“Digital tax administration, corporate tax revenue and the informal economy: Panel evidence from 25 transition economies, with a focus on Armenia, Kazakhstan, and Ukraine”

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DIGITAL TAX ADMINISTRATION, CORPORATE TAX REVENUE AND THE INFORMAL ECONOMY: PANEL EVIDENCE FROM 25 TRANSITION ECONOMIES, WITH A FOCUS ON ARMENIA, KAZAKHSTAN, AND UKRAINE

Abstract

Transition economies combine large informal sectors with constrained fiscal capacity, and many have turned to digital tax administration to raise revenue and curb informality. This study assesses digital tax administration as a fiscal-governance innovation in 25 transition economies, asking whether it increases corporate tax revenue and reduces the informal economy, and whether these effects are linked. Using a balanced annual panel for 2008–2022 (375 country-years) and fixed-effects models, it proxies digital administration by the United Nations Online Service Index – a broad measure of digital-government maturity – and tests mediation between revenue and informality. A higher Online Service Index is robustly associated with higher corporate tax revenue ($\beta = 0.89$, $p < 0.01$) – an increase of about 0.89 percentage points of GDP, roughly 41% of the sample mean – that holds across alternative specifications including two-way fixed effects, alternative constructions of the index, and sub-periods. Its association with a smaller informal economy ($\beta = -3.62$, $p < 0.05$) is fragile: it is concentrated in the pandemic years 2020–2021, turns insignificant once they are excluded ($\beta = -1.54$, $p = 0.12$), and does not survive two-way fixed effects or all alternative informality measures. An exploratory decomposition finds no evidence that this association runs through corporate tax revenue: the indirect path is insignificant (about 16% of the total effect), indicating parallel rather than sequential channels. Digitalizing tax administration is associated with a reliable corporate-revenue dividend, whereas the informality association is conditional, pandemic-bound, and does not operate through tax revenue.

Keywords digital taxation, e-government, corporate tax, informal economy, tax revenue, transition economies

JEL Classification H25, H26, O17, O33

INTRODUCTION

Transition economies carry some of the world's largest informal sectors. The shadow economy averages around 15% of GDP in advanced economies, roughly 30–35% across emerging and developing economies, and more in several post-socialist and Commonwealth of Independent States countries (IMF, 2021; Medina & Schneider, 2018); across the 25 transition economies studied here, MIMIC-based estimates frequently exceed a quarter of national output (Asllani et al., 2026). Such informality narrows the tax base, depresses productivity, and weakens fiscal capacity, making informality reduction and revenue mobilization intertwined priorities.

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Governments have increasingly turned to digital tax administration to tackle both at once: electronic registration, filing, payment, and invoicing lower compliance costs, expand third-party information, and render transactions more visible (ADB, 2022; Nose & Mengistu, 2023). The OECD's Tax Administration 3.0 vision frames taxation as embedded in taxpayers' own digital systems, with online registration, filing and payment offered by around 90% of surveyed administrations (OECD, 2020, 2024). This shift reached the transition world too. The study follows three former Soviet economies most closely – Ukraine, Armenia and Kazakhstan – non-high-income reformers with large informal sectors and varied digital trajectories, from Armenia's low connectivity base to Kazakhstan's near-frontier online provision. The rationale for these focal cases – contrasting digital-government trajectories within the post-Soviet subgroup – is set out in the Data and Methodology section. In all three, the United Nations Online Service Index rose substantially between 2008 and 2022, alongside sharp gains in internet penetration. Yet the fiscal payoff remains contested, and evidence that digitalization shrinks the informal economy is limited and drawn largely from single-country, firm-level studies (Nose & Mengistu, 2023; World Bank, 2021).

This study asks whether digital tax administration delivers measurable fiscal returns in transition economies, and through which channel. Using the 25-country panel and country fixed effects, it estimates the association of digital administrative capacity – proxied by the United Nations Online Service Index, a broad measure of digital-government maturity of which tax administration is one component – with corporate tax revenue and with the informal economy, and tests whether revenue and informality respond through a single mechanism or as distinct channels. (Azerbaijan, an active regional reformer, is excluded only because comparable informal-economy estimates are unavailable.) The paper thus contributes cross-country evidence on the heterogeneous fiscal effects of tax-administration digitalization.

1. LITERATURE REVIEW

The size of the informal economy is shaped at least as much by the design of the fiscal and regulatory environment as by development itself: although informality recedes as economies mature, it co-evolves with weak institutions, corruption and regulatory friction (Bachas et al., 2024; Yarovenko et al., 2024). The shadow economy is usually quantified with the Multiple Indicators Multiple Causes (MIMIC) approach, which links its size to labor-market institutions – higher minimum wages relative to median earnings expand informal employment – and to the fiscal and regulatory environment (Giedraitis et al., 2025). The tax-structure evidence is mixed: higher personal income and value-added tax rates enlarge the shadow economy, whereas a higher effective corporate income tax can curtail it by closing avenues for profit shifting (Giedraitis et al., 2024), and stringent command-and-control environmental rules push firms into the grey market to escape compliance costs (Lyeonov et al., 2025c). Environmental instruments cut both ways – carbon pricing and market-based climate policy are associated with smaller informal activity (Lyeonov et al., 2025b; Kusumawati et al., 2025), yet informality can itself sustain decentralized renewable initiatives in under-served regions (Lyeonov et al., 2025a). Informality also tracks broader conditions: wider financial inclusion accompanies stronger, more inclusive growth (Saienko et al., 2025), while in economies such as Kazakhstan its persistence is bound up with regional income inequality (Kurmanov et al., 2026). These mixed determinants motivate a closer look at administration, not tax rates alone, as a lever against informality.

A second strand turns from tax rates to tax administration, framing compliance as a behavioral response to detection and deterrence. The canonical model treats evasion as a gamble against the probability of audit and the size of penalties (Allingham & Sandmo, 1972), while modern work formalizes the administrative side through an enforcement elasticity of revenue – how collection responds to administrative effort (Keen & Slemrod, 2017). Two levers recur. Third-party information comes first: rewarding consumers for requesting receipts raises firms' reported revenue (Naritomi, 2019), and value-added-tax paper trails from electronic billing strengthen enforcement even where ghost

firms and misreporting persist (Brockmeyer et al., 2024), while machine-readable digital formats of corporate financial reporting widen the same information base for analysis and audit (Shygun et al., 2023). The second is institutional trust and tax morale, which can substitute for scarce enforcement capacity but are easily eroded – for instance, by amnesties that signal leniency (Erina et al., 2026). At the corporate margin, avoidance is tied to firms' profitability and size, so the discretionary corporate base is where administrative leverage is greatest (Shubita, 2024a, 2024b). In transition economies, the level and structure of taxation are themselves consequential for growth (Shapovalova et al., 2023), so collecting the corporate base efficiently – not raising statutory rates – carries particular weight. These channels – visibility, deterrence and morale – are what digital tools were later built to operate at scale.

The literature accordingly studies digital tax administration as the practical instrument of these channels. Causal micro-evidence is encouraging: replacing in-person with electronic filing lowers compliance costs, roughly doubles payments among firms previously prone to evasion and cuts bribery (Okunogbe & Pouliquen, 2022), while text-message reminders raise compliance by about seven percent where the state's reach is thin (Cohen, 2024). At the macro level, mobile-money adoption is associated with higher tax revenue in developing countries (Apeti & Edoh, 2023), and syntheses of low-income settings argue that targeted investment in taxpayer registries and automated third-party verification is needed to close the administrative gaps growth alone leaves open (Okunogbe & Tourek, 2024). The dividend is not automatic: across 159 countries, digitalization raises domestic revenue only when matched by governmental responsiveness and regulatory quality (Lee, 2025), and at the organizational level its returns depend on digital service quality and employee engagement during transformation (Nafei et al., 2025; Hernik et al., 2025).

A fourth body of work links digitalization to governance quality, especially salient in transition economies. Structural analyses for Ukraine find that deeper digital and technological development reduces corruption and improves transparency by removing human discretion from administration (Yefimenko et al., 2025a, 2025b), consistent with evidence that the tax burden and the scale of public consumption are among the strongest correlates of corruption (Bozhenko et al., 2022). Integrated reforms – system-wide digital procurement and financial management, not piecemeal fixes – catalyze accountability (Ntuli et al., 2026), with anti-corruption audit supplying the verification layer of such systems (Bezverkhyi et al., 2024; Parasii-Verhunenko et al., 2024), while ethical leadership co-moves with digital competence and institutional convergence across European states (Kyzenko et al., 2026). Regional public-finance work adds that government spending and exchange rates track macroeconomic fundamentals and that early-stage democratization can raise outlays before institutions mature (Filipova et al., 2025; Ahmed, 2025), and governance frameworks for public-private partnerships and rural administration stress tailored institutional design (Oe et al., 2025; Beyi, 2025). Country fiscal studies point the same way: the intensity of fiscal structural reform is now measurable as administrations modernize, with Armenia a case in point (Mkrtchyan & Petrosyan, 2025), even as small post-Soviet economies remain exposed to macroeconomic vulnerability that constrains fiscal space (Mkrtchyan et al., 2026). Yet asymmetric adoption widens a digital gap that can entrench rather than dissolve existing inequalities (Kolupaieva & Tiesheva, 2023) – a double-edged quality recurring across the wider digital economy.

Beyond taxation, a large applied literature documents how digital tools restructure operations across sectors, with effects that are uneven and sometimes adverse. Digital payments and enablement reshape banking stability and insurance performance (Mustafa, 2024; Dillianti et al., 2024); cloud and messaging platforms transform marketing and customer support (Al-Hamamy et al., 2025; Kostiushko et al., 2025); fintech lending, wider financial access and quasi-viral technologies extend formal finance and the sustainability transition (Waliszewski et al., 2024; Budhathoki et al., 2025; Melnyk et al., 2025). Adjacent work on environmental taxation, transparency and decar-

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bonization maps the fiscal-governance interface from the green side (Dobrovolska et al., 2024; Samusevych et al., 2024; Kuzior et al., 2023), and studies of healthcare, tourism and inclusive development show digitalization diffusing into ever more domains (Tossekbayev et al., 2025; Mshana & Postrzednik-Lotko, 2026; Alemu, 2025). Human-centered and inclusive-design concerns recur, from aligning technology with social ends to the well-being of remote workers (Siemon and Wolff, 2024; Sarwar et al., 2026), and inclusive employment and persistent gaps in inclusive growth are first-order constraints (Zahorodnia et al., 2026; Saher et al., 2025). Digitalization can also enable new harms – machine-learning privacy risks, sophisticated illicit channels – so technology may displace rather than eliminate the shadow activity it is meant to curb (Wieczorek & Postrzednik-Lotko, 2025; Burrell et al., 2025).

