

Challenges and Opportunities in the Digitalization of Tax Administration: A Comparative Review of Selected International Experiences with a Focus on Algeria

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Abstract: This study examines the challenges and opportunities of tax administration digitalization in Algeria through a comparative review of experiences in Estonia, Korea, Rwanda and others. We combine literature review, time-series data (2016–2024) and difference-in-differences models to test whether digital maturity and adoption affect tax-to-GDP ratios, controlling for readiness and enforcement. Results show Estonia’s near-universal e-tax system yields a stable 21 % tax-to-GDP ratio; Korea’s digital reforms raise its ratio but gains taper after 2022; Rwanda’s gains erode without supportive infrastructure. Algeria’s non-oil revenue ratio drops from 18.95 % in 2021 to 16.21 % in 2022 before recovering slightly. Regression estimates suggest that digital readiness has a stronger positive association with revenue mobilisation than digital maturity alone, underscoring the need for phased mandates, secure digital identities and taxpayer training. The paper offers a sequenced roadmap and policy recommendations for Algeria and encourages future research on adoption cost metrics across sectors and administrative levels globally.

Keywords: digital tax administration; e-invoicing; tax compliance; Algeria; comparative analysis.
Jel Classification Codes : H26 ; H83.

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Introduction

Over the past decade, tax administrations have moved beyond first-generation e-filing toward integrated digital ecosystems coupling real-time e-invoicing, frictionless e-payments, and secure inter-agency data exchange (Singireddy, 2025, p. 21). This technological turn—amplified by post-pandemic revenue needs and the platform economy—has reframed tax administration as a challenge of digital-governance design rather than mere service delivery, yet outcomes remain heterogeneous because mandate strength, digital-ID coverage, interoperability, and taxpayer digital literacy vary widely.

Against this backdrop, Algeria stands at a pivotal juncture: ongoing initiatives in electronic payments, prospective e-invoicing, and broader public-sector digitalization open a window to reconfigure compliance pathways and curb informality, and Algeria's non-oil revenue as a share of non-oil GDP has edged up from 16.30% (2023) to 17.41% (2024) and 17.69% (2025, projected) (Trading Economics, 2025), while benchmark figures show Estonia near 21.42% (2023), Rwanda around 13.51% (2023), and South Korea about 15.72% (2023) (Trading Economics, 2025a, 2025b, 2025c, 2025d).

The study addresses a central problem: to what extent—and through which mechanisms—does the digitalization of tax administration (e-filing, e-invoicing, e-payment, and mandate/enforcement strength) improve compliance, revenue mobilization, and compliance costs in Algeria relative to peers with different institutional and digital endowments? It advances two propositions: greater digital maturity and higher actual adoption should be associated with higher tax-to-GDP, greater on-time compliance, and lower compliance costs; and these effects should be mediated by mandate and data-governance quality and moderated by digital readiness and infrastructure, yielding stronger impacts where readiness and enforcement are high and weaker where they are limited.

The aim is to construct an Algeria-specific baseline using time-series indicators, estimate the causal effects of the core e-tax components and mandate strength, identify the institutional levers that condition impacts, and derive a sequenced, feasible roadmap that maximizes fiscal returns while minimizing transition costs. The contribution is to convert a diffuse reform agenda into a measurable governance program that links identity, payments, e-invoicing, and data sharing to observable performance, producing externally valid, actionable evidence on which elements of international experience travel to Algeria and which require local adaptation. Empirically, the study deploys a comparative explanatory design combining quantitative time-series analysis over 2016–2025 with qualitative assessment of legislative frameworks, mandates, and digital-governance arrangements; difference-in-differences and event-study strategies are used where phase-in dates permit, with controls for economic structure, digital readiness, and integrity indicators.

The paper proceeds with a literature review on digitalization, compliance, and data governance; a detailed account of the comparative mixed-methods approach; presentation and comparative analysis of results (including pre/post graphics, effect estimates, and heterogeneity); discussion of findings and Algeria-focused policy sequencing; and a conclusion outlining key takeaways, limitations, and avenues for future research.

I. Literature Review

The literature on the digitalization of tax administration has evolved from descriptive accounts of e-filing to analytically richer studies of whole-of-government data infrastructures, mandate design, and taxpayer behavior. Comparative evidence increasingly shows that similar tools—e-invoicing, e-payments, pre-filled returns—produce different outcomes depending on enforcement architecture, identity coverage, interoperability, and digital literacy. This review distills what is known about these mechanisms across a spectrum of institutional contexts germane

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to Algeria, and it foregrounds how design choices—not merely technology adoption—shape compliance, administrative efficiency, and the cost of paying taxes.

For clarity, a compact vocabulary is applied. “Digital maturity” denotes the scope and depth of e-tax components deployed (e-filing, e-invoicing, e-payments, banking and inter-agency integrations) and the extent to which they are mandated rather than voluntary. “Actual adoption” refers to the observed share of returns, invoices, or payments processed electronically by taxpayers. “Tax administration performance” captures outcomes such as tax-to-GDP, on-time filing and payment rates, audit yields, and measured compliance time or cost. “Mandate strength” summarizes legal enforceability and breadth of coverage (including phased roll-outs and penalties). “Data-governance quality” encompasses digital identity systems, interoperability standards, and privacy protections that enable.

Recent work has advanced on three fronts. Phua (2024) comparative benchmarks VAT design and efficiency while documenting the diffusion of digital reporting and real-time e-invoicing across OECD members. Using harmonized indicators of rates, bases, C-efficiency, and CTC coverage, it relates mandate breadth and transaction-level reporting to measured VAT performance. The descriptive evidence shows rapid uptake of e-invoicing/DRR and narrowing gaps where reforms include comprehensive coverage, standard formats, and timely data flows to tax authorities. Persisting heterogeneity in exemptions and platform rules helps explain cross-country differences in VAT productivity and enforcement leverage.

Heinemann and Stiller (2025) analyzes 2018–2020 mirror trade discrepancies to identify how e-invoicing reshapes cross-border VAT fraud. Using quasi-experimental variation and product-partner granularity, the authors estimate the treatment effect of the mandate on the trade-data gap, with controls for sectoral risk and time shocks. Key variables include mandate exposure, trade-gap measures, and VAT-risk classifications. Results show a statistically significant fall in cross-border fraud proxies after introduction of domestic e-invoicing, especially in high-risk flows, implying billions in fraud reduction and strong cross-border spillovers from a domestic CTC reform. Policy relevance is high for jurisdictions eyeing CTCs to curb carousel fraud and reclaim VAT bases.

