channel-level identification than is achievable for Ghana. The poor adjusted R^2 for the ASYCUDA trade channel model is a statistical artefact arising from the very limited post-reform window of three observations (2022, 2023, and 2024), rather than a substantive model failure. UNCTAD (2024) administrative data reporting a 23% customs revenue increase in the year following ASYCUDA World's launch provides corroborating evidence consistent with the positive interaction

[6] The negative Adj. R^2 for M4-GM is a mechanical consequence of the severely limited post-reform window: with only three post-reform observations (2022–2024) and a parameter-rich ARDL(2,1) specification, the model exhausts available degrees of freedom and fits worse than an intercept-only benchmark. This does not invalidate the positive and significant γ_1 coefficient, which is corroborated by UNCTAD (2024) administrative data.

coefficient. Re-estimation with data covering 2025–2027, when the post-reform window will have expanded to at least five years, is expected to yield substantially more precise estimates.

5.4 Supporting GDP-Ratio Models

Supporting models were estimated using tax-to-GDP ratios as dependent variables, with trade openness and the log nominal exchange rate as controls but without an interaction term (full output in Appendix B, Table B.2). These specifications are reported for completeness but are not the basis for the principal conclusions of this study. Because the GDP-ratio models omit the interaction term, the reform dummy coefficient conflates two conceptually distinct effects — the level shift in revenue (γ_2) and the income-dependent efficiency gain (γ_1), into a single reduced-form parameter. This conflation prevents clean identification of whether a reform raised revenue conversion efficiency or merely produced a one-off structural break. The primary per-capita ARDL models with the interaction term, reported in Sections 5.2 and 5.3, remain the authoritative basis for answering the research question.

5.5 Interpreting the Results: Interaction Effects, Net Reform Impact, and the Negative Level Dummy

The principal interpretive task in this section is to explain: (a) why the level dummies γ_2 are negative across all primary models despite the reforms being revenue-positive; (b) what the positive interaction coefficients γ_1 mean economically; and (c) why the negative level dummy γ_2 in M3-GM does not indicate a revenue decline.

On the positive interaction coefficients ($\gamma_1 > 0$): The central finding of this study is that all interaction coefficients are positive, confirming that each reform raised the GDP-elasticity of per-capita tax revenue. Ghana's ITaPS yields $\gamma_1 = +0.211$ ($p < 0.01$), meaning each additional USD of GDP per capita generates approximately USD 0.21 more in per-capita tax revenue in the post-reform period. ASYCUDA World for The Gambia produces the largest coefficient ($\gamma_1 = +0.545$, $p < 0.01$), consistent with the country's high structural dependence on trade taxation and the substantial customs compliance gap that ASYCUDA World is designed to close.

On the net reform effect: Since γ_2 is negative and γ_1 is positive across all models, the net reform effect at any given GDP per capita level is $\gamma_2 + \gamma_1 \times$ gdp_pc. For Ghana's ICUMS at the post-reform mean GDP per capita of approximately USD 2,000, the net effect is −243.7 + (0.121 × 2,000) = +USD 98.3 per capita. For ASYCUDA World in The Gambia at the post-reform mean

of approximately USD 800, the net effect is −462.3 + (0.545 × 800) = +USD 73.7 per capita. Both are strongly positive, confirming that the reforms were unambiguously revenue-enhancing within the observed income range. The negative γ_2 values reflect the model's partitioning of the total reform effect and do not indicate revenue contraction.

On the GamTaxNet negative level dummy in the domestic channel model: In M3-GM, which estimates domestic tax per capita against the GamTaxNet interaction, the level dummy coefficient γ_2 is negative and statistically significant ($\gamma_2 = -37.8$, $p = 0.037$). This reflects the algebraic structure of a model containing both a level dummy and an interaction term: because γ_1 captures the income-scaled component of the reform effect, γ_2 captures only the residual intercept shift net of that income-dependent gain, and the two parameters cannot be read in isolation. The net reform effect at the post-reform mean GDP per capita of USD 728 is −37.8 + (0.068 × 728) = +USD 11.9 per capita, confirming that the overall domestic channel impact is positive. The negative γ_2 in isolation is a modelling artefact of the parameter partition, not evidence of revenue contraction.