Taken together, the literature leaves a clear gap. The most credible evidence that digital administration changes taxpayer behavior is overwhelmingly single-country and micro – electronic filing in Tajikistan, reminders in Uganda, receipt lotteries in Brazil – while the few cross-country panels concern mobile money or aggregate digitalization and revenue rather than informality (Apeti & Edoh, 2023; Lee, 2025). Cross-country macro evidence linking targeted digital tax administration to the size of the informal economy is therefore scarce, and a prior theoretical question is unresolved: whether revenue and informality respond to digitalization through a single enforcement mechanism (Keen & Slemrod, 2017) or through several parallel channels – lower compliance costs, reduced extortion, a broader base and shifting tax morale – that need not move together (Okunogbe & Tourek, 2024). The present study addresses both gaps. It assembles a balanced 2008–2022 panel of 25 transition economies, proxies digital tax administration with the United Nations Online Service Index, and tests whether corporate tax revenue mediates any informality effect, gauging how far that effect depends on the pandemic-era digital surge. It thus joins two literatures that have developed largely apart – the macro-fiscal returns to digitalization and the determinants of the shadow economy – and offers cross-country evidence on a transmission question micro-studies can address only one country at a time.

2. DATA AND METHODOLOGY

2.1. Data and sample

The study uses a balanced annual panel of 25 transition economies over 2008–2022 (T = 15; N = 375), spanning former Soviet (non-Baltic), Central and Eastern European EU, and Western Balkan economies (listed in Appendix A); Azerbaijan and a few others are excluded for lack of comparable informal-economy estimates. The dependent variable, the informal economy (% of GDP), is the MIMIC C.1 estimate of Asllani et al. (2026), with three alternative scalings (DGE, Elgin, Medina–Schneider) and a Quality of Government series used for robustness. The mediator, corporate tax revenue (% of GDP), is from the ICTD/UNU-WIDER Government Revenue Dataset. Digital tax administration is proxied by the UN Online Service Index (OSI) from the E-Government Survey, with the E-Government Development Index, its subcomponents, and the World Bank GovTech Maturity Index as alternatives. The OSI is a broad measure: it captures the online maturity of public administration across policy areas rather than the implementation of tax-specific instruments such as electronic filing, e-invoicing, or digital VAT reporting. Three considerations nevertheless support its use while bounding the interpretation. First, no indicator of tax-administration digitalization is available as a country-year panel for the 25 economies over 2008–2022: tax-specific sources such as the GovTech Maturity Index cover only recent cross-sections (2020 and 2022 in these data) and cannot support fixed-effects estimation. Second, the index is not unrelated to tax digitalization: the online provision of income-tax services is among the services assessed by the UN Survey's Online Service Questionnaire, so movements in the OSI partly reflect the digitalization of revenue administration itself. Third, in the sample economies, tax e-services are typically delivered through the same national portals and interoperability infrastructure that the OSI evaluates. The estimates are therefore read as associations between the digital maturity of public ad-

ministration – of which digital tax administration is a core component – and fiscal outcomes, not as effects of tax-specific instruments alone (see Limitations). Institutional controls come from the Worldwide Governance Indicators, Transparency International, and V-Dem; macroeconomic controls from the World Development Indicators. Biennial digital indices are forward-filled; definitions and descriptive statistics are in Table 1.

2.1.1. Selection of focal economies

Three economies – Armenia, Kazakhstan, and Ukraine – receive separate descriptive attention (Figure 1). Their selection is transparent rather than formal: it is partly project-motivated, as the study was prepared within a research project on government digitalization centered on Ukraine (see Acknowledgement), and partly theory-driven, as the three form contrasting digital-government trajectories within the former-Soviet (non-Baltic) subgroup rather than representatives of the full sample. Armenia is a low-base digitalizer, entering the period with the sample's lowest internet penetration; Kazakhstan is a high-OSI regional frontrunner, approaching frontier provision by 2022; Ukraine is a rapid digitalizer operating under institutional shock, sustaining reform through the pandemic and, in 2022, war. Their role is illustrative – tracing the within-country variation that the fixed-effects estimator exploits – rather than a comparative case design: no country-specific regressions are estimated, and all inferential results refer to the full panel or to the income-group splits (Table 3).

2.1.2. Variables and transformations

The regressor of interest is the OSI, bounded in [0, 1]. Controls comprise control of corruption (WGI), log GDP per capita, the inverse hyperbolic sine of inflation, trade openness (% of GDP), internet penetration, and urbanization. GDP per capita is logged for right-skewness; inflation is transformed by the inverse hyperbolic sine, which accommodates the deflationary episodes a logarithm cannot and reduces skewness from +3.7 to −0.5. Because the institutional indicators are highly collinear (|r| up to 0.97; Appendix B), only control of corruption enters the primary models, the rest reserved for robustness.

2.1.3. Model specification

Two specifications are estimated for each outcome and reported side by side (Table 2). The first is a one-way fixed-effects model with a common linear time trend (Equation 1):

$$Y_{it} = \alpha_i + \beta \cdot OSI_{it} + \gamma' X_{it} + \delta \cdot t + \varepsilon_{it}, \qquad (1)$$

where i indexes countries (i = 1, ..., 25) and t years (t = 2008, ..., 2022); Y_{it} is the outcome; OSI_{it} the Online Service Index; X_{it} the control vector and γ' its coefficients; δ the coefficient on the common trend t; α_i country fixed effects; and ε_{it} the idiosyncratic error. Y is corporate tax revenue in the primary model and the informal economy in the secondary one; β, the coefficient on OSI_{it}, is the parameter of interest, with standard errors clustered by country throughout.

The second is the two-way fixed-effects model (Equation 2). The two identify β from different variation, and neither dominates a priori. The OSI rises secularly across almost all 25 economies while informality declines, so year fixed effects absorb not only common shocks but also the common component of digitalization itself; the two-way estimator then identifies β only from deviations of a biennial, forward-filled index around year means – variation that is limited and partly mechanical. A two-way null is therefore consistent both with the absence of a within-country relationship and with the absence of usable identifying variation, and these data cannot separate the two. The common linear trend removes the shared secular movement while preserving cross-country differences in the pace and timing of digitalization as identifying variation. We acknowledge the interpretive limit this creates: if the association reflected common temporal developments – the pandemic, coordinated digital-government reforms, shared infrastructure gains – the trend specification could overstate it relative to the two-way model. Interpretation is therefore anchored on the more restrictive two-way model: for corporate tax revenue the two specifications agree, and the effect is treated as robust; for the informal economy the two-way model returns a null, so the trend-specification association is read as the alternative, not the headline, estimate (see Results). As robustness, we also estimate pooled OLS, one-way

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country and year fixed effects, and country-specific trends (Equation 3):

$$Y_{it} = \alpha_i + \lambda_t + \beta \cdot OSI_{it} + \gamma^{'X_{it}} + \varepsilon_{it}, \quad (2)$$

$$Y_{it} = \alpha_i + \beta \cdot OSI_{it} + \gamma' X_{it} + \delta_i \cdot t + \varepsilon_{it}, \quad (3)$$

where λ_t is year fixed effects (Equation 2), and δ_i is country-specific trend coefficients (Equation 3); other symbols are as in Equation 1.

2.1.4. Mediation analysis

To test whether the OSI–informality association runs through tax compliance, we estimate a product-of-coefficients model with corporate tax revenue (*M*) as mediator: the a-path regresses the mediator on the *OSI* (Equation 4), and the b-path and direct effect add the mediator to the informal-economy equation (Equation 5):

$$M_{it} = \alpha_i + a \cdot OSI_{it} + \gamma' X_{it} + \delta \cdot t + u_{it}, \quad (4)$$

$$IE_{it} = \alpha_i + c' \cdot OSI_{it} + b \cdot M_{it} + \gamma' X_{it} + \delta \cdot t + \varepsilon_{it}, \quad (5)$$

where M_{it} is the mediator; α the a-path coefficient and u_{it} its error; IE_{it} the informal economy; b the b-path coefficient and c' the direct effect of OSI_{it} conditional on the mediator; the rest as in Equation 1. The total effect c is the OSI coefficient in Equation 1 with informality as the outcome; the indirect effect ($\alpha \cdot b$) is assessed with the Sobel test, and the proportion mediated is ($\alpha \cdot b$ / c).

Because a mediation decomposition is informative only to the extent that the total effect is itself stable, and the OSI–informality association is concentrated in the pandemic years (see Results), the decomposition is reported as an exploratory, descriptive exercise: its purpose is to test whether the conventional compliance channel finds support within the primary specification, not to quantify a structural mediation mechanism.

2.1.5. Estimation and diagnostics

Models are estimated by within (fixed-effects) OLS with cluster-robust (CRV1) standard errors by country. Fixed over random effects rests on theory rather than a Hausman test (whose variance matrix is not positive definite under clustering): the economies are a non-random group, and time-invariant attributes such as Soviet legacy and EU membership plausibly correlate with governance and development, rendering random effects inconsistent. Multicollinearity is not a concern (all variance-inflation factors below 5, maximum 4.12). Robustness spans four dimensions: alternative MIMIC scalings and digital-administration proxies, alternative fixed-effects structures, and period and income-group sub-samples (Table 3). A further set of checks addresses the temporal construction of the biennial OSI (actual survey waves, linear interpolation, one- and two-year lags), corporate-tax coverage (a near-balanced subpanel, exclusion of thin clusters and of the focal economies, country-level leave-one-out), and small-cluster inference (CRV3 jackknife standard errors and the wild cluster bootstrap) (Table 5).

2.1.6. Limitations

Several limitations apply. First, the informal economy is not observed but MIMIC-estimated, and its 2020–2021 pandemic contraction-and-rebound (Figure 1) drives the association, which vanishes and reverses before 2020; we therefore treat it as pandemic-era and secondary to the period-stable corporate-tax finding. Second, the principal regressor is imperfectly targeted: the OSI measures the digital maturity of government service delivery broadly, not tax-administration instruments specifically, and no tax-specific panel measure exists for these economies over the study window; the estimates therefore cannot separate the contribution of tax digitalization from the wider digital transformation in which it is embedded, and the paper's use of 'digital tax administration' should be read with this caveat. Third, the design is associational, not causal: time-varying confounders and reverse causality cannot be excluded, and – given a near-universal digital upswing and a common pandemic shock – within-country institutional change cannot be fully separated from shared temporal developments, as the two-way fixed-effects results illustrate. Fourth, structural data features are handled explicitly: Kazakhstan's corporate-tax data begin only in 2019 (contributing later years only), and Ukraine's 2022 tax revenue is inflated by war-related grants while its 2022 informality

value is missing. Fifth, the sample excludes a few economies lacking comparable estimates, and the 2022 cutoff places the latest GovTech data (2025) outside the window.

3. RESULTS

3.1. Descriptive statistics

The analysis is based on a balanced panel of 25 transition economies observed annually over 2008–2022 (T = 15; N = 375), spanning the Baltic and Central European EU members, the Western Balkans, and the non-Baltic former Soviet republics. Table 1 reports descriptive statistics for the dependent variable, the mediating channel, the digital-administration proxies, and the institutional and macroeconomic controls.