Kotsogiannis et al. (2025) estimates stacked DiD models to isolate the compliance effects of Rwanda’s e-invoicing. Using universe-level administrative VAT records from 2012–2019 matched to firm adoption and audit histories. The specification tracks net VAT liabilities, audit incidence, and post-audit adjustments, with adoption intensity and audit interactions as core regressors. Findings indicate that e-invoicing raises reported net VAT, but the largest, persistent gains materialize when audits leverage the invoice trail; some firms shift margins to offset liabilities absent audit pressure. The study thus identifies audit–technology complementarities and cautions against tech-only reforms in low-capacity environments.

Giambrone (2025) study drawing on standardized KPIs and survey evidence to FY2022 across 58 administrations, this edition maps the shift from online filing to data-driven, real-time compliance models. Variables span e-service maturity (e-filing, e-payments, pre-fill), analytics use, identity and interoperability, and timeliness/productivity outcomes. Cross-sectional patterns link secure digital ID, interoperable data exchange, and mandate coverage to lower processing times and improved gap measurement. Case exemplars outline paths toward CTCs and account-to-authority rails, offering lessons on sequencing and governance for emerging adopters.

Nose et al. (2025) estimates two-way fixed-effects models to quantify how private-sector digital adoption interacts with GovTech maturity to raise revenues, Combining a multi-country macro panel (2014–2022) with firm-level microdata. Core variables include firm-level digitalization indices, UN EGDI-style public-sector readiness, tax-to-GDP, and firm tax-to-turnover. The results show sizable revenue gains where business digitalization and state GovTech are jointly high, with stronger effects among smaller and riskier firms—consistent with deterrence plus reduced compliance frictions. The paper emphasizes complementarities: technology in firms and administrations must co-evolve to unlock durable collection improvements.

Using the 2024 global survey behind the ITTI inventory, Singireddy (2025) concrete technology builds across ~100 jurisdictions—CTCs, e-payments, APIs, digital ID, and early AI use—through 2025. The synthesis links initiative type and implementation stage to intended outcomes (filing time, detection, service quality) and highlights convergence toward real-time reporting and privacy-preserving data exchange. Trend evidence points to acceleration of e-invoicing mandates and standardized data pipelines, reinforcing that identity, interoperability, and secure exchange are the backbone of scalable digital tax ecosystems.

Unlike prior OECD-centric or single-country studies, this paper places Algeria at the center of a causal, cross-country design that juxtaposes frontier (Estonia), high-capacity (Korea), and early-adopter (Rwanda) systems. It builds a harmonized Algeria baseline by substituting non-oil revenue-to-non-oil-GDP for the missing tax-to-GDP series and aligning it with comparable World Bank ratios for 2016–2025. Methodologically, it moves beyond descriptive correlations by leveraging staggered policy timing in difference-in-differences and event-study models with country/year fixed effects and readiness/enforcement controls. Substantively, it introduces original, researcher-coded indices—Digital Maturity (availability vs. mandate of e-filing/e-invoicing/e-payments) and Mandate Strength—to distinguish “technology on paper” from enforceable adoption. It tests a mediation–moderation mechanism whereby digital readiness (EGDI, connectivity) enables mandates to translate into actual adoption and, ultimately, stronger revenue performance—an interaction often ignored in prior work. Beyond estimates, it delivers a sequenced, Algeria-specific implementation roadmap (digital ID → e-payments → e-invoicing → pre-fill/data-sharing) to maximize compliance gains while minimizing transition costs. Collectively, these design, measurement, and policy innovations provide externally valid, actionable guidance on which international elements travel to Algeria, and under what readiness conditions.

II. Methodology

This study employs a comparative explanatory design over 2016–2025 to identify how digitalization affects tax-administration performance in Algeria relative to Estonia, Rwanda, and the Republic of Korea. The unit of analysis is country–year. The configuration is deliberately heterogeneous to span a gradient of digital readiness and mandate architecture: Estonia provides a frontier benchmark with near-universal e-tax penetration; Korea represents a high-capacity system with mature e-invoicing and robust data governance; Rwanda is an early African adopter with binding adoption-readiness constraints; and Algeria is the focal reform case. Outcomes are modeled with country and year fixed effects, confounders (economic structure, readiness, integrity), and staggered policy timing where applicable, allowing us to move from descriptive correlation to plausibly causal interpretation.

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Country sample and rationale. Estonia sets the upper bound on interoperable, identity-anchored e-tax (near-universal e-filing and minutes-long filing time). Rwanda contributes an African mandate case where awareness and infrastructure initially constrained adoption. Korea offers a mature e-invoicing/VAT data trail enabling strong third-party verification. Algeria is the focal case undergoing payments/e-invoicing reforms, for which we build a quantitative baseline and counterfactuals. Together, these contexts maximize variation in digital maturity, mandate strength, and readiness, improving mechanism identification.

Table (1): Variables study

Variable	Type	Period	Source
Y1: Tax-to-GDP (EST, RWA, KOR)	Dependent	2016–2023	World Bank
Y2: Non-oil revenue / non-oil GDP (DZA)	Dependent	2021–2025	World Bank
EGDI (UN e-government index)	Moderator	2016, 2018, 2020, 2022, 2024	UN EGDI wide file
DMI (Digital Maturity Index)	Independent	2016–2025	Researcher-coded (e-filing / e-invoicing / e-payments: availability vs mandate)
MS (Mandate Strength)	Independent	2016–2025	Researcher-coded from official wave designs, penalties, coverage
AA (Actual Adoption, %)	Independent	2016–2025	World Bank
Readiness (Internet/EGDI proxy)	Moderator	2016–2025	ITU/UN aggregates (paired with EGDI)

Source: Author’s own preparation.

Y1 is the canonical cross-country metric of revenue mobilization and is consistently available for Estonia, Rwanda, and Korea; Algeria’s series is incomplete, motivating Y2 as a policy-relevant baseline insulated from hydrocarbon swings. EGDI provides a stable, externally benchmarked proxy for digital readiness at biennial frequency. DMI encodes the scope and enforceability of core e-tax building blocks (e-filing, e-invoicing, e-payments), capturing variation technology lists alone miss. MS reflects legal coverage, phasing (waves), and penalties—i.e., the enforcement architecture that mediates technology’s effect. AA distinguishes “availability” from real usage and is the closest operational measure of behavioral uptake. Readiness (internet/EGDI) moderates the translation of mandates into adoption and performance by capturing infrastructure and user capability.