On the ASYCUDA results for The Gambia: The ASYCUDA World reform dummy activates from 2022, yielding only three post-reform observations — 2022, 2023, and 2024 — within the study window. The resulting sample imbalance severely constrains statistical power. The large positive interaction coefficient ($\gamma_1 = +0.545$, $p < 0.01$) is the strongest in the study and is directionally consistent with UNCTAD's (2024) report of a 23% increase in customs revenue following ASYCUDA World's launch. Formal long-run inference should be treated as directional given the three post-reform observations available.

Chapter 6: Conclusion and Discussion

6.1 Summary of Findings

This study examined whether digital tax administration reforms increased per-capita tax revenue and improved the efficiency of revenue conversion in Ghana and The Gambia over 2006–2024, employing ARDL time-series models with reform-event dummies and GDP per capita interaction terms. The central research question is answered affirmatively for both countries, with the strength of evidence varying across reforms and channels.

Five principal conclusions emerge. First, all interaction coefficients γ_1 are positive, confirming that each reform raised the GDP-elasticity of per-capita tax revenue, consistent with H1. Ghana's ITaPS ($\gamma_1 = +0.211$, $p < 0.01$) and ICUMS ($\gamma_1 = +0.121$, $p < 0.05$) are both statistically significant. The Gambia's ASYCUDA World produces the largest effect ($\gamma_1 = +0.545$, $p < 0.01$), consistent with the 23% customs revenue increase documented by UNCTAD (2024). Supporting GDP-ratio models provide directional corroborating evidence for the domestic channel reforms in Ghana.

Second, the net reform effect, computed as $\gamma_2 + \gamma_1 \times \text{gdp\_pc}$, is positive at all observed post-reform income levels for all significant models. For ICUMS at the post-reform mean GDP per capita of USD 2,000, the net effect is approximately +USD 98 per capita; for ASYCUDA World at the post-reform mean of USD 800, it is approximately +USD 74 per capita. The positive γ_1 values confirm that each reform raised, rather than diminished, the GDP-elasticity of tax revenue.

Third, the channel decomposition models support H2: ITaPS yields a significant positive interaction term on the domestic channel ($\gamma_1 = +0.157$, $p < 0.05$) and GamTaxNet yields a significant positive interaction on the domestic channel ($\gamma_1 = +0.068$, $p < 0.05$). ASYCUDA World produces a significant positive interaction on the trade channel ($\gamma_1 = +0.073$, $p < 0.05$), consistent with each reform exerting its strongest revenue efficiency gain on the channel for which it was institutionally designed.

Fourth, the supporting GDP-ratio specifications provide corroborating evidence: For Ghana, ITaPS is associated with a positive directional shift in the domestic tax-to-GDP ratio, providing corroborating evidence that the reform raised the share of GDP mobilised as domestic tax revenue. For The Gambia, the negative level dummy in M3-GM reflects a transitional dip in domestic revenue per capita during the initial GamTaxNet deployment period; the positive and

significant interaction term (γ_1 = +0.068, p = 0.014) confirms that the reform ultimately improved revenue conversion efficiency on the domestic channel, with a positive net effect at all observed post-reform income levels. Structural stability diagnostics are reported in Appendix C, Figure A1. CUSUM tests confirm parameter stability for all headline models.

6.2 Discussion

The findings situate well within the broader empirical literature on digital tax administration. The positive interaction coefficients identified in this study are consistent with what may be termed the digital frontier hypothesis: revenue authorities transitioning from predominantly manual administrative systems to integrated digital platforms realise substantial initial revenue gains, attributable to the recovery of previously uncaptured compliance gaps. Fan et al. (2018) document an analogous pattern in China, where VAT computerisation yielded the largest revenue gains in the first three years following implementation. Okunogbe and Santoro (2023) note that initial efficiency gains tend to be largest in the years immediately following reform implementation, as the most readily recoverable compliance gaps are closed first — an observation consistent with the attenuating marginal returns implied by the model structure, even as all interaction coefficients remain positive.

The cross-country divergence in results reflects a structural correspondence between the tax handle targeted by each reform and the dominant source of administrative revenue leakage. For The Gambia, customs mis-declaration associated with re-export trade has historically represented the most significant form of revenue leakage (Cantens & Raballand, 2020), which ASYCUDA World is specifically designed to address. For Ghana, the domestic tax base comprising VAT, income taxation, and excise duties represented the larger administrative tax gap opportunity that ITaPS targets. This is consistent with the IMF's (2023) finding that the fastest revenue gains accrue to reforms targeting the tax handle with the highest administrative tax gap. At the local government level in Ghana, Dzansi, Jensen, Lagakos and Telli (2022) document an analogous pattern: technology adoption substantially expanded property tax collection capacity by enabling revenue collectors to better target compliant households, reinforcing the conclusion that technology-driven capacity gains are broadly replicable across levels of government.