The informal economy, measured by the primary MIMIC estimates of Asllani et al. (2026), averages 26.6% of GDP (SD = 13.6) and ranges from 1.1% to 54.8%, reflecting wide heterogeneity between highly formalized and shadow-intensive economies. The principal proxy for digital tax administration, the UN Online Service Index (OSI), averages 0.575 (SD = 0.198) and covers almost the entire theoretical range (0.037–1.000), so the sample includes both early-stage and frontier digitalizers. Corporate tax revenue – the fiscal channel examined below – averages 2.18% of GDP (SD = 0.86).

Ukraine, Armenia, and Kazakhstan, the three focal economies (their selection is set out in the Data and Methodology section), illustrate the digital transformation that underlies the sample. Between 2008 and 2022, the OSI rose from 0.54 to 0.82 in Ukraine, from 0.27 to 0.72 in Armenia, and from 0.32 to 0.93 in Kazakhstan, the last reaching near-frontier provision (Figure 1). Internet penetration expanded sharply over the same period (Ukraine 11.0% to 82.7%; Armenia 6.2% to 77.0%; Kazakhstan 11.0% to 92.3%), with Armenia starting from the lowest connectivity in the sample. In all three countries, the informal-economy series shows a marked contraction in 2020 followed by a rebound in 2021 (Ukraine 22.7% to 43.8%; Armenia 17.6% to 27.6%; Kazakhstan 25.4% to 42.0%) – a pattern reflecting the pandemic adjustment embedded in the underlying estimates, to which we return when assessing robustness.

Table 1. Descriptive statistics

Sources: Asllani et al. (2026); ICTD/UNU-WIDER; UN (2022); World Bank (2022, 2023, 2025); Transparency International (2023); V-Dem Institute (2023).

Variable	N	Mean	SD	Min	Median	Max
Dependent variable – informal economy (% of GDP)						
ie_main – Informal economy, MIMIC primary (Asllani et al., 2026, C.1)	374	26.61	13.64	1.11	26.77	54.76
ie_dge – DGE scaling (C.2), robustness	329	32.67	10.42	15.89	29.72	67.76
ie_m1 – Elgin scaling (C.3), robustness	329	34.53	10.59	16.60	32.87	71.03
ie_m2 – Medina–Schneider (C.4), robustness	314	27.08	10.22	8.75	24.60	62.80
ie_qog_mimic – QoG MIMIC (robustness, to 2020)	286	34.15	10.30	16.60	32.78	67.99
Mediating channel – tax revenue (% of GDP)						
tax_total – Total tax revenue incl. social contributions (ICTD)	366	35.52	7.37	16.48	37.47	50.09
tax_income – Income, profits, capital gains (ICTD)	360	6.08	1.78	1.12	6.02	10.52
tax_gs – Goods and services, incl. VAT (ICTD)	360	13.11	3.01	3.06	12.94	20.07
tax_corp – Corporate income (ICTD)	329	2.18	0.86	0.16	2.06	6.00
tax_wdi – Tax revenue (WDI, fallback)	333	18.08	3.26	8.32	17.94	25.35
Digital tax / government administration						
osi – UN Online Service Index (primary proxy)	375	0.575	0.198	0.037	0.588	1.000
egdi – UN E-Government Development Index	375	0.643	0.128	0.315	0.645	0.947
hci_egov – Human Capital Index (EGDI)	375	0.846	0.073	0.652	0.850	0.979
tii_egov – Telecom Infrastructure Index (EGDI)	375	0.510	0.202	0.017	0.540	0.921
epi – E-Participation Index (EGDI)	375	0.508	0.270	0.000	0.557	1.000
gtmi – WB GovTech Maturity Index (2020 & 2022)	50	0.671	0.159	0.262	0.685	0.967
Institutional controls						
corr_wgi – Control of Corruption (WGI)	375	−0.142	0.694	−1.442	−0.206	1.596
gov_eff – Government Effectiveness (WGI)	375	0.061	0.641	−1.233	−0.009	1.371

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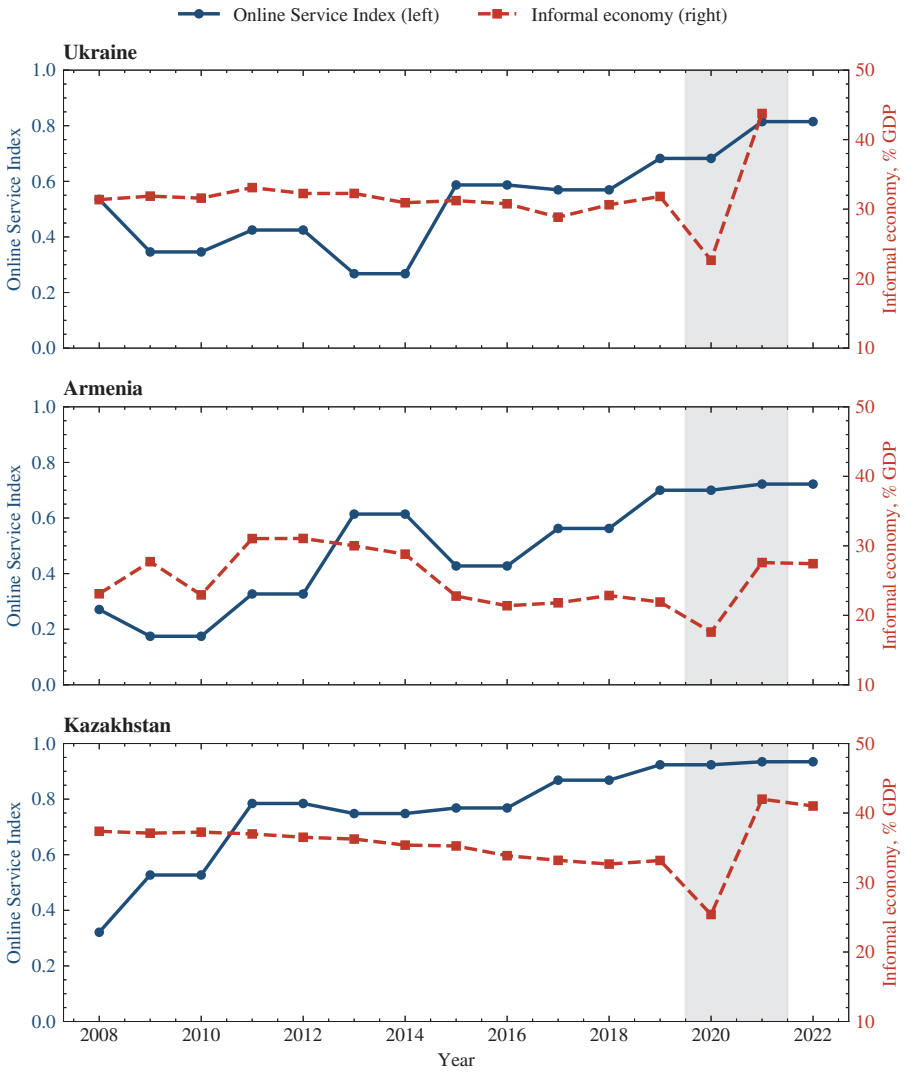
Table 1 (cont.). Descriptive statistics

Variable	N	Mean	SD	Min	Median	Max
rule_law – Rule of Law (WGI)	375	−0.013	0.672	−1.363	−0.115	1.522
reg_qual – Regulatory Quality (WGI)	375	0.213	0.700	−1.581	0.274	1.607
cpi – Corruption Perceptions Index (TI)	275	43.6	12.5	17.0	43.0	75.0
pubcorr_vdem – Public Sector Corruption (V-Dem)	375	0.422	0.274	0.028	0.336	0.914
Macroeconomic controls						
gdp_pc – GDP per capita, current USD (WDI)	375	9,976	7,053	665	7,621	29,193
gdp_pc_ppp – GDP per capita, PPP intl $ (WDI)	375	20,098	11,060	2,120	18,642	51,710
inflation – Inflation, consumer prices, % (WDI)	366	5.31	6.74	−1.58	3.32	59.22
trade_gdp – Trade, % of GDP (WDI)	375	108.57	34.47	29.19	102.62	204.06
urban – Urban population, % (WDI)	375	58.37	11.95	26.13	59.38	78.47
internet – Internet users, % (WDI)	373	61.35	21.09	6.21	67.10	92.30

Note: Balanced panel of 25 transition economies, 2008–2022 (N = 375). Variable-level N reflects raw coverage before listwise deletion. WGI scores range from −2.5 to +2.5; indices (OSI, EGDI, GTMI, V-Dem) range from 0 to 1.

Sources: UN (2022); Asllani et al. (2026).



Note: Online Service Index (left axis, solid) and the informal economy as a share of GDP (right axis, dashed) for Ukraine, Armenia, and Kazakhstan; the shaded band marks the 2020–2021 pandemic window.

Figure 1. Digital-government maturity (OSI) and the informal economy in the focal economies, 2008–2022

3.2. Digital-government maturity and corporate tax revenue

All estimates use country fixed effects and a common linear time trend, with standard errors clustered by country (the choice of specification is justified in the Data and Methodology section). The first and most robust finding concerns the fiscal channel.

Table 2, column 1, reports the association of digital-government maturity (OSI) with corporate tax revenue. The OSI coefficient is positive and significant ($\beta = 0.890$, SE = 0.282, $p = 0.005$; 95% CI [0.306, 1.475]). In economic terms, moving from no online service provision to full provision (OSI from 0 to 1) is associated with an increase of 0.89 percentage points of GDP in corporate tax revenue – about 41% of the sample mean (2.18%) – while a one-standard-deviation increase in the OSI (0.198) corresponds to a rise of 0.18 percentage points. Among the controls, GDP per capita enters strongly and positively ($\beta = 1.873$, $p < 0.01$) and control of corruption negatively ($\beta = -0.942$, $p = 0.009$). The model accounts for 29.4% of the within-country variation (R^2 within = 0.294; N = 327; 23 countries). Figure 2 visualizes this association as an added-variable plot, where the slope of the fitted line equals the estimated coefficient.