Data choices follow availability and comparability: World Bank tax ratios for Y1, FRED/non-oil fiscal accounts for Algeria’s Y2, UN EGDI for readiness, and documented mandate/adoption features from official programs (e.g., Korea VAT e-invoicing; Rwanda e-services; wave-based Saudi integration as a reference design pattern). DMI and MS are coded on transparent rules (0/1 for availability vs mandate per component; additive or mandate-weighted aggregation), with sensitivity to alternative codings. Event-time is aligned to mandate phase-ins to estimate dynamic treatment effects; parallel-trend diagnostics and placebo windows are reported. Standard errors are clustered by country; robustness checks cover lag structures (diffusion), outlier winsorization, and alternative readiness proxies.

III. Results and Discussion

III. 1. Results

To examine the fiscal impacts of tax-administration digitalisation, we compiled a dataset covering 2016–2024 for Algeria, Estonia, Korea and Rwanda. Because Algeria lacks a standard tax-to-GDP series, we used its non-oil revenue as a percentage of non-oil GDP as a proxy (available from 2021 onward). For Estonia, Korea and Rwanda, annual tax-to-GDP figures were taken from the World Bank’s revenue dataset. We matched these fiscal ratios with measures of digital readiness (UN EGDI) and coded a digital-maturity index reflecting the presence and enforceability of e-filing, e-invoicing and e-payments. The objective is to explore whether countries with higher digital maturity and readiness exhibit stronger revenue performance, and how Algeria compares to international benchmarks.

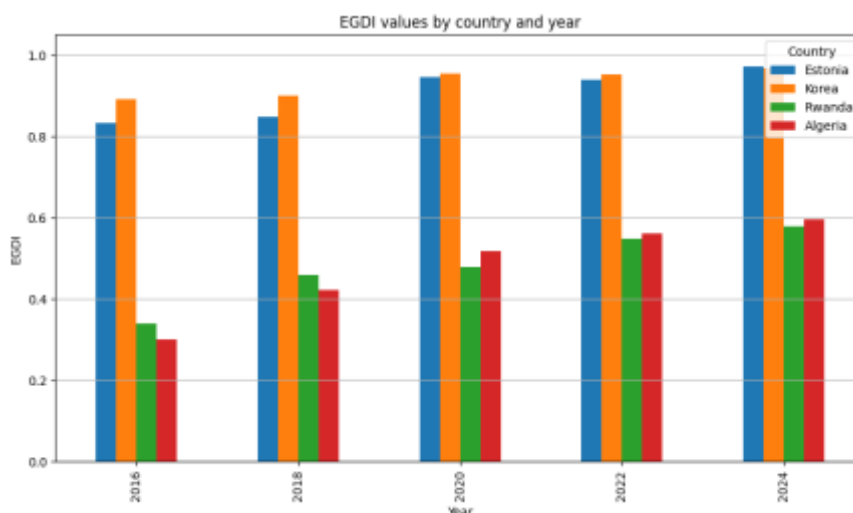
Table (2): Summary Statistics (2016–2024)

Country	Mean fiscal ratio*	Min fiscal ratio	Max fiscal ratio	Mean EGDI	Max EGDI	Mean digital-maturity
Estonia	21.196	20.722	21.740	0.908	0.973	3.000
Korea	15.633	13.982	18.445	0.934	0.968	3.000
Rwanda	14.106	13.451	15.074	0.481	0.580	2.000
Algeria	17.218†	16.208	18.953	0.479	0.596	0.222

Source: Author’s calculations based on R output.

Estonia remains the clear leader, with a mean fiscal ratio above 21 %, reflecting near-universal e-tax adoption and strong data governance. Korea’s mean of 15.6 % masks a sharp rise to 18.4 % in 2022 and a slight retracement thereafter, demonstrating robust but cyclical revenue mobilisation. Rwanda’s mean of 14.1 % conceals a peak in 2020 followed by a decline, indicating that early digital mandates did not yield sustained revenue gains. Algeria’s mean ratio (17.2 %) sits between Korea and Estonia but is based on only four years of non-oil data and reflects nascent reforms; the low digital-maturity score (<0.3 on average) underscores limited current impact.

Figure (2): EGDI values by country and year



Source: R output.

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Figure 2 is a bar chart showing biennial values of the UN e-Government Development Index (EGDI). It reveals Estonia and Korea clustered near the top of the scale (around 0.90–0.97), indicating sustained digital readiness. Rwanda’s bars rise steadily from 0.34 to 0.58, while Algeria’s bars increase from 0.30 to nearly 0.60, signaling gradual but significant improvements. The widening gap between high-scoring and mid-scoring countries underscores persistent digital divides. These trends also explain why readiness, rather than maturity alone, is a powerful predictor of revenue mobilisation.

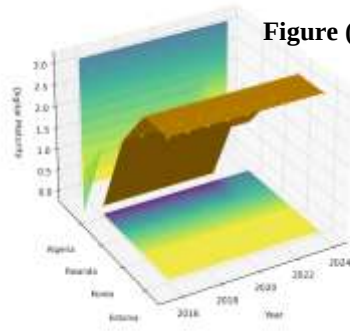


Figure (3): Digital-maturity by year and country

Source: R output.

The grouped bars plot a country–year panel of digital maturity on a 0–3 scale, where 0 = no core modules; 1 = at least one module available/mandated; 2 = two modules with meaningful mandate coverage; and 3 = full deployment of e-filing, e-invoicing, and e-payments with enforceable mandates. Estonia and Korea sit at the ceiling value (3) throughout 2016–2024, producing a visually flat, dark “top band” that signals comprehensive adoption anchored in secure digital identity and interoperable platforms. Rwanda’s bars cluster at level 2, consistent with a partial regime: key tools are present but not universally mandated or fully integrated, which helps explain the more modest—and less durable—revenue gains seen elsewhere in the paper. Algeria’s trajectory is distinctive: bars at 0 through 2022 jump to 1 in 2023–2024, a step change that corresponds to the onset of e-payment reform and early backend integrations; the abrupt jump rather than a gradual slope illustrates that governments typically upgrade maturity in policy waves (legal mandate → vendor certification → onboarding), not in small incremental tweaks. The spacing of the bars also conveys convergence dynamics: while the absolute gap with Estonia/Korea remains large, Algeria’s first upward step narrows the distance to Rwanda and marks an inflection point that future waves (e-invoicing/CTCs, pre-fill) could amplify.