6.3 Practical Implications

For the Ghana Revenue Authority: The empirical evidence supports continued prioritisation of investment in ITaPS and e-VAT enforcement infrastructure. The principal next priority is deepening ITaPS penetration among SMEs, which occupy the formal-informal boundary and represent the segment for which digital compliance tools yield the highest marginal revenue impact. ICUMS should be progressively extended beyond major ports of entry to comprehensively capture the customs revenue potential of all border crossing points.

For the Gambia Revenue Authority: The strong early revenue signal from ASYCUDA World corroborates that the investment in customs digitalisation is generating meaningful fiscal returns. Priority next steps comprise: (a) expanding GamTaxNet coverage to currently underserved taxpayer segments; (b) integrating GamTaxNet with ASYCUDA World to enable cross-referencing of domestic and trade tax data; and (c) proceeding with the procurement and implementation of the new Integrated Tax Administration System (ITAS).

For ECOWAS Policymakers and Development Partners: while the findings are based on two countries and require corroboration before generalization, three tentative reform sequencing lessons emerge from the comparative evidence. First, the simultaneous deployment of domestic and customs digitalisation can generate rapid combined revenue gains but constrains identification of individual system effects. Second, customs digitalisation may yield faster initial revenue gains in small, structurally trade-dependent economies. Third, the full revenue effects of digital tax reform require an estimated 5–7 years to materialise; donor conditionalities should accordingly provide for an adequate ramp-up period.

For Future Research: Re-estimation with data covering 2025–2027, by which time the ASYCUDA World post-reform window will have expanded to at least five years, will substantially improve the statistical precision of The Gambia's estimates. Extending the empirical design to a broader Sub-Saharan Africa panel would enable formal cross-country hypothesis testing. A synthetic control approach drawing on a donor pool of comparable West African economies would provide an alternative counterfactual that does not rely on the pre-reform parallel trend assumption.

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Appendix A: Tax System Details — Legal Framework and Tax Rates

This appendix provides the legal and institutional context for the tax systems of Ghana and The Gambia. These tables are referenced in Section 1.3 of the main text.

A.1 Legal Framework

Country	Key Legislation
Ghana	Income Tax Act, 2015 (Act 896) · Value Added Tax Act, 2013 (Act 870) · Revenue Administration Act, 2016 (Act 915) · Customs Act, 2015 (Act 891) · Ghana Revenue Authority Act, 2009 (Act 791)
The Gambia	Income and Value Added Tax Act, 2012 · Customs and Excise Act (with subsequent amendments) Gambia Revenue Authority Act, 2004

Source: Ghana Revenue Authority; Gambia Revenue Authority; ECOWAS CET Schedule.

A.2 Individual Tax Rates — Ghana

Tax	Rate / Structure
Personal Income Tax (PIT)	Progressive structure, 0%–35%. PAYE withholding mandatory for employees. Self-employed assessed separately.
Corporate Income Tax (CIT)	Standard rate 25%. Sector rates: mining 35%, petroleum 35%. Free-zone enterprises 0% (first 10 years), 15% thereafter.
Value Added Tax (VAT)	Standard rate 15%, plus National Health Insurance Levy (2.5%) and GetFund Levy (2.5%) effective burden on standard-rated goods exceeds 17%.
Excise Duties	Apply to alcohol, tobacco, petroleum products, beverages, and luxury goods. Digital Excise Stamps introduced 2018 for authentication and track-and-trace.
Import Duties	ECOWAS CET tariff bands 0%–35% by product classification. Additional levy of 0.5% ECOWAS CET levy on all imports.

Source: Ghana Revenue Authority (2024); Income Tax Act, 2015 (Act 896); Value Added Tax Act, 2013 (Act 870).

A.3 Individual Tax Rates — The Gambia

Tax	Rate / Structure
Corporate Income Tax (CIT)	27%. Small businesses (turnover < GMD 1 million) qualify for simplified flat-tax regime.