This relationship is stable across specifications. It is significant in every model that includes country fixed effects – country fixed effects only ($\beta = 0.743$), two-way fixed effects ($\beta = 0.748$), and country-specific trends ($\beta = 0.743$), all $p < 0.05$ – and washes out only in pooled OLS and year-fixed-effects-only models that ignore cross-country heterogeneity. In particular, the fiscal estimate survives the restrictive two-way specification, reported in full in Table 2, column 2, so it does not depend on how common time shocks are treated. Crucially, and in contrast to the informal-economy estimate discussed next, the corporate-tax effect does not depend on the pandemic period: it remains significant when 2020–2021 are excluded ($\beta = 0.947$, $p = 0.004$) and is in fact strongest in the pre-2020 subsample ($\beta = 1.293$, $p < 0.001$). The fiscal channel is therefore a structural, period-independent fea-

Table 2. Fixed-effects estimates under the trend and two-way specifications: the Online Service Index, corporate tax revenue, and the informal economy

Variable	Corporate tax revenue		Informal economy	
	(1) FE + trend	(2) Two-way FE	(3) FE + trend	(4) Two-way FE
Online Service Index	0.890***	0.748**	−3.622**	0.094
	(0.282)	(0.355)	(1.514)	(2.095)
Linear time trend	−0.029	–	−0.260***	–
	(0.031)		(0.086)	
Control of corruption	−0.942***	−1.017***	−0.484	−0.018
	(0.331)	(0.313)	(1.416)	(1.156)
Log GDP per capita	1.873***	2.105***	4.035***	−0.595
	(0.268)	(0.540)	(1.092)	(1.763)
Inflation (asinh)	−0.036	−0.070**	0.296**	−0.220
	(0.028)	(0.030)	(0.123)	(0.173)
Trade (% GDP)	0.002	0.003	0.032**	−0.022
	(0.003)	(0.004)	(0.014)	(0.019)
Internet users (%)	−0.006	−0.004	0.032	−0.010
	(0.008)	(0.008)	(0.024)	(0.026)
Urban population (%)	−0.011	−0.019	0.185	0.128
	(0.045)	(0.047)	(0.285)	(0.250)
Observations	327	327	365	365
Countries	23	23	25	25
R^2	0.756	0.806	0.956	0.974
R^2 (within)	0.294	–	0.096	–

Note: Columns 1 and 3: country fixed effects with a common linear time trend. Columns 2 and 4: country and year (two-way) fixed effects; the linear trend is absorbed by the year effects, and within R2 is reported for the trend specifications. Cluster-robust standard errors (by country) in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Dependent variables: corporate tax revenue (% of GDP) in columns 1-2; informal economy (% of GDP, Asllani et al., 2026) in columns 3-4.

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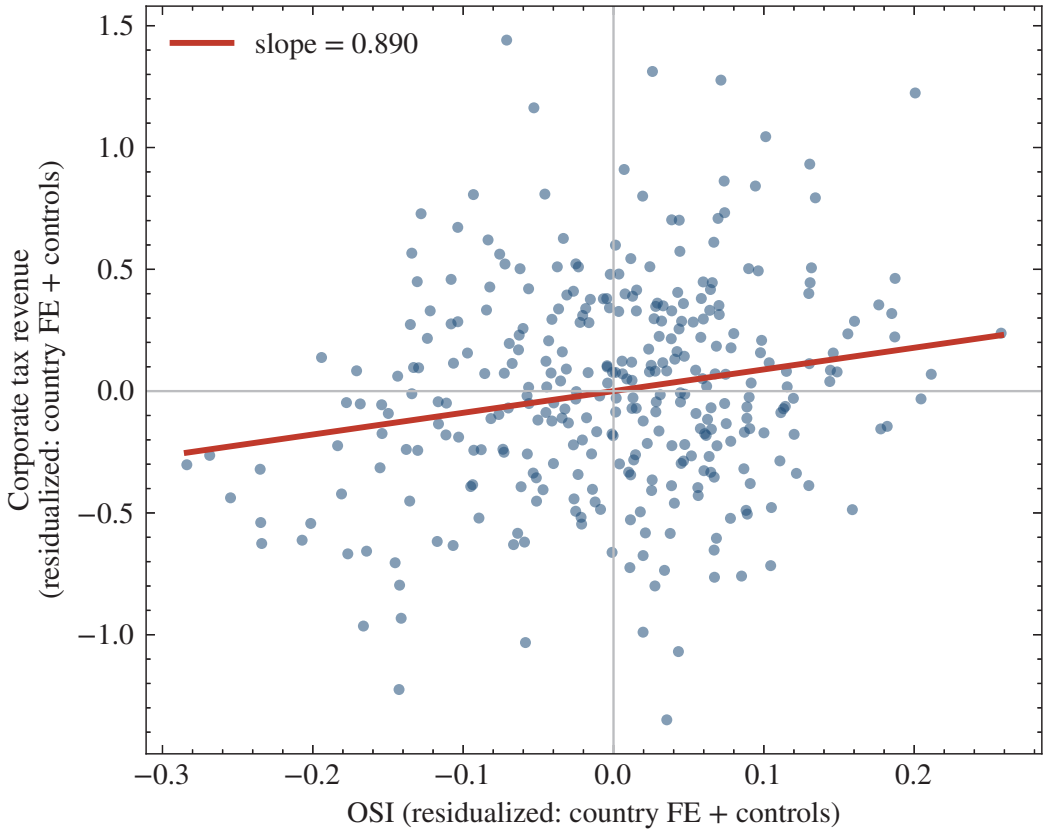

Note: Residuals of corporate tax revenue against residuals of the Online Service Index, each after partialling out country fixed effects and the full set of controls. The fitted slope (0.890) equals the OSI coefficient in the primary specification (Table 2, column 1).

Figure 2. The Online Service Index and corporate tax revenue: added-variable plot

ture of the data. Kazakhstan contributes only the final years to this estimate, because comparable corporate-tax data are available there from 2019 onward following a change in revenue accounting; Ukraine and Armenia contribute the full window.

3.3. Digital-government maturity and the informal economy

Table 2, columns 3 and 4, report the relationship between the OSI and the informal economy under the two specifications. The two-way model – the anchor of interpretation for this outcome – returns a null (β = 0.09, SE = 2.09, p = 0.96). Under the trend specification, the coefficient is negative and significant (β = –3.622, SE = 1.514, p = 0.025; 95% CI [–6.746, –0.498]): full digitalization is associated with a reduction of 3.62 percentage points in the informal economy – roughly 13.6% of the 26.6% mean – and a one-standard-deviation increase in the OSI with a reduction of 0.72 percentage points. The within-country explanatory power of the trend specification is modest (R^2 within = 0.096; N = 365; 25 countries).

This estimate is considerably less robust than the fiscal one, and its sensitivity is reported transparently in Table 3. Across fixed-effects structures it is significant under country fixed effects (β = –4.92, p = 0.003) and under the primary specification (β = –3.62, p = 0.025) but collapses to zero under two-way fixed effects (β = +0.09, p = 0.96; Table 2, column 4), indicating that common year shocks absorb much of the identifying variation. Alternative MIMIC scalings of the dependent variable share the negative sign but differ in significance: the effect strengthens under the DGE and Elgin scalings (β = –4.61 and –4.47, both p ≤ 0.001) and weakens under the Medina–Schneider scaling (β = –1.25, p = 0.15).

Most importantly, the informal-economy effect is concentrated in the pandemic period. Excluding 2020–2021 reduces the coefficient and removes

its significance (β = –1.54, p = 0.118), and in the pre-2020 sub-sample the estimate changes sign and is null (β = +0.59, p = 0.475). As the trajectories of the focal countries show, the 2020 contraction and 2021 rebound in the MIMIC series account for much of the within-country variation that identifies the effect. Figure 3 contrasts the period robustness of the two outcomes: the corporate-tax coefficient remains bounded away from zero across all windows, whereas the informal-economy coefficient loses significance and reverses sign once the pandemic years are removed. Taken together, the informal-economy estimate is fragile along three dimensions: it does not survive two-way fixed effects; it loses significance under the Medina-Schneider scaling and the QoG series, while retaining it under the DGE and Elgin scalings; and it disappears – and reverses sign – once the pandemic years are removed. Its fragility does not, however, extend to the temporal construction of the OSI: the association persists – indeed strengthens – on the actual survey waves, under linear interpolation, and with lagged values (see Sensitivity analyses, Table 5). We therefore do not read the evidence as showing that digitalization reduces the informal economy across transition economies in general. The defensible statement is narrower: within countries, higher online service provision is associated with lower estimated informality only in the pandemic window of 2020–2022. Throughout, the result is treated as secondary, fragile, and potentially pandemic-specific – not as evidence of a general structural relationship between digital-government maturity and informality.

A split by income group is consistent with this reading: the coefficient is negative in both groups – larger and marginally significant among non-high-income economies (β = –4.29, p = 0.065), which include Ukraine, Armenia, and Kazakhstan, and smaller and not significant among high-income economies (β = –2.11, p = 0.128) – so the negative sign is not confined to the group most affected by the pandemic adjustment, even if neither subgroup estimate reaches conventional significance.

Table 3. Robustness of the informal-economy estimate

Specification	N	β (OSI)	p-value
Alternative fixed-effects structures			
Pooled OLS	365	–3.601	0.656
Country fixed effects	365	–4.917***	0.003
Year fixed effects	365	–4.656	0.685
Two-way fixed effects	365	0.094	0.964
Country FE + linear trend (primary)	365	–3.622**	0.025
Country FE + country-specific trends	365	–4.917***	0.003
Alternative dependent variable (MIMIC scaling)			
Asllani C.1 (primary)	365	–3.622**	0.025
DGE scaling (C.2)	323	–4.605***	0.001
Elgin scaling (C.3)	323	–4.468***	0.001
Medina–Schneider (C.4)	308	–1.254	0.153
QoG MIMIC	282	–0.151	0.794
Alternative digital-administration proxy			
Online Service Index (primary)	365	–3.622**	0.025
E-Participation Index	365	–3.856***	0.002
E-Government Development Index	365	–4.116	0.291
Period sub-samples			
Full sample (2008–2022)	365	–3.622**	0.025
Excluding 2020–2021	317	–1.538	0.118
Pre-2020 (2008–2019)	294	0.587	0.475
Income groups (full sample)			
High-income economies	135	–2.106	0.128
Non-high-income economies	230	–4.292*	0.065

Note: Each row reports the OSI coefficient from a separate estimation; cluster-robust standard errors (by country). *** p < 0.01, ** p < 0.05, * p < 0.10. Unless stated otherwise, the dependent variable is the Asllani et al. (2026) C.1 measure, and the specification is country FE + linear trend.

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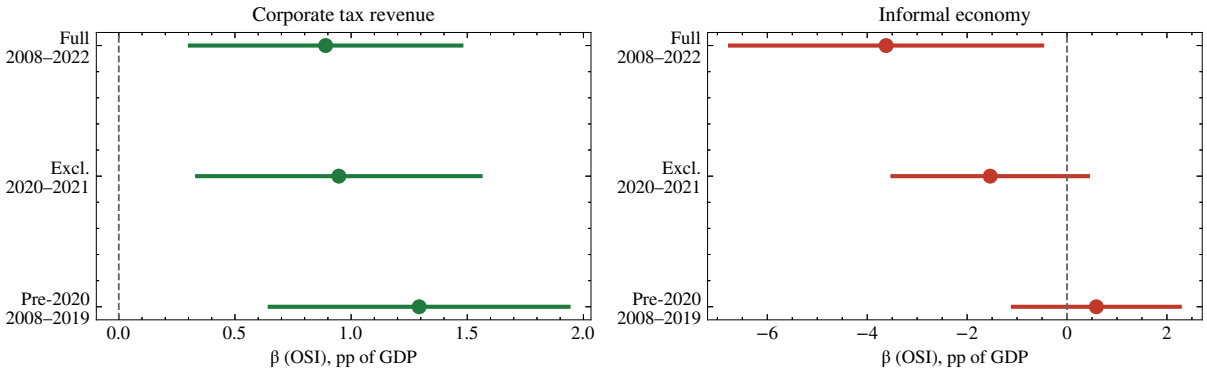


Note: Point estimates with 95% confidence intervals (cluster-robust by country) from the primary specification, estimated on the full sample, excluding 2020–2021, and on the pre-2020 sub-sample. Left: corporate tax revenue. Right: informal economy. The dashed line marks zero.