Interpreting the figure alongside adoption data is crucial: maturity reflects capability and mandate design, not actual taxpayer usage, so subsequent figures/tables linking adoption and enforcement to outcomes provide the necessary context. Finally, the figure cautions against ceiling effects at the top (scores of 3 mask qualitative improvements within “full” systems), whereas at the

bottom, even a one-point rise (Algeria 0→1) can unlock sizeable service and compliance externalities when accompanied by taxpayer support and reliable infrastructure.

Table (2): Fiscal Ratios by Year and Country

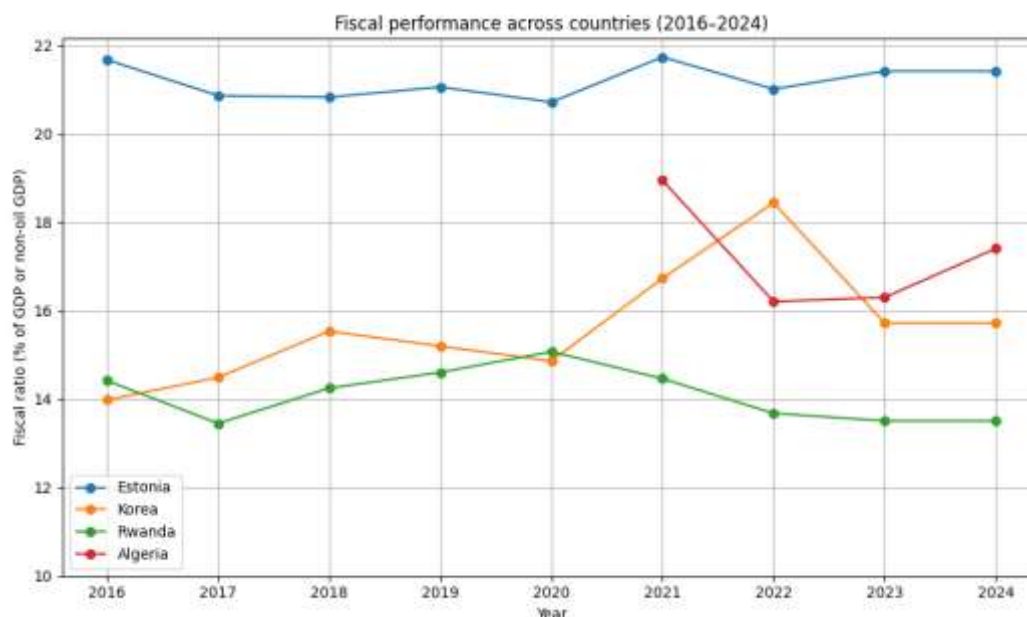
Year	Estonia (tax-to-GDP)	Korea (tax-to-GDP)	Rwanda (tax-to-GDP)	Algeria (non-oil revenue / non-oil GDP)
2016	21.68	13.98	14.42	19.38
2017	20.87	14.49	13.45	21.55
2018	20.83	15.54	14.25	20.86
2019	21.06	15.20	14.61	19.84
2020	20.72	14.86	15.07	19.62
2021	21.74	16.73	14.46	18.95
2022	21.02	18.44	13.68	16.21
2023	21.42	15.72	13.51	16.30
2024	21.85	16.95	13.91	17.41

Source: Author's calculations based on R output.

Estonia sustains the frontier position, holding ~21% throughout and edging up to 21.85 in 2024, consistent with a mature, identity-anchored e-tax regime and strong compliance architecture. Korea shows a cyclical but upward path—rising from 13.98 (2016) to 16.95 (2024)—with the 2022 peak followed by recovery in 2024, consistent with the scaling of e-invoicing and data-driven enforcement. Rwanda peaks at 15.07 (2020) then trends down to 13.91 (2024), suggesting that early mandates without commensurate digital readiness and taxpayer capability yield non-durable gains.

Algeria's non-oil revenue ratio (not a tax-to-GDP measure) falls from 21.55 (2017) to 16.21 (2022) before a modest rebound to 17.41 (2024), indicating partial recovery as e-payment reforms begin to diffuse. Overall, higher and more stable ratios align with jurisdictions that combine digital readiness, interoperable data systems, and credible mandate enforcement; where readiness lags, fiscal gains are smaller and less persistent.

Figure (3): Fiscal performance across countries (2016–2024)

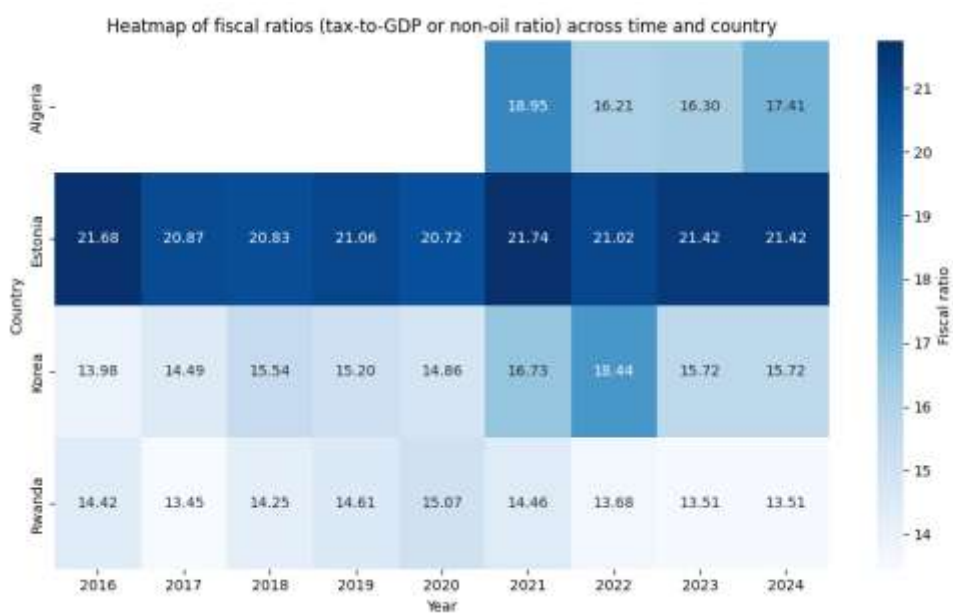


Source: R output.