Personal Income Tax (PIT)	Progressive structure, 0%–30%. PAYE for withholding salaried employees.
Value Added Tax (VAT)	15%, introduced in 2013. Administered through GamTaxNet, with Electronic Fiscal Devices used for compliance monitoring at VAT-registered businesses.
Import Duties	ECOWAS CET framework (0%–35%). Transit and re-export goods obtain duty refund where verified re-export is documented through ASYCUDA World tracking system.
Withholding Tax	Apply to service payments, rents, dividends, interest, and contract payments. Collection agent model — payers withhold and remit on behalf of Gambia-RA.

Source: Gambia Revenue Authority (2024); Income and Value Added Tax Act, 2012; ECOWAS CET Schedule.

A.4 Other Digital Initiatives (Not Modelled)

Item	**Detail**
Ghana — Digital Excise Stamps (2018)	Applied to alcohol, tobacco, and selected consumer goods for authentication and track-and-trace. Not included in primary regression specifications because it predates ITaPS and targets a narrow excise category only.
Gambia — Fuel Marking (2025)	Supplementary enforcement measures for petroleum products. Helps detect adulteration and diversion. Not separately modelled — insufficient time variation.
Gambia — Electronic Cargo Tracking Systems	Complement ASYCUDA World for cargo monitoring and transit verification. Treated as part of the broader ASYCUDA reform ecosystem.
Gambia — Digital Tax Stamps (2024)	Introduced after the study window ends (2024); excluded from regression analysis. Expected to be a major reform in the next study period.
Ghana — E-Levy (2022)	Electronic Transfer Levy (1.5%) on mobile-money transactions. While novel, this is a tax-policy change rather than an administration reform and is not modelled separately.

Source: Ghana Revenue Authority; Gambia Revenue Authority institutional documentation; Authors' compilation.

Appendix B: Full Regression Output Tables

This appendix presents the full coefficient tables for all primary and supporting ARDL models. Coefficients, standard errors (HAC), t-statistics, and p-values are reported. Significance: *** p<0.01, ** p<0.05, * p<0.10.

Table B.1.a: Full ARDL Regression Output — Primary Models (Ghana)

Parameter	M1-GH Total Tax Per Capita (ITaPS)	M2-GH Total Tax Per Capita (ICUMS)	M3-GH Domestic Tax Per Capita (ITaPS)	M4-GH Trade Tax Per Capita (ICUMS)
Constant	5.471 (0.707)	17.330 (0.067)*	−3.170 (0.664)	19.202 (0.042)**
tax_pc(t−1)	0.452 (0.132)	0.075 (0.746)	0.546 (0.005)***	−0.043 (0.837)
tax_pc(t−2)	−0.062 (0.643)	−0.151 (0.176)	−0.065 (0.669)	−0.474 (0.079)*
gdp_pc(t)	0.061 (0.022)**	0.066 (0.029)**	0.033 (0.115)	0.010 (0.094)*
gdp_pc(t−1)	−0.008 (0.660)	0.003 (0.861)	−0.003 (0.802)	−0.004 (0.322)
trade_pc(t)	0.129 (0.002)***	0.132 (0.001)***	0.079 (0.018)**	0.006 (0.609)
trade_pc(t−1)	−0.091 (0.164)	−0.040 (0.362)	−0.062 (0.114)	0.013 (0.338)
γ_1 (D×gdp_pc)	+0.211 (0.001)***	+0.121 (0.037)**	+0.157 (0.022)**	+0.007 (0.608)
γ_2 (Dummy)	−481.0 (0.002)***	−243.7 (0.070)*	−360.2 (0.020)**	−25.7 (0.449)
COVID-19 (2020)	45.307 (0.065)*	11.894 (0.554)	30.098 (0.049)**	−1.518 (0.476)
Adj. R^2	0.926	0.924	0.819	0.348
DW	1.967	1.881	1.488	2.325
N	17	17	17	17

Table B.1.b : Full ARDL Regression Output — Primary Models (The Gambia)