Figure 3. Robustness of the OSI coefficient by period

3.4. Exploratory mediation analysis: parallel channels

A natural hypothesis is that digital tax administration reduces the informal economy by improving tax compliance, with corporate tax revenue as the transmitting channel. Because the total OSI–informality association is itself unstable across specifications and concentrated in the pandemic years (Table 3), the decomposition below is exploratory and descriptive (see Data and Methodology): it asks whether the conventional compliance channel finds support within the primary specification. It does not.

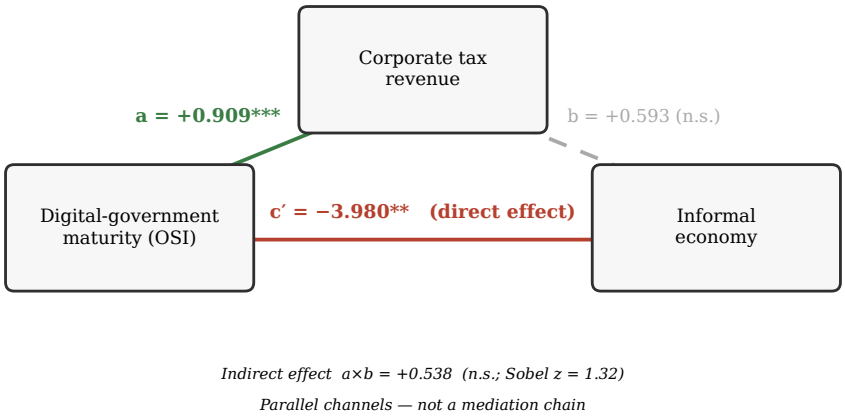
Table 4 decomposes the total effect. The a-path (OSI to corporate tax revenue) is positive and significant (a = 0.909, p = 0.004), but the b-path (corporate tax revenue to the informal economy, conditional on the OSI) is insignificant and of the opposite sign to the mediation hypothesis (b = 0.593, p = 0.160). The indirect effect is therefore small and insignificant (a × b = 0.538; Sobel z = 1.32, p = 0.186; proportion mediated ≈ 15.6%), whereas the direct effect remains large and significant ($c' = -3.980$, p = 0.044) and close to the total effect (c = –3.442, p = 0.049).

The evidence thus points to two parallel and independent channels rather than a mediation chain (Figure 4): the OSI is associated with higher corporate tax revenue and, separately, is associated with a smaller informal economy in the pandemic-era data, but the former does not transmit the latter. Given the instability of the total effect, we attach no structural interpretation to this decomposition; the conclusion retained from it is negative and conservative – there is no evidence that the fiscal gains of digitalization transmit into lower informality – and it holds a fortiori if the total association is weaker than the primary estimate suggests. Where digitalization is associated with lower informality – in the pandemic-era data – this is consistent with direct mechanisms – greater transactional visibility and audit trails, stronger deterrence, and lower costs of formal compliance – operating independently of realized tax collections.

Table 4. Mediation decomposition (parallel channels)

Effect	Coefficient	Std. error	p-value
a: OSI → corporate tax revenue	0.909	0.287	0.004
b: corporate tax revenue → informal economy	0.593	0.408	0.160
Total effect c: OSI → informal economy	–3.442	1.649	0.049
Direct effect c′: OSI → informal economy | tax	–3.980	1.867	0.044
Indirect effect (a × b)	0.538	0.407	0.186

Note: Decomposition based on the primary specification (country FE + linear trend), N = 326 (observations with both corporate tax revenue and the informal economy). Cluster-robust standard errors (by country). Sobel test z = 1.32 (p = 0.186); proportion mediated ≈ 15.6%.



Note: Coefficients from the primary specification. The a-path (OSI → corporate tax revenue) is positive and significant; the b-path (corporate tax revenue → informal economy) is insignificant (dashed); the direct effect c′ remains large and significant. The small, insignificant indirect effect indicates parallel channels rather than mediation.

Figure 4. Online Service Index, corporate tax revenue, and the informal economy: parallel channels

3.5. Sensitivity analyses

The biennial OSI is forward-filled between survey waves, so Table 5 re-estimates both models under alternative temporal constructions of the index: the actual survey waves only, linear interpolation between waves, and one- and two-year lags. The corporate-tax estimate is insensitive to this choice – it strengthens on the waves (β = 1.107) and under interpolation (β = 1.318) and holds with a one-year lag (β = 0.715, p = 0.021) – attenuating only at a two-year lag, consistent with a contemporaneous-to-short-lag association. Restricting the sample to waves halves the observations; combined with two-way fixed effects, the coefficient remains positive but loses precision (β = 0.578, p = 0.157). The informal-economy association is likewise no artifact of forward-filling – it strengthens on the waves, under interpolation, and with lags – so its fragility lies specifically in the treatment of common time shocks, the measurement source, and the pandemic window (Table 3), not in the construction of the regressor.

Coverage and inference checks target the corporate-tax model, whose estimation panel is unbalanced: Uzbekistan reports no corporate-tax data, while Kazakhstan, the Kyrgyz Republic, and Tajikistan enter with four, nine, and two years. A near-balanced subpanel excluding these three

Table 5. Sensitivity analyses: temporal construction of the OSI, corporate-tax coverage, and small-cluster inference

Specification	N	β (OSI)	p-value
Temporal construction of the OSI (dependent variable: corporate tax revenue)			
Forward-filled index (primary)	327	0.890***	0.005
Actual survey waves only	174	1.107***	0.003
Linear interpolation between waves	327	1.318***	0.002
One-year lag	306	0.715**	0.021
Two-year lag	285	0.230	0.472
Actual waves + two-way fixed effects	174	0.578	0.157
Temporal construction of the OSI (dependent variable: informal economy)			
Forward-filled index (primary)	365	−3.622**	0.025
Actual survey waves only	194	−7.350***	0.001
Linear interpolation between waves	365	−5.876***	0.002
One-year lag	341	−4.475***	0.002
Two-year lag	317	−3.299**	0.027
Actual waves + two-way fixed effects	194	−3.076	0.219

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Table 5 (cont.). Sensitivity analyses: temporal construction of the OSI, corporate-tax coverage, and small-cluster inference

Specification	N	β (OSI)	p-value
Corporate-tax coverage and small-cluster inference			
Near-balanced subpanel (≥ 14 of 15 years; excl. KAZ, KGZ, TJK)	314	0.938***	0.004
Excluding focal economies (UKR, ARM, KAZ)	293	0.920***	0.005
Leave-one-out by country (range across 25 estimates)	–	0.774…1.002	≤ 0.016
CRV3 standard errors, trend specification	327	0.890**	0.012
CRV3 standard errors, two-way specification	327	0.748	0.106
Wild cluster bootstrap, trend specification	327	0.890**	0.014
Wild cluster bootstrap, two-way specification	327	0.748*	0.088
Coverage and inference (dependent variable: informal economy)			
Excluding focal economies (UKR, ARM, KAZ)	321	−4.299***	0.008
Wild cluster bootstrap, trend specification	365	−3.622**	0.025

Note: Each row reports the OSI coefficient from a separate estimation; unless stated otherwise, the specification is country fixed effects with a common linear trend, the full control set, and CRV1 cluster-robust standard errors (by country). Survey waves are the biennial UN E-Government Survey years, 2008–2022. The leave-one-out row spans the 25 country-deletion estimates. The wild cluster bootstrap uses Rademacher weights, 9,999 replications, and the null imposed (WCR11). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

thin-coverage economies raises the coefficient to 0.938 ($p = 0.004$); excluding the focal trio leaves it at 0.920 ($p = 0.005$); and leave-one-out estimation across all 25 economies bounds it within [0.774, 1.002] with a maximum p-value of 0.016, so no single country drives the result. Conservative small-cluster inference points the same way: CRV3 jackknife standard errors and the wild cluster bootstrap (Rademacher weights, 9,999 replications, null imposed) leave the trend estimate significant ($p = 0.012$ and $p = 0.014$), while both render the two-way estimate marginal ($p = 0.106$ and $p = 0.088$), with the point estimate unchanged. The trend-specification informality association likewise survives the bootstrap ($p = 0.025$). The informality association is, if anything, stronger without the focal economies ($\beta = -4.299$, $p = 0.008$).

4. DISCUSSION

The most robust result – a positive, period-independent association between digital tax administration and corporate tax revenue – sits squarely within the literature. It echoes evidence that mobile-money adoption lifts revenue (Apeti & Edoh, 2023) and that digitalization raises revenue where state responsiveness and regulatory quality already exist (Lee, 2025), while micro-experiments supply the mechanism: e-filing expands third-party information and curbs negotiable discretion (Okunogbe & Pouliquen, 2022). Its concentration on the corporate base fits this logic: corporate income is where discretion and profit-shifting are largest. Lee's (2025) conditionality is instructive, not contradictory – in these comparatively developed administrations the complementarity is already met, explaining the effect's stability across specifications and periods.

The informal-economy association is more equivocal, and prior work explains why. It accords with evidence that digitalization suppresses the corruption and extortion sustaining informality, including structural analyses for Ukraine (Yefimenko et al., 2025b) and the bribery-reducing effect of e-filing (Okunogbe & Pouliquen, 2022). Yet digital tools can also open new shadow channels – cyber-fraud, digital laundering, illicit crypto flows – so their net effect is neither guaranteed nor uniform (Yarovenko et al., 2024). That tension matches our pandemic-bound finding: the 2020–2022 shock most plausibly acted as a catalyst, forcing informal activity into trackable digital channels (Sitnicka & Serhiienko, 2025), not a structural, always-on effect.

Finally, the rejected compliance-mediation chain – digitalization shrinking informality by first raising collection – aligns with the view that digital administration works through several independent pathways, not one sequence. Syntheses of tax capacity hold that technology at once broadens the base, lowers costs and reconfigures detection,

with no presumption that formalization precedes revenue (Okunogbe & Tourek, 2024), while optimal-administration theory treats enforcement as parallel behavioral margins rather than a series (Keen & Slemrod, 2017). Our result is thus less an anomaly than a cross-country counterpart to that micro-evidence: where digital administration is associated with formalization, the channel is visibility, while revenue is mobilized through the base, and the two need not coincide.