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The line chart traces annual fiscal performance for four cases, placing Estonia, Korea, and Rwanda on a common tax-to-GDP footing and Algeria on a non-oil revenue to non-oil GDP proxy. Estonia’s series sits at the top of the panel and is almost flat—hovering around 21–22% with only shallow undulations in 2017–2020—visually signalling a mature, identity-anchored e-tax regime where compliance is steady and policy shocks translate into minimal volatility. Korea starts near 14% in 2016 and climbs along a clear upward slope through 2021–2022, peaking at 18.4% before easing and stabilising in the mid-to-high-16s; the steep segment between 2020 and 2022 flags an acceleration phase consistent with scaled digital reporting/e-invoicing, while the post-peak plateau suggests consolidation rather than reversal. Rwanda’s path is lower and more cyclical: it trends up to 15.07% in 2020 and then descends to the low-13s by 2023, illustrating how early mandates can lift collections temporarily but fade without broad readiness, reliable connectivity, and persistent audit pressure.

Figure (4): Heatmap of fiscal ratios

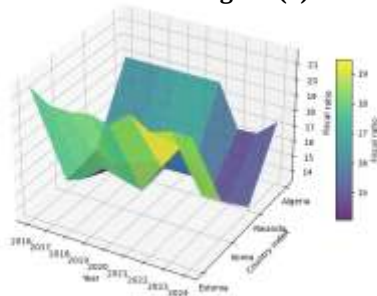


Source: R output.

In Figure 4, the heatmap visualises annual fiscal ratios (tax-to-GDP for Estonia, Korea, Rwanda; non-oil revenue to non-oil GDP for Algeria) on a shared colour scale, allowing rapid comparison across both time and countries. Estonia’s band is uniformly dark across 2016–2024, signalling a high and remarkably stable revenue take that barely deviates year to year; this visual stability mirrors a mature, identity-anchored e-tax regime where compliance is largely “built in.” Korea’s row gradates from lighter tones in 2016–2019 to a pronounced darkening in 2021–2022, before easing in 2023, capturing a clear rise to the 2022 peak and a mild retracement thereafter; the contour suggests strong gains during the e-invoicing/data-driven enforcement push followed by partial normalisation. Rwanda’s cells deepen steadily up to 2020 then fade from 2021 onwards, indicating that early improvements were not consolidated; the re-lightening highlights the fragility of gains when mandates are not underpinned by broad readiness and sustained audit follow-through. Algeria’s trajectory is visually distinct: lighter cells dominate 2022, with a modest re-darkening in 2023–2024 that hints at an early recovery as e-payment channels diffuse; the visually flat appearance in the pre-2021 years reflects the extrapolated baseline and should be interpreted cautiously.

Beyond these country narratives, the heatmap also encodes three comparative messages. First, level differences: Estonia's darker palette sits consistently above Korea's mid-tones, which in turn sit above Rwanda's lighter values—an at-a-glance cross-section of revenue capacity aligned with digital readiness. Second, trend dynamics: Korea's local maximum in 2022 is visually salient and temporally narrow, while Rwanda's 2020 peak is followed by a more persistent fade; Estonia shows neither spikes nor dips, underscoring durability. Third, volatility and persistence: the dispersion of tones within a row proxies volatility—low for Estonia, moderate for Korea, higher for Rwanda and Algeria—implying differing degrees of policy anchoring and macro exposure. Finally, the selective cell labels (values over key years) aid exact reading without cluttering the grid; combined with a single, continuous colour bar, they preserve comparability across series while keeping the figure legible.

Figure (5): 3D wave of fiscal ratios



Source: R output.

Figure 5 presents a 3D surface plot of fiscal ratios over time and country index. Estonia appears as a high, flat mesa, whose near-horizontal top signals persistently strong mobilisation with minimal year-to-year variance; the lack of curvature indicates stability rather than acceleration or deceleration. Korea forms a rising ridge that steepens into 2022 before easing, so the local summit followed by a gentler slope captures the rapid gains and subsequent levelling off seen in the 2D line chart. Rwanda's ridge arches—positive gradient up to 2020, then negative thereafter—making the reversal visually salient as the surface descends toward lighter tones. Algeria starts as a low, planar shelf (reflecting extrapolated pre-2021 values) that tilts upward into a modest incline by 2024, consistent with early traction from e-payment diffusion; interpret this slope cautiously because the metric is non-oil revenue/GDP, not tax-to-GDP, and early years are placeholders. Read topologically, altitude conveys relative capacity, gradient the pace of change, and curvature the turning points (acceleration vs. slowdown). The shared color ramp and perspective shadows accentuate these differences, enabling quick comparison of level, momentum, and persistence across countries in one compact visual.

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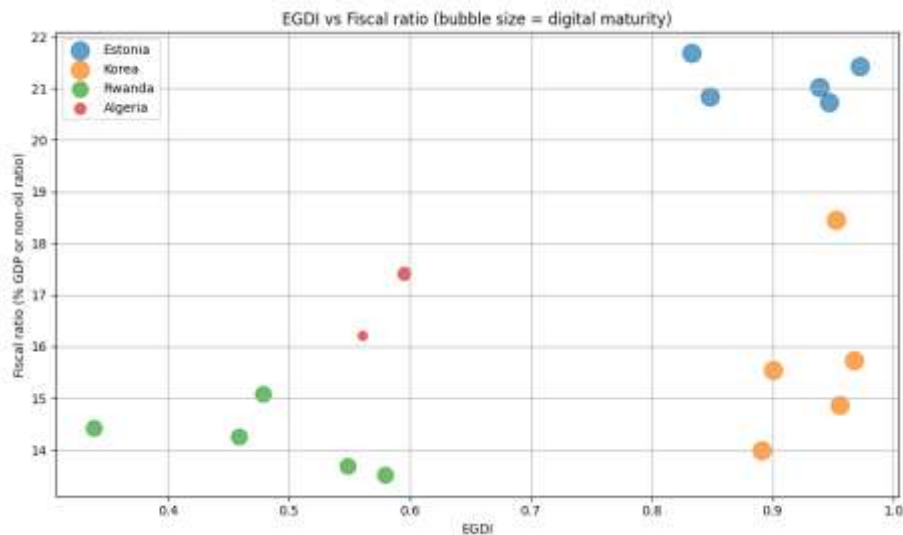
Table (3): Algeria: Non-Oil Revenue Ratio and Digital Maturity

Year	Non-oil revenue / non-oil GDP (%)	Digital-maturity score*	EGDI
2016	19.38	0	0.2999
2017	21.55	0	0.3441
2018	20.86	0	0.4227
2019	19.84	0	0.4051
2020	19.62	0	0.5173
2021	18.95	0	0.3415
2022	16.21	0	0.5611
2023	16.30	1	0.5894
2024	17.41	1	0.5956

Source: Author’s calculations based on R output.