Parameter	M1-GM Total Tax Per Capita (GamTaxNet)	M2-GM Total Tax Per Capita (ASYCUDA)	M3-GM Domestic Tax Per Capita (GamTaxNet)	M4-GM Trade Tax Per Capita (ASYCUDA)
Constant	92.337 (0.015)**	8.175 (0.588)	50.071 (0.056)*	15.967 (0.128)
tax_pc(t−1)	0.268 (0.335)	1.250 (0.003)***	0.509 (0.076)*	0.494 (0.096)*
tax_pc(t−2)	−0.645 (0.025)**	−0.430 (0.070)*	−0.444 (0.101)	−0.082 (0.647)
gdp_pc(t)	0.024 (0.167)	0.011 (0.535)	−0.010 (0.458)	−0.007 (0.322)
gdp_pc(t−1)	0.010 (0.764)	−0.042 (0.085)*	−0.018 (0.063)*	−0.002 (0.901)
trade_pc(t)	−0.049 (0.304)	0.013 (0.522)	−0.018 (0.500)	−0.018 (0.181)
trade_pc(t−1)	−0.014 (0.690)	0.070 (0.011)**	0.016 (0.268)	0.022 (0.129)
γ_1 (D×gdp_pc)	+0.063 (0.169)	+0.545 (0.001)***	+0.068 (0.014)**	+0.073 (0.031)**
γ_2 (Dummy)	−27.4 (0.469)	−462.3 (0.001)***	−37.8 (0.037)**	−61.4 (0.027)**
COVID-19 (2020)	−0.343 (0.898)	−6.160 (0.143)	0.611 (0.705)	−1.664 (0.290)
Adj. R^2	0.646	0.724	0.768	-0.882^5
DW	2.081	2.214	2.030	2.095
N	17	17	17	17

Table B.2: Supporting GDP-Ratio Models (no interaction term)

Model	DV	Reform	Coef.	p-value	Adj. R^2
S1-GH	Domestic Tax/GDP	ITaPS	+0.334 n.s.	0.468	0.458
S2-GH	Trade Tax/GDP	ICUMS	+0.080 n.s.	0.631	0.684
S1-GM	Domestic Tax/GDP	GamTaxNet	−0.292 n.s.	0.164	0.877
S2-GM	Trade Tax/GDP	ASYCUDA	−0.542*	0.054	−0.379

Controls: trade openness, log exchange rate. HAC standard errors. Note: these models omit the interaction term; the reform dummy coefficient conflates γ_1 and γ_2 into a single reduced-form parameter. See Section 5.4.

Table B.3: ADF Unit Root Test Results

Country	Variable	ADF (levels)	p-value	ADF (1st diff)	Order
Ghana	Total Tax PC	−1.332	0.615	−4.810***	I(1)
Gambia	Total Tax PC	+0.752	0.991	−4.376***	I(1)
Ghana	Domestic Tax PC	−1.434	0.566	−3.805***	I(1)
Gambia	Domestic Tax PC	+0.208	0.973	−3.565***	I(1)
Ghana	Trade Tax PC	−2.053	0.264	−3.606***	I(1)
Gambia	Trade Tax PC	−3.487***	0.008	—	I(0)
Ghana	GDP per Capita	−1.526	0.521	−5.473***	I(1)
Gambia	GDP per Capita	−1.344	0.609	−3.892***	I(1)
Ghana	Trade PC	−1.820	0.371	−3.827***	I(1)
Gambia	Trade PC	−2.960**	0.039	—	I(0)
Ghana	GDP Growth	−2.825*	0.055	−5.380***	I(1)

Gambia	GDP Growth	−4.441***	0.000	—	I(0)

Table B.3: ADF unit root test results. Lag selection by AIC (max 2). *** p<0.01, ** p<0.05, * p<0.1. Null hypothesis: unit root.

Table B.4: ARDL Bounds F-Test Results

Model	**Country**	**Dep. Variable**	**Reform**	**F-stat**	**I(0)/I(1) 10%**	**I(0)/I(1) 5%**	**Decision**
M1-GH	Ghana	Total Tax PC	ITaPS	1.290	3.96/4.34	4.93/5.39	n.s.
M2-GH	Ghana	Total Tax PC	ICUMS	1.943	3.96/4.34	4.93/5.39	n.s.
M1-GM	Gambia	Total Tax PC	GamTaxNet	3.561	3.96/4.34	4.93/5.39	Inconclusive
M2-GM	Gambia	Total Tax PC	ASYCUDA	1.799	3.96/4.34	4.93/5.39	n.s.
M3-GH	Ghana	Dom. Tax PC	ITaPS	1.143	3.96/4.34	4.93/5.39	n.s.
M4-GH	Ghana	Trade Tax PC	ICUMS	3.880	3.96/4.34	4.93/5.39	Inconclusive
M3-GM	Gambia	Dom. Tax PC	GamTaxNet	5.139*	3.96/4.34	4.93/5.39	Cointegration
M4-GM	Gambia	Trade Tax PC	ASYCUDA	1.910	3.96/4.34	4.93/5.39	n.s.