CONCLUSION

This study asked whether digitalizing tax administration acts as a fiscal-governance innovation in transition economies, shaping corporate tax revenue and the informal economy. Using a balanced panel of 25 transition economies over 2008–2022 (N = 375), we estimated country-fixed-effects models with the UN Online Service Index – a broad measure of the digital maturity of public administration – and tested mediation between revenue and informality.

Greater online service provision is associated with higher corporate tax revenue ($\beta = 0.890$, $p = 0.005$) – about 0.89 percentage points of GDP, roughly 41% of the 2.18% mean – stable across periods and specifications, including two-way fixed effects and alternative constructions of the index, strongest before the pandemic. The informal-economy evidence is weaker: under two-way fixed effects the coefficient is null, and the association that appears under the trend specification ($\beta = -3.622$, $p = 0.025$) is confined to the 2020–2022 window, vanishes pre-2020, is not supported by all alternative informality measures, and is largest among non-high-income economies, including Ukraine, Armenia, and Kazakhstan. Crucially, an exploratory decomposition finds the two effects parallel, not sequential – corporate tax revenue does not transmit the informality association (Sobel $z = 1.32$) – so where digitalization is associated with lower informality, this operates independently of tax collection.

Because this corporate-revenue association is reliable and pandemic-independent, governments can expect a revenue dividend from broad digital-government maturity, within which tax e-services – e-filing, e-invoicing, digital cross-checking – are typically bundled; the evidence concerns the maturity of online service provision as a whole, not the causal effect of any specific tax instrument. The gain is meaningful in low-capacity settings, accruing through the corporate base, where discretion and underreporting are greatest.

Expectations for informality should be more measured: the association appears only during the pandemic-era surge and is sensitive to specification and to how informality is measured – secondary, fragile, and potentially pandemic-specific rather than structural – so digitalization alone is unlikely to shrink informality without complementary enforcement, simplified compliance, and formalization incentives – especially in Ukraine, Armenia, and Kazakhstan, where the association is strongest yet pandemic-bound. Since revenue and formalization respond through separate channels, they are best pursued as distinct tracks; and given the fragility of model-based informality estimates, digitalization programs should be judged against administrative tax-collection data rather than informality indicators alone.

DATA AVAILABILITY

All data used in this study are publicly available. The informal-economy estimates (MIMIC method) are from Asllani et al. (2026); corporate tax revenue and the other tax aggregates are from the ICTD/UNU-WIDER Government Revenue Dataset (International Centre for Tax and Development & UNU-WIDER, 2023); the Online Service Index and the other e-government indices are from the UN E-Government Survey (United Nations, Department of Economic and Social Affairs, 2022); the GovTech Maturity Index is from the World Bank (2022); institutional quality is captured by the Worldwide Governance

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Indicators (World Bank), the Corruption Perceptions Index (Transparency International, 2023), and the V-Dem public-sector-corruption index (V-Dem Institute, 2023); and the macroeconomic controls and income classifications are from the World Bank World Development Indicators (World Bank, 2023) and the World Bank country and lending groups (World Bank, 2021).

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REFERENCES

1. Ahmed, M. A. M. (2025). The Impact of Government Expenditure Policies on the Exchange Rate. *Public Governance, Regulation and Law, 1*(1), 65-74. https://doi.org/10.61093/pgrl.1(1).65-74.2025
2. Alemu, B. A. (2025). Leveraging Knowledge Management for Sustainable Innovation: Advancing Public Health Leadership Interventions. *Health Economics and Management Review, 6*(1), 22-38. https://doi.org/10.61093/hem.2025.1-02
3. Al-Hamamy, M. A., Al-Qotaje, B. T., & Alsammak, M. (2025). How cloud knowledge management platforms enhance innovation in digital marketing strategies? *Innovative Marketing, 21*(4), 261-276. https://doi.org/10.21511/im.21(4).2025.19
4. Allingham, M. G., & Sandmo, A. (1972). Income tax evasion: a theoretical analysis. *Journal of Public Economics, 1*(3), 323-338. https://doi.org/10.1016/0047-2727(72)90010-2
5. Apeti, A. E., & Edoh, E. D. (2023). Tax revenue and mobile money in developing countries. *Journal of Development Economics, 161,* 103014. https://doi.org/10.1016/j.jdeveco.2022.103014
6. Asian Development Bank (ADB). (2022). *Launching a digital tax administration transformation*. Asian Development Bank. Retrieved from https://www.adb.org/sites/default/files/publication/792586/digital-tax-administration-transformation.pdf
7. Asllani, A., Dell'Anno, R., & Schneider, F. (2026). Global estimates of informal economies and new insights for 152 countries (1997-2022): Using an enhanced modelling approach. *Economic Analysis and Policy, 89,* 721-741. https://doi.org/10.1016/j.eap.2025.11.027
8. Bachas, P., Jensen, A., & Gadenne, L. (2024). Tax Equity in Low- and Middle-Income Countries. *Journal of Economic Perspectives, 38*(1), 55-80. https://doi.org/10.1257/jep.38.1.55
9. Beyi, W. A. (2025). Designing an effective New Public Management Framework for Rural Com-

munes: Empowerment Agencies. *Public Governance, Regulation and Law, 1*(1), 16-40. https://doi.org/10.61093/pgrl.1(1).16-40.2025

10. Bezverkhyi, K., Parasii-Verhunenko, I., Yurchenko, O., Kazak, O., Zhytar, M., & Poddubna, N. (2024). Conceptual basis of anti-corruption audit. *Financial and Credit Activity: Problems of Theory and Practice, 6*(59), 77-89. https://doi.org/10.55643/fcaptp.6.59.2024.4482

11. Bozhenko, V. V., Lyeonov, S. V., Polishchuk, E. A., Boyko, A. O., & Artyukhova, N. O. (2022). Identification of determinants of corruption in government: a marspline approach. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 6,* 176-180. https://doi.org/10.33271/nvngu/2022-6/176

12. Brockmeyer, A., Mascagni, G., Nair, V., Waseem, M., & Almunia, M. (2024). Does the Value-Added Tax Add Value? Lessons Using Administrative Data from a Diverse Set of Countries. *Journal of Economic Perspectives, 38*(1), 107-132. https://doi.org/10.1257/jep.38.1.107

13. Budhathoki, P. B., Karki, M., Lama, P. B., & Chataut, M. K. (2025). Financial Access and Its Socioeconomic Dilemmas: Assessing the Impact on Bank Performance. *SocioEconomic Challenges, 9*(1), 58-69. https://doi.org/10.61093/sec.9(1).58-69.2025

14. Burrell, D. N., Wansi, T., Morin, S. L., Rahim, E., Tessema, D. B., Alemu, B. A., Harris, N., & Conley, L. (2025). Harnessing Behavioral Economics, Green Promotions, and Financial Incentives as Catalysts for Sustainable Practices. *Green Transition and Sustainable Development, 1*(1), 1-16. https://doi.org/10.61093/gtsd.1(1).1-16.2025

15. Cohen, I. (2024). Technology and the state: Building capacity to tax via text. *Journal of Public Economics, 236,* 105154. https://doi.org/10.1016/j.jpubeco.2024.105154

16. Dillianti, R., Prabowo, H., Rahim, R. K., & Kurniawan, Y. (2024). From readiness to excellence: The role of digital enablement and innovation in life insurance performance. *Insurance Markets and Companies, 15*(2), 35-46. https://doi.org/10.21511/ins.15(2).2024.04

17. Dobrovolska, O., Günther, S., Chernetska, O., Dubrova, N., & Kachula, S. (2024). Environmentally related taxes and their influence on decarbonization of the economy. *Environmental Economics, 15*(1), 174-189. https://doi.org/10.21511/ee.15(1).2024.13

18. Erina, L., Saptawan, A., & Martina, M. (2026). Rebuilding Trust, Restoring Compliance: An Experimental Study of Tax Morale among Young Taxpayers. *Financial Markets, Institutions and Risks, 10*(1), 1-17. https://doi.org/10.61093/fmir.10(1).1-17.2026

19. Filipova, M., Djakona, A., & Haram, V. (2025). Determinants of Government Expenditures in the Baltic States. *Financial Markets, Institutions and Risks, 9*(2), 66-89. https://doi.org/10.61093/fmir.9(2).66-89.2025

20. Giedraitis, V. R., Stavytskyy, A., Kharlamova, G., Ulvidienė, E., & Jorgenson, A. (2024). Mitigating the shadow: Exploring taxes as solutions. *Journal of International Studies, 17*(2), 283-297. https://doi.org/10.14254/2071-8330.2024/17-2/15

21. Giedraitis, V., Stavytskyy, A., Ulvidienė, E., Kavaliauskaitė, B., Kharlamova, G., & Gabnytė-Baranauskė, V. (2025). Seeing the light in the shadows: The impact of the Kaitz index in explaining the shadow economy. *Problems and Perspectives in Management, 23*(3), 766-779. https://doi.org/10.21511/ppm.23(3).2025.54

22. Hernik, J., Sagan, A., Jarecki, W., & Grinberga-Zalite, G. (2025). Digital transformation in business process management: The role of employee engagement. *Human Technology, 21*(1), 203-221. https://doi.org/10.14254/1795-6889.2025.21-1.10

23. International Centre for Tax and Development & UNU-WIDER. (2023). *Government Revenue Dataset* [Data set]. UNU-WIDER. Retrieved from https://www.wider.unu.edu/project/grd-government-revenue-dataset

24. International Monetary Fund (IMF). (2021). *Five things to know about the informal economy*. IMF News. Retrieved from https://www.imf.org/en/News/Articles/2021/07/28/na-072821-five-things-to-know-about-the-informal-economy

25. Keen, M., & Slemrod, J. (2017). Optimal tax administration. *Journal of Public Economics, 152,* 133-142. https://doi.org/10.1016/j.jpubeco.2017.04.006

26. Kolupaieva, I., & Tiesheva, L. (2023). Asymmetry and convergence in the development of digital technologies in the EU countries. *Equilibrium. Quarterly Journal of Economics and Economic Policy, 18*(3), 687-716. https://doi.org/10.24136/eq.2023.022

27. Kostiushko, I., Juhászová, Z., & Dyvynska, Y. (2025). Mobile Social Smart Technologies to Optimise Customer Support Services. *Knowledge Economy and Lifelong Learning, 1*(1), 66-82. https://doi.org/10.61093/kell.1(1).66-82.2025

28. Kurmanov, N., Spankulova, L., Sabyrzhan, A., Kudebayeva, A., & Kirichok, O. (2026). Factors influencing income inequality in the regions of Kazakhstan. *Montenegrin Journal of Economics, 22*(2), 55-67. https://doi.org/10.14254/1800-5845/2026.22-2.5

29. Kusumawati, A., Suhanda, S., Darmawati, Natsir, A. I. P., & Juanda, I. S. K. (2025). Bibliometric analysis of research trends and networks in carbon tax studies: Insights into environmental and economic policy implications. *Environmental Economics, 16*(1), 43-58. https://doi.org/10.21511/ee.16(1).2025.04