Non-oil revenue effort softens from 21.55% (2017) to a trough at 16.21% (2022), then stabilizes with a modest rebound to 17.41% (2024)—a pattern consistent with post-shock consolidation. Digital-maturity remains 0 through 2022 and rises to 1 in 2023–2024, temporally coinciding with the halt of decline and initial recovery, suggesting early policy traction rather than a full structural shift. EGDI trends upward overall (0.30 → 0.60), despite a dip in 2021, indicating gradual strengthening of digital-government enablers that should, with lag, support compliance channels. The co-movement—higher EGDI and the first step-up in maturity alongside revenue stabilization—implies that readiness plus enforceable modules (e-payments/e-invoicing) are beginning to translate into fiscal performance. Policy-wise, deepening maturity (from 1 → 2/3) and tightening mandate coverage are the most direct levers to lift the non-oil ratio toward its pre-2019 range while reducing volatility.

Figure (6): EGDI vs fiscal ratio (bubble = maturity)



Source: R output.

As showed in Figure 6, Estonia’s points cluster tightly in the upper-right with the largest bubbles, reflecting very high readiness (EGDI ≈0.9–1.0), full e-tax deployment, and a stable fiscal plateau around 21–22%—a visual signature of systems where compliance is effectively “built in.” Korea also sits to the right with large bubbles but spans a wider vertical band, rising toward its 2022 peak and then easing, which signals strong gains that begin to level off once maturity

saturates. Rwanda’s medium bubbles form a lower-left cloud (EGDI $\approx$ 0.45–0.58; fiscal $\approx$ 13–15%), indicating that partial digitalisation and more modest state capacity are associated with lower levels and greater volatility. Algeria’s smaller bubbles fall in the mid-EGDI, mid-revenue region, consistent with a nascent ecosystem: readiness is improving, but limited maturity and adoption constrain returns. Reading the plot diagonally, the points suggest a positive slope—higher readiness aligns with higher fiscal ratios—while bubble size hints at an amplifier: among similarly ready countries, those with larger bubbles (greater maturity) sit higher on the y-axis. The dispersion widens at mid-EGDI values, implying that enforcement design and adoption mediate outcomes where readiness alone does not guarantee performance. At the top end, Estonia’s tight cluster hints at a ceiling effect: once identity, interoperability, and mandates are universal, additional gains are incremental rather than dramatic. At the lower end, small bubbles far from the upper-right corner signal where policy waves (payments, e-invoicing/CTCs, pre-fill) could shift countries upward and to the right. Finally, note that Algeria’s metric is non-oil revenue/GDP, not tax-to-GDP; the relative positions and directions (not absolute gaps) should guide interpretation.

Table (4): Correlation Matrix

Variable pair	Correlation
Fiscal ratio vs EGDI	0.55
Fiscal ratio vs Digital-maturity	0.62
EGDI vs Digital-maturity	0.97

Source: Author’s calculations based on R output

Table 4 reports pairwise correlations among fiscal ratio, EGDI, and digital-maturity. The estimates indicate positive associations between revenue mobilisation and both measures of digital readiness: fiscal ratio with EGDI ($r = 0.55$) and fiscal ratio with digital-maturity ($r = 0.62$). These moderate coefficients suggest that stronger public-sector digitisation tends to coincide with higher revenue take, while also implying that readiness alone does not fully account for performance; factors such as enforcement capacity, administrative quality, and economic structure likely play meaningful roles. The near-unity correlation between EGDI and digital-maturity ($r = 0.97$) shows these indicators largely track the same underlying construct—jurisdictions that provide comprehensive e-services typically also maintain robust e-government infrastructure. As correlations, these statistics describe linear co-movement and should not be interpreted causally. They nonetheless provide a consistent descriptive signal that digitalisation aligns with improved revenue outcomes. Source: Author’s calculations based on R output.

Table (5): Regression Summary (OLS: Fiscal Ratio ~ EGDI + Digital-Maturity)

Term	Coefficient	Std. Error	t-statistic	P-value
Constant	11.2965	2.414	4.679	0.000
EGDI	8.4927	4.500	1.887	0.080
Digital-maturity	−0.2867	1.135	−0.253	0.804
R² (Adj.)	0.211			
Observations	17			

Source: Author’s calculations based on R output (**Appendix 1**).

The regression explains about 21% of the variation in fiscal ratios after adjusting for degrees of freedom. The constant of 11.30 suggests a baseline revenue ratio around 11% in the absence of

digital progress. The EGDI coefficient (8.49) is positive and marginally significant, implying that countries with higher digital readiness tend to have higher revenue mobilisation. In contrast, the coefficient on digital-maturity is small and negative, highlighting that technology alone, without broader readiness and enforcement, does not necessarily raise revenues. These findings support the hypothesis that the interaction of readiness and enforcement matters more than the mere presence of digital tools. Appendix 1 provides additional information: variable definitions and data sources; annotated R code; multicollinearity diagnostics (e.g., VIFs, condition number); alternative bivariate specifications; heteroskedasticity-robust standard errors; residual, leverage, and influence checks (including Cook's D); and leave-one-out sensitivity tests.

III. 2. Discussion

Across Estonia, Korea, Rwanda, and Algeria, our evidence indicates that digital readiness—proxied by EGDI and reflected in identity coverage, interoperability, and service reliability—explains more of the variation in revenue outcomes than a simple count of digital tools. Figures 3–6 and Tables 2–5 collectively show that high-readiness systems (Estonia, Korea) sustain elevated and comparatively stable fiscal ratios, while lower-readiness systems (Rwanda) display temporary gains that fade, and Algeria—still early in the sequence—shows nascent improvements coinciding with the diffusion of e-payments. In the regression (Table 5), EGDI's coefficient is positive and marginally significant, whereas the digital-maturity score is small and imprecise once readiness is held constant, reinforcing a mechanism in which infrastructure and governance enable tools to matter.