Table B.4: ARDL Bounds F-Test Results. H_0: No long-run level relationship. Parsimonious UECM, k = 1 forcing variable. Critical values: Narayan (2005), Case III, T ≈17. * p<0.10. n.s. = not significant (F-statistic falls below the I(0) lower bound; no cointegration detected). Source: Authors.

Appendix C: Model Diagnostics

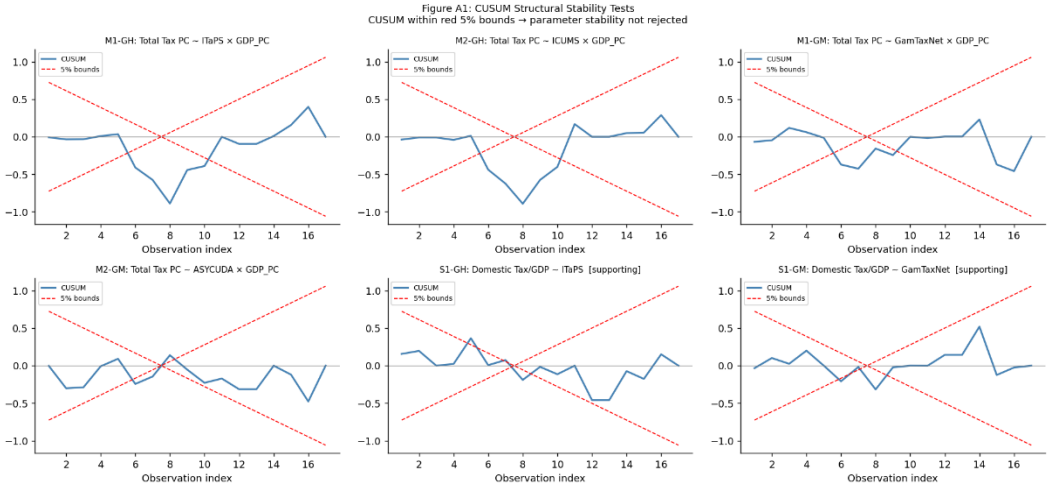

Figure A1: CUSUM Structural Stability Tests. CUSUM within red 5% bounds → parameter stability not rejected.

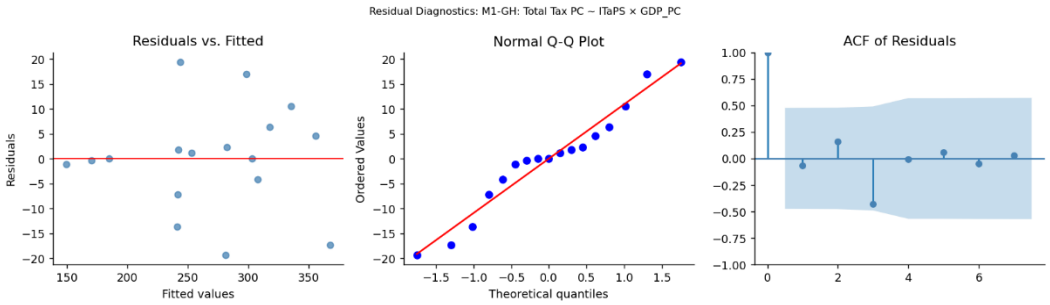

Figure A2: Residual Diagnostics — M1-GH (Total Tax PC ~ ITaPS × GDP_PC).