30. Kuzior, A., Zakharkina, L., Kubaščikova, Z., Chentsov, V., & Lyeonov, S. (2023). Insurance market transparency research trends: Bibliometric analysis. *Insurance Markets and Companies, 14*(1), 136-152. https://doi.org/10.21511/ins.14(1).2023.12

http://dx.doi.org/10.21511/imfi.23(3).2026.30

31. Kyzenko, O., Sitnicki, M. W., Zahorodnia, K., Hrebeshkova, O., & Verba, V. (2026). Ethical Leadership and Institutional Convergence in European Management Consulting: A Cluster-Based Comparative Analysis. *Business Ethics and Leadership, 10*(1), 345-366. https://doi.org/10.61093/bel.10(1).345-366.2026

32. Lee, S. (2025). Digitalization and Domestic Revenue Mobilization: Governmental Responsiveness and Capabilities Matter. *Governance*, *38*(4), e70076. https://doi.org/10.1111/gove.70076

33. Lyeonov, S., Danileviča, A., & Horsch, A. (2025a). Renewable energy sources and the shadow economy: Social responsibility against tax evasion. *Problems and Perspectives in Management, 23*(3), 728-750. https://doi.org/10.21511/ppm.23(3).2025.52

34. Lyeonov, S., Kulawiecka, E., Krawczyk, D., & Oláh, J. (2025b). Decarbonisation and informality: Empirical evidence on the shadow economy response to climate policy mix. *Economics & Sociology, 18*(3), 274-295. https://doi.org/10.14254/2071-789X.2025/18-3/15

35. Lyeonov, S., Moroz, A., Dudziuk, I., & Chuluunbaatar, E. (2025c). Green rules & grey markets: Do environmental policies influence the informal economy? *Economics & Sociology*, *18*(1), 313-338. https://doi.org/10.14254/2071-789X.2025/18-1/17

36. Medina, L., & Schneider, F. (2018). *Shadow economies around the world: What did we learn over the last 20 years?* (IMF Working Paper No. 18/17). International Monetary Fund. https://doi.org/10.5089/9781484338636.001

37. Melnyk, L., Vasa, L., Singh, S., Kubatko, O., & Kalinichenko, L. (2025). Quasi-Viral Technologies as the Drivers of the Economy Digital Transformation Towards sustainability. *HighTech and Innovation Journal, 6*(1), 183-200. https://doi.org/10.28991/HIJ-2025-06-01-013

38. Mkrtchyan, T. M., & Petrosyan, N. (2025). Measuring fiscal structural reform intensity: The case of Armenia. *Public and Municipal Finance, 14*(3), 93-104. https://doi.org/10.21511/pmf.14(3).2025.07

39. Mkrtchyan, T. M., Vardanyan, K. J., Avagyan, G. A., Gharagyozyan, M., & Navasardyan, M. (2026). Assessment of macroeconomic vulnerability of the economy based on the example of South Caucasus countries. *Proceedings on Engineering Sciences, 8*(1), 207-216. https://doi.org/10.24874/PES08.01.022

40. Mshana, S., & Postrzednik-Lotko, K. (2026). Use of Modern Technologies for Development of Sustainable Tourism in Tanzania. *Green Transition and Sustainable Development, 2*(1), 40-64. https://doi.org/10.61093/gtsd.2(1).40-64.2026

41. Mustafa, J. A. (2024). From innovation to stability: Evaluating the ripple influence of digital payment systems and capital adequacy ratio on a bank's Z-score. *Banks and Bank Systems, 19*(3), 67-79. https://doi.org/10.21511/bbs.19(3).2024.07

42. Nafei, W. A., Ghoneim, M. A., Mujtaba, B. G., & Khanfar, N. M. (2025). Digitalization as a Socioeconomic Challenge: Assessing the Mediating Role of Digital Service Quality on Digitalization's Impact on Sustainable Competitive Advantage. *SocioEconomic Challenges, 9*(1), 1-20. https://doi.org/10.61093/sec.9(1).1-20.2025

43. Naritomi, J. (2019). Consumers as Tax Auditors. *American Economic Review*, *109*(9), 3031-3072. https://doi.org/10.1257/aer.20160658

44. Nose, M., & Mengistu, A. (2023). *Exploring the Adoption of Selected Digital Technologies in Tax Administration: A Cross-Country Perspective* (IMF Notes No. Note/2023/008). Retrieved from https://doi.org/10.5089/9798400258183.068

45. Ntuli, F., Ntshangase, B. A., & Msosa, S. K. (2026). Innovative Financial Management Reforms: A Catalyst of Good Governance in the South African Public Sector. *Financial Markets, Institutions and Risks, 9*(4), 16-29 https://doi.org/10.61093/fmir.9(4).16-29.2025

46. Oe, H., Yamaoka, Y., & Weeks, M. (2025). Public-Private Partnerships in Traditional Industries: A Comparative Governance Framework for Regional Revitalization in Japan and Central Europe. *Public Governance, Regulation and Law, 1*(1), 1-15. https://doi.org/10.61093/pgrl.1(1).1-15.2025

47. OECD. (2020). *Tax administration 3.0: The digital transformation of tax administration*. OECD Publishing. https://doi.org/10.1787/ca274cc5-en

48. OECD. (2024). *Tax administration digitalisation and digital transformation initiatives*. OECD Publishing. https://doi.org/10.1787/c076d776-en

49. Okunogbe, O., & Pouliquen, V. (2022). Technology, Taxation, and Corruption: Evidence from the Introduction of Electronic Tax Filing. *American Economic Journal: Economic Policy, 14*(1), 341-372. https://doi.org/10.1257/pol.20200123

50. Okunogbe, O., & Tourek, G. (2024). How Can Lower-Income Countries Collect More Taxes? The Role of Technology, Tax Agents, and Politics. *Journal of Economic Perspectives, 38*(1), 81-106. https://doi.org/10.1257/jep.38.1.81

51. Parasii-Verhunenko, I., Bezverkhyi, K., Hryhorevska, O., Matiukha, M., Yurchenko, O., & Hryshchenko, N. (2024). Analytical procedures in an anti-corruption audit system to ensure the economic security of the enterprise. *Financial and Credit Activity: Problems of Theory and Practice, 4*(57), 82-97. https://doi.org/10.55643/fcaptp.4.57.2024.4376

52. Saher, L., Vakulenko, I., & Oleksich, Z. (2025). What Makes Growth Inclusive? Cluster-Based Insights for EU Member States. *Business Ethics and Leadership, 9*(3), 275-289. https://doi.org/10.61093/bel.9(3).275-289.2025

53. Saienko, V., Skomorovskyi, A., Iermak, V., Sereda, O., & Bulavynets, O. (2025). The role of financial inclusion in driving economic

growth. *African Journal of Applied Research, 11*(1), 472-483. https://doi.org/10.26437/ajar.v11i1.864

54. Samusevych, Y., Rącka, I., Vasylieva, T., & Tóth, Á. (2024). Environmental tax reform efficiency: Prerequisites and consequences. *Journal of International Studies, 17*(4), 90-108. https://doi.org/10.14254/2071-8330.2024/17-4/6

55. Sarwar, S., Gowindasamy, M., Ashraf, S., & Kashif, I. (2026). Remote Work Challenges in the Knowledge Economy: The Mediating Role of Family Motivation in Well-Being and Leadership Trust Dynamics. *Knowledge Economy and Lifelong Learning, 2*(1), 34-47. https://doi.org/10.61093/kell.2(1).34-47.2026

56. Shapovalova, A., Prokopova, O., Kuzmenko, O., Saienko, V., & Lazebnyk, L. (2023). Taxation and economic growth in transition economies. *Review of Economics and Finance, 21*(1), 776-782. Retrieved from https://refpress.org/ref-vol21-a83/

57. Shubita, M. F. (2024a). Relationship between bank value, tax avoidance, and profitability. *Banks and Bank Systems, 19*(2), 161-171. https://doi.org/10.21511/bbs.19(2).2024.13

58. Shubita, M. F. (2024b). The relationship between sales growth, profitability, and tax avoidance. *Innovative Marketing, 20*(1), 113-121. https://doi.org/10.21511/im.20(1).2024.10

59. Shygun, M., Bezverkhyi, K., Pylypenko, O., Yurchenko, O., & Poddubna, N. (2023). Presenting financial information in digital formats as a base for analysis and audit of business activities of enterprises. *Financial and Credit Activity: Problems of Theory and Practice, 6*(53), 233-246. https://doi.org/10.55643/fcaptp.6.53.2023.4165

60. Siemon, D., & Wolff, A. (2024). Humanization of digital technologies. *Human Technology, 20*(2), 178-182. https://doi.org/10.14254/1795-6889.2024.20-2.0

61. Sitnicka, K., & Serhiienko, R. (2025). Business Adaptation to Extreme Conditions: Analysis of Business Shocks in the Context of the War in Ukraine. *SocioEconomic Challenges, 9*(4), 216-255. https://doi.org/10.61093/sec.9(4).216-255.2025

62. Tossekbayev, K., Dinits, R., & Rekun, Y. (2025). Digitalization in Healthcare Industry: Is There a Nexus with the Population's Life Expectancy? *Health Economics and Management Review, 6*(1), 71-94. https://doi.org/10.61093/hem.2025.1-05

63. Transparency International. (2023). *Corruption Perceptions Index* [Data set]. Transparency International. Retrieved from https://www.transparency.org/en/cpi

64. United Nations (UN). (2022). *UN E-Government Survey: Online Service Index and E-Government Development Index* [Data set]. United Nations, Department of Economic and Social Affairs. Retrieved from https://publicadministration.un.org/egovkb/

65. V-Dem Institute. (2023). *Varieties of Democracy (V-Dem) dataset* [Data set]. University of Gothenburg, V-Dem Institute. Retrieved from https://www.v-dem.net/data/the-v-dem-dataset/

66. Waliszewski, K., Cichowicz, E., Gębski, Ł., Kliber, F., Kubiczek, J., Niedziółka, P., Solarz, M., & Warchlewska, A. (2024). Digital loans and buy now pay later from LendTech versus bank loans in the era of 'black swans': Complementarity in the area of consumer financing. *Equilibrium. Quarterly Journal of Economics and Economic Policy, 19*(1), 241-278. https://doi.org/10.24136/eq.2982

67. Wieczorek, A., & Postrzednik-Lotko, K. (2025). Machine Learning Algorithms on Social Media: Privacy Risks, User Awareness and Security Implications. *Safety and Security Advances, 1*(1), 18-43. https://doi.org/10.61093/ssa.1(1).18-43.2025

68. World Bank. (2021). *The promise and limitations of technology for tax mobilization* [O. Okunogbe]. World Bank. Retrieved from https://www.worldbank.org/en/events/2021/11/16/the-promise-and-limitations-of-technology-for-tax-mobilization

69. World Bank. (2021). *World Bank country and lending groups: Income classifications* [Data set]. World Bank. Retrieved from https://datahelpdesk.worldbank.org/knowledgebase/articles/906519