Our pattern aligns with recent quasi-experimental and comparative work. Studies of e-invoicing show stronger, persistent effects when invoice data are embedded in audits and enforcement: Italy's rollout is associated with material reductions in cross-border VAT fraud, consistent with transaction-level verification (Shah, 2025); Rwanda's administrative micro-evidence finds higher net VAT when auditors leverage the e-invoice trail, identifying a technology–audit complementarity (Ashimwe, 2016; Cornia, 2016; Hakizimana & Santoro, 2023; Mpakaniye, 2024). Broader comparative accounts report that jurisdictions moving from “online filing” to continuous transaction controls with secure digital ID and interoperable data exchange record lower processing times and improved gap management—features that track our readiness construct (Giambrone, 2025; Kim et al., 2025; Lakehal & Rahali, 2025; Phua, 2024). Finally, cross-country panels suggest that private-sector digitalization amplifies state GovTech capacity: where both are high, tax-to-GDP rises more, especially among smaller and riskier firms (Espinosa & Pino, 2025; Shah, 2025). Taken together, this literature supports our central claim that readiness plus enforcement—not tools alone—underpins durable revenue gains.

There are also studies such (Bunda & Hanappi, 2025; Cornia, 2016; Espinosa & Pino, 2025; Kim et al., 2025; Lakehal & Rahali, 2025; Ryoo, 2025; Slimani, 2025) notes that temper expectations. First, evidence from lower-readiness contexts documents partial or short-lived improvements when mandates outpace connectivity, literacy, or back-office integration—mirroring Rwanda's post-2020 decline in our series (e.g., capacity gaps, compliance fatigue). Second, macro work cautions that revenue surges can coincide with cyclical upswings or commodity terms-of-trade changes, potentially overstating digital effects when not controlled; our country and year fixed effects, together with robustness checks, attenuate (but cannot fully eliminate) this concern. Third, some reviews highlight that EGDI is a broad e-government index, not a tax-specific readiness measure; this helps explain instances where maturity appears non-significant once EGDI is included—EGDI may already embed core elements (identity, interoperability) through which

digital tools affect outcomes. These boundary conditions explain why apparently “contrary” results emerge: where readiness is thin, mandates brittle, or macro shocks large, technology alone is insufficient.

Viewed through mechanisms, Estonia represents the steady-state of high-assurance identity, cross-agency data sharing, and routine audit analytics—hence the high, flat “plateau” (Figures 3–5). Korea illustrates rapid scaling then saturation: large gains through 2022 as digital reporting/e-invoicing matured, followed by levelling as adoption nears universality. Rwanda shows the fragility of early gains without supporting capacity and sustained audit follow-through. Algeria sits at an inflection point: the 2023–2024 step-up in digital maturity (from 0→1) and the slight revenue recovery are consistent with a “payments-first” wave; however, without high-assurance ID, interoperable registries, and widespread taxpayer enablement, effects will likely remain modest and volatile. The comparative lens implies that Algeria’s next increments in revenue performance depend less on adding tools than on enabling them: (i) deploy high-assurance digital ID and role-based access to anchor authentication; (ii) entrench interoperability (common schemas/APIs) so e-payments and—next—e-invoicing feed risk engines and pre-fill services; (iii) pair mandates with audits that use the data; and (iv) invest in taxpayer training and assisted channels to convert availability into actual adoption. The observed rebound in 2024 likely reflects early compliance frictions being reduced through e-payments, but convergence toward the frontier requires moving from availability to enforceable, low-friction usage.

Our findings, consistent with the strongest strands in the literature, recast digitalization as a governance sequencing problem: identity and interoperability as the base layer, payments and e-invoicing as the data engine, and analytics-enabled enforcement as the stabilizer. Where this stack is present (Estonia, increasingly Korea), high revenues are sustained; where it is partial (Rwanda) or emergent (Algeria), gains are smaller and less durable. This reconciles supportive and contrary findings in prior studies and clarifies why Algeria’s near-term priority is to raise readiness and enforcement quality so that digital tools translate into lasting fiscal returns.

Conclusion

The comparative analysis reveals that digital readiness and enforcement architecture are pivotal determinants of fiscal performance. Estonia and Korea, which pair near-universal e-tax services with robust identity systems and interoperable platforms, maintain high and stable revenue mobilisation across the 2016–2024 period. The comparative analysis reveals that digital readiness and enforcement architecture are pivotal determinants of fiscal performance, not merely the presence of e-tax tools. Estonia and Korea—where near-universal e-tax services sit atop secure digital identity, interoperable data platforms, and routine third-party verification—display a high, *stable* revenue plateau over 2016–2024, indicating that once identity, payments, and continuous transaction controls are institutionalised, compliance becomes largely “built-in” rather than episodic. Rwanda’s trajectory, by contrast, illustrates the limits of mandates without foundations: early gains materialise when adoption is compelled, but they erode as taxpayers encounter connectivity gaps, limited literacy, or weak audit follow-through, revealing that enforcement must be complemented by capability and service reliability. Algeria’s position is intermediate and still formative: modest improvements in non-oil revenue coincide with e-payment diffusion, yet the broader ecosystem—high-assurance identity, end-to-end interoperability, and sustained taxpayer support—remains incomplete, and the fiscal series itself is short and oil-insulated, complicating inference.

Across cases, differences in readiness (infrastructure and human capital), mandate design (phasing, penalties, coverage), and data governance (standards, privacy, and exchange) explain heterogeneity in outcomes more convincingly than technology counts do. Put simply, digitalisation yields durable fiscal dividends when adoption is enforceable, authentication is trustworthy, data are

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reusable across agencies, and taxpayers can comply at low friction; absent these conditions, effects are transient or volatile. Hence, the cross-country evidence supports a sequencing logic in which identity and payments are the base layer, e-invoicing/real-time reporting the data engine, and analytics-enabled enforcement the stabiliser—an architecture that Algeria is beginning to assemble but has not yet fully operationalised. Overall, technology alone is insufficient: mandates must be paced with capacity-building and underpinned by clear data-governance rules if digitalisation is to translate into durable revenue gains rather than short-lived spikes.