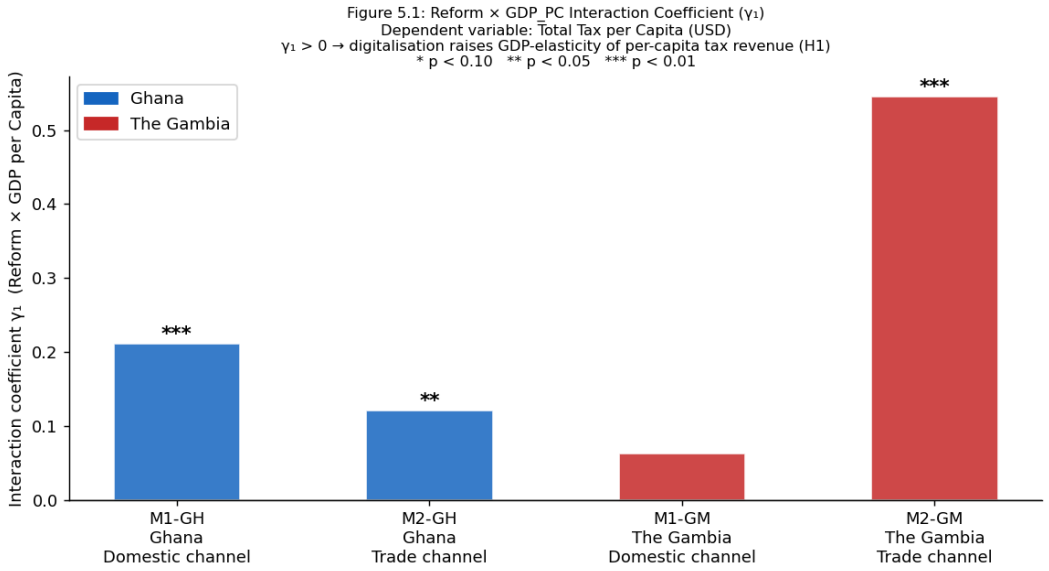

Figure A3: Interaction Coefficient γ_1 (Reform × GDP per Capita) — Primary Models, Total Tax PC. $\gamma_1 > 0 \rightarrow$ digitalisation raises GDP-elasticity of per-capita tax revenue.

Appendix D: List of Abbreviations

Abbreviation	Definition
ARDL	Autoregressive Distributed Lag
ASYCUDA	Automated System for Customs Data (UNCTAD)
CET	Common External Tariff (ECOWAS)
CPIA	Country Policy and Institutional Assessment (World Bank)
DTD	Domestic Tax Department (Gambia-RA)
ECM	Error Correction Model
ECOWAS	Economic Community of West African States
EFD	Electronic Fiscal Device
EGDI	E-Government Development Index (United Nations)
e-VAT	Electronic Value Added Tax System
GamTaxNet	Gambia Integrated Tax Administration System
GDP	Gross Domestic Product

Ghana-RA / GRA	Ghana Revenue Authority
Gambia-RA	Gambia Revenue Authority
HAC	Heteroskedasticity and Autocorrelation Consistent (Standard Errors)
ICUMS	Integrated Customs Management System (Ghana)
IMF	International Monetary Fund
ITAS	Integrated Tax Administration System
ITaPS	Integrated Tax Application and Processing System (Ghana)
NSW	National Single Window (Gambia)
OECD	Organisation for Economic Co-operation and Development
PAYE	Pay As You Earn
PIT	Personal Income Tax
SARA	Semi-Autonomous Revenue Authority
SSA	Sub-Saharan Africa
UNDESA	United Nations Department of Economic and Social Affairs
UNCTAD	United Nations Conference on Trade and Development
VAT	Value Added Tax
WDI	World Development Indicators (World Bank)

Description of Used Generative Model

1. Grammarly: https://www.grammarly.com

This was applied across all chapters during the editing stage to correct grammar and punctuation and to improve word choice. All thesis text was written by the authors; Grammarly suggestions were reviewed and selectively accepted. This was effective in improving readability and ensuring a consistent academic tone across all chapters.

2. Semantic Scholar: https://www.semanticscholar.org

Semantic Scholar was used during the research and planning stage to identify and verify academic sources for the literature review. It served as an AI-assisted search tool to locate relevant papers on digital tax administration, fiscal capacity, and ARDL methodology. It was effective in identifying relevant and recent literature, particularly sources on digital tax administration in Sub-Saharan Africa.

3. Turnitin and Antiplagiat

Both platforms were applied to the full thesis for plagiarism screening only. The completed thesis was submitted through both tools to verify originality in compliance with HSE University academic integrity requirements. Both tools were effective in confirming the originality of the submitted thesis text.

4. Cursor: https://www.cursor.com

Cursor was used during the research stage to assist with writing, improving, and debugging the Python code used for the ARDL econometric estimation. The tool provided code suggestions and error corrections, and it was effective in reducing the time spent on routine coding tasks and resolving syntax errors in the estimation pipeline.