70. World Bank. (2022). *GovTech Maturity Index* [Data set]. World Bank. Retrieved from https://www.worldbank.org/en/programs/govtech/gtmi

71. World Bank. (2023). *World Development Indicators* [Data set]. World Bank. Retrieved from https://databank.worldbank.org/source/world-development-indicators

72. World Bank. (2025). *Worldwide Governance Indicators* [Data set]. World Bank. https://www.worldbank.org/en/publication/worldwide-governance-indicators

73. Yarovenko, H., Vasilyeva, T., Ustinovichius, L., & Remsei, S. (2024). Illicit practices: Experience of developed countries. *Journal of International Studies, 17*(2), 146-177. https://doi.org/10.14254/2071-8330.2024/17-2/8

74. Yefimenko, A., Boronos, V., Serpeninova, Y., & Koldovskyi, A. (2025a). Innovative and Technological Determinants of Corruption Reduction: How do Knowledge and Technology Contribute to Public Integrity and Transparency? *Knowledge Economy and Lifelong Learning, 1*(1), 21-34. https://doi.org/10.61093/kell.1(1).21-34.2025

75. Yefimenko, A., Malaniuk, V., Bagirzadeh, M., Duranowski, W., Djakona, A., Celika, M., & Kalenyuk, I. (2025b). Can Digitalisation and Technological Development Reduce Corruption? Evidence from a Structural Analysis in Ukraine. *Business Ethics and Leadership, 9*(2), 266-287. https://doi.org/10.61093/bel.9(2).266-287.2025

76. Zahorodnia, K., Uhabakin, O., Titov, E., & Tverdovska, Z. (2026). Inclusive Employment as a Factor of Social Security: Enterprise Readiness to Employ Persons with Disabilities in Ülemiste City, Estonia. *Safety and Security Advances, 2*(1), 81-107. https://doi.org/10.61093/ssa.2(1).81-107.2026

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APPENDIX A. Sample composition: economies, regions, and income groups

Table A1 lists the 25 transition economies in the estimation sample, grouped into the four regions used throughout the study, together with each economy's World Bank income classification and the binary income group employed in the income-split robustness analysis (Table 3).

Table A1. Transition economies in the sample (N = 25), 2008–2022

No.	Economy	ISO3	World Bank income group (2020 classification)	Analysis group
		Baltic states (EU)		
1	Estonia	EST	High income	High
2	Latvia	LVA	High income	High
3	Lithuania	LTU	High income	High
		Central and Eastern Europe (EU)		
4	Bulgaria	BGR	Upper-middle income	Non-high
5	Croatia	HRV	High income	High
6	Czechia	CZE	High income	High
7	Hungary	HUN	High income	High
8	Poland	POL	High income	High
9	Romania	ROU	Upper-middle income	Non-high
10	Slovak Republic	SVK	High income	High
11	Slovenia	SVN	High income	High
		Western Balkans		
12	Albania	ALB	Upper-middle income	Non-high
13	Bosnia and Herzegovina	BIH	Upper-middle income	Non-high
14	Montenegro	MNE	Upper-middle income	Non-high
15	North Macedonia	MKD	Upper-middle income	Non-high
16	Serbia	SRB	Upper-middle income	Non-high
		Former Soviet Union (non-Baltic)		
17	Armenia	ARM	Upper-middle income	Non-high
18	Belarus	BLR	Upper-middle income	Non-high
19	Georgia	GEO	Upper-middle income	Non-high
20	Kazakhstan	KAZ	Upper-middle income	Non-high
21	Kyrgyz Republic	KGZ	Lower-middle income	Non-high
22	Moldova	MDA	Upper-middle income	Non-high
23	Tajikistan	TJK	Lower-middle income	Non-high
24	Ukraine	UKR	Lower-middle income	Non-high
25	Uzbekistan	UZB	Lower-middle income	Non-high

Note: Regions are the authors' grouping. The World Bank income classification is given as of 2020 (fiscal year 2021, based on 2020 gross national income per capita, Atlas method); classifications are time-varying, and Romania and Bulgaria – upper-middle income in 2020 – subsequently reached high-income status (Romania from 2021, Bulgaria from 2024). The analysis income group (High vs. Non-high) follows high-income status as of 2020 and matches the split used in Table 3 (9 high-income vs. 16 non-high-income economies). The three focal economies (Ukraine, Armenia, Kazakhstan) are examined descriptively in the Results; the selection rationale is set out in the Data and Methodology section.

APPENDIX B. Correlation matrix and the single-institutional-control design

The six institutional-quality measures – Control of Corruption, Government Effectiveness, Rule of Law, Regulatory Quality, the Corruption Perceptions Index, and the V-Dem public-sector-corruption index – are very highly intercorrelated (|r| between 0.79 and 0.97; Table B1), reflecting a single underlying governance dimension. Including more than one would induce severe multicollinearity and unstable estimates; the main specifications therefore retain a single institutional control, Control of Corruption

(WGI), and use the remaining measures only as alternatives in the robustness analysis. Among the regressors that enter the models jointly, the strongest associations are between Control of Corruption and log GDP per capita (r = 0.82) and between the Online Service Index and internet penetration (r = 0.74) – both well within the range consistent with the low variance-inflation factors reported in the Methodology.

Table B1. Pairwise correlations among model variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Informal economy	1.00													
(2) Tax revenue (total)	−0.44	1.00												
(3) Online Service Index	−0.22	0.13	1.00											
(4) Control of corruption	−0.46	0.43	0.45	1.00										
(5) Government effectiveness	−0.53	0.41	0.52	0.91	1.00									
(6) Rule of law	−0.55	0.47	0.45	0.93	0.93	1.00								
(7) Regulatory quality	−0.50	0.30	0.39	0.88	0.90	0.93	1.00							
(8) CPI (Transparency Intl.)	−0.48	0.44	0.43	0.97	0.89	0.93	0.90	1.00						
(9) Public-sector corr. (V-Dem)	0.42	−0.44	−0.36	−0.92	−0.82	−0.82	−0.79	−0.90	1.00					
(10) log GDP per capita	−0.48	0.51	0.51	0.82	0.82	0.85	0.76	0.80	−0.78	1.00				
(11) Inflation (asinh)	0.23	−0.26	−0.03	−0.31	−0.36	−0.38	−0.38	−0.34	0.26	−0.27	1.00			
(12) Trade (% of GDP)	−0.48	0.53	0.27	0.58	0.57	0.57	0.55	0.63	−0.64	0.56	−0.12	1.00		
(13) Internet users (%)	−0.33	0.34	0.74	0.61	0.66	0.61	0.55	0.60	−0.56	0.69	−0.23	0.48	1.00	
(14) Urban population (%)	−0.19	0.36	0.33	0.51	0.46	0.45	0.43	0.48	−0.56	0.62	−0.06	0.39	0.44	1.00

Note: Pearson correlations over the estimation panel of 25 transition economies, 2008–2022; only the lower triangle is shown. Variables are numbered as in the row labels; codes correspond to those defined in Table 1 and Appendix C.

APPENDIX C. Panel balance and data coverage

The estimation panel is balanced – 25 economies observed over 2008–2022 (15 years), or 375 country-years. Table C1 reports raw data coverage by variable before listwise deletion; Table C2 reports the non-missing count by year for the variables with material gaps; and Table C3 reports the resulting sample sizes for the two primary specifications.

Table C1. Data coverage by variable (out of 375 country-years)

Variable	Description	N	Coverage %	Countries	Years	Full-25y
ie_main	Informal economy – MIMIC C.1 (primary DV)	374	99.7	25	2008–2022	14
ie_dge	Informal economy – DGE (robustness)	329	87.7	22	2008–2022	0
ie_m1	Informal economy – Elgin (robustness)	329	87.7	22	2008–2022	0
ie_m2	Informal economy – Medina–Schneider (rob.)	314	83.7	21	2008–2022	0
tax_corp	Corporate tax revenue	329	87.7	24	2008–2022	0
tax_total	Total tax revenue	366	97.6	25	2008–2022	7
osi	Online Service Index (primary IV)	375	100.0	25	2008–2022	15
egdi	E-Government Development Index	375	100.0	25	2008–2022	15
epi	E-Participation Index	375	100.0	25	2008–2022	15
corr_wgi	Control of Corruption (WGI)	375	100.0	25	2008–2022	15
log_gdp_pc	Log GDP per capita	375	100.0	25	2008–2022	15
asinh_inflation	Inflation (asinh)	366	97.6	25	2008–2022	6
trade_gdp	Trade (% of GDP)	375	100.0	25	2008–2022	15
internet	Internet users (%)	373	99.5	25	2008–2022	13
urban	Urban population (%)	375	100.0	25	2008–2022	15
cpi	Corruption Perceptions Index (TI)	275	73.3	25	2012–2022	11

Note: Coverage is the share of the 375 country-years with non-missing values. "Countries" is the number of economies with at least one observation; "Full-25y" is the number of years in which all 25 economies are observed. The digital-administration proxies (OSI, EGDI, EPI) reach full coverage after forward-filling the biennial UN E-Government Survey within each economy; lagged levels enter only the supplementary specifications.

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Table C2. Non-missing observations by year (maximum 25 per cell)

Year	ie_main	tax_total	tax_corp	cpi	internet
2008	25	24	21	0	25
2009	25	24	21	0	25
2010	25	24	21	0	25
2011	25	24	21	0	25
2012	25	24	21	25	25
2013	25	23	21	25	25
2014	25	24	22	25	25
2015	25	25	22	25	25
2016	25	25	22	25	25
2017	25	25	22	25	25
2018	25	25	22	25	24
2019	25	25	23	25	24
2020	25	25	23	25	25
2021	25	25	24	25	25
2022	24	24	23	25	25

Note: The Corruption Perceptions Index is comparable only from 2012 onward; Ukraine 2022 is the single missing informal-economy observation, owing to the war-related data gap in Asllani et al. (2026).

Corporate tax revenue is the least complete variable entering the models (329 of 375 country-years; 87.7%). Uzbekistan reports no corporate-tax data, and coverage is sparse for Tajikistan (two years), Kazakhstan (four) and the Kyrgyz Republic (nine), reflecting later or revised corporate-tax reporting. After listwise deletion and the removal of singleton fixed effects, the corporate-tax model covers 23 economies and 327 country-years, whereas the informal-economy model – which does not use corporate tax – retains 25 economies and 365 country-years (Table C3). These figures match the samples reported in Table 2.

Table C3. Listwise sample sizes for the primary specifications

Estimation sample	Country-years	Countries	Dropped
Corporate tax model (DV: corporate tax revenue)	327	23	48
Informal economy model (DV: informal economy)	365	25	10

Note: Both specifications use country fixed effects, a common linear time trend, and the full control set; standard errors are clustered by economy. "Dropped" is the number of country-years removed from the balanced panel of 375 through listwise deletion and singleton removal.