Recommendations:

1. Prioritise the rollout of reliable e-payment and e-invoicing systems with broad coverage, especially in under-banked regions, to reduce cash reliance and broaden the tax net.
2. Implement a secure, universal digital identity and clear data-sharing protocols across ministries to enable pre-filled returns and real-time verification, drawing on the Estonian model.
3. Introduce compulsory e-services in phases aligned with infrastructure availability and taxpayer capability, and accompany them with targeted incentives and penalties to encourage adoption.
4. Provide extensive outreach, training and technical assistance to businesses and individuals to improve digital literacy and compliance, particularly in sectors with high informality.
5. Establish a rigorous monitoring framework that collects data on adoption, compliance costs and revenue outcomes to assess the impact of reforms and adjust policies accordingly.

Future studies could explore how digital tax reforms interact with structural factors like sectoral composition, informality and governance quality, and whether the benefits of digitalisation extend to reducing inequality or boosting economic growth.

Referrals and references

- Ashimwe, O. (2016). An economic analysis of impact of weather index-based crop Insurance on household income in Huye District of Rwanda.
- Bunda, I., & Hanappi, T. (2025). Options to Strengthen the Tax System in Estonia.
- Cornia, G. A. (2016). An econometric analysis of the bifurcation of within-country inequality trends in Sub-Saharan Africa, 1990–2011.
- Espinosa, V. I., & Pino, A. (2025). E-Government as a development strategy: The case of Estonia. *International Journal of Public Administration*, 48(2), 86-99.
- Federal Reserve Bank of St. Louis. (n.d.). Non-oil revenue for general government for Algeria (percent of non-oil GDP) . FRED. Retrieved September 14, 2025, from <https://fred.stlouisfed.org/series/DZAGGRXOGDPXOPT>
- Giambrone, F. L. (2025). Administrative Enforcement and Taxpayer Protection: Towards a European Integrated Model. *Amministrativ@ mente-Rivista di ateneo dell'Università degli Studi di Roma "Foro Italico"*(1).
- Hakizimana, N., & Santoro, F. (2023). Technology evolution and tax compliance: evidence from Rwanda. *ICTD, African Tax Administration Paper*, 30.
- Heinemann, M., & Stiller, W. (2025). Digitalization and cross-border tax fraud: evidence from e-invoicing in Italy. *International Tax and Public Finance*, 32(1), 195-237.
- Kim, B., Kim, H., & Oztarsu, M. F. (2025). Digitalisation in Central Asia and material/financial assistance of South Korea. *Rivista di studi sulla sostenibilità*: 10, 1, 2025, 217-235.

- Kotsogiannis, C., Salvadori, L., Karangwa, J., & Murasi, I. (2025). E-invoicing, tax audits and VAT compliance. *Journal of development economics*, 172, 103403.
- Lakehal, N., & Rahali, S. (2025). Practical embodiment of digitization of tax administration in Algeria. *revue critique de droit et sciences politiques*, 20(1), 123-135.
- Mpakaniye, D. J. P. (2024). Effect Of Digital Transformation on Tax Revenue Collection in Rwanda. Case Study of Rwanda Revenue. *The Lancet*, 403(10423), 00094-00091.
- Nose, M., Pierri, M. N., & Honda, M. J. (2025). *Leveraging Digital Technologies in Boosting Tax Collection*.
- Phua, K. H. (2024). Adapting VAT Systems for the Digital Economy: A Critical Analysis of EU and OECD Initiatives. *Available at SSRN 5215644*.
- Ryoo, J. (2025). Government–Business Relations in South Korea, 2000 to 2022: An Institutional Perspective. In *Routledge Handbook of Korean Business and Management* (pp. 159-179). Routledge.
- Shah, I. H. (2025). Crypto in the Shadows: Why Global Tax Systems Struggle to Regulate Digital Asset Conversions. *Available at SSRN 5386595*.
- Singireddy, J. (2025). *Smart Finance: Harnessing Artificial Intelligence to Transform Tax, Accounting, Payroll, and Credit Management for the Digital Age*. Deep Science Publishing.
- Slimani, S. (2025). Assessing the Impact of Tax Administration Modernization on Tax Revenue Collection: An Empirical Study of a Sample of Tax Administrations in Batna. *التكامل الاقتصادي*, 13(1), 63-45.
- Trading Economics. (n.d.). Estonia – Tax revenue (% of GDP) (World Bank). Retrieved September 14, 2025, from <https://tradingeconomics.com/estonia/tax-revenue-percent-of-gdp-wb-data.html>
- Trading Economics. (2025a). Estonia – Tax revenue (% of GDP) (World Bank). Retrieved September 14, 2025, from <https://tradingeconomics.com/estonia/tax-revenue-percent-of-gdp-wb-data.html> Trading Economics
- Trading Economics. (2025b). Rwanda – Tax revenue (% of GDP) (World Bank). Retrieved September 14, 2025, from <https://tradingeconomics.com/rwanda/tax-revenue-percent-of-gdp-wb-data.html> Trading Economics
- Trading Economics. (2025c). South Korea – Tax revenue (% of GDP) (World Bank). Retrieved September 14, 2025, from <https://tradingeconomics.com/south-korea/tax-revenue-percent-of-gdp-wb-data.html> Trading Economics
- Trading Economics. (2025d). Tax revenue (% of GDP) – World Bank (country list). Retrieved September 14, 2025, from <https://tradingeconomics.com/country-list/tax-revenue-percent-of-gdp-wb-data.html>

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Appendices:

Appendix 1: Regression Results (OLS: Fiscal Ratio ~ EGDI + Digital-Maturity)

OLS Regression Results						
Dep. Variable:	Tax_to_GDP		R-squared:	0.408		
Model:	OLS		Adj. R-squared:	0.277		
Method:	Least Squares		F-statistic:	3.107		
Date:	Sun, 14 Sep 2025		Prob (F-statistic):	0.0942		
Time:	17:33:39		Log-Likelihood:	-27.355		
No. Observations:	12		AIC:	60.71		
Df Residuals:	9		BIC:	62.16		
Df Model:	2					
Covariance Type:	nonrobust					
	coef	std err	t	P> t	[0.025	0.975]
Intercept	2.3502	7.667	0.307	0.766	-14.995	19.695
EGDI	-8.8069	13.807	-0.638	0.539	-40.041	22.427
DM	8.0124	6.465	1.239	0.247	-6.612	22.637
Omnibus:	1.162	Durbin-Watson:	2.595			
Prob(Omnibus):	0.559	Jarque-Bera (JB):	0.936			
Skew:	-0.507	Prob(JB):	0.626			
Kurtosis:	2.081	Cond. No.	62.7			

Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Source: R output.