

“Models of digital government, rule of law, and financial innovation: Comparative evidence across developed, developing, and transition economies, with focal cases of Ukraine, the United States, and Brazil”

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MODELS OF DIGITAL GOVERNMENT, RULE OF LAW, AND FINANCIAL INNOVATION: COMPARATIVE EVIDENCE ACROSS DEVELOPED, DEVELOPING, AND TRANSITION ECONOMIES, WITH FOCAL CASES OF UKRAINE, THE UNITED STATES, AND BRAZIL

Abstract

Global account ownership rose from 51 to 76 percent of adults between 2011 and 2021, much of it through digital channels, yet the depth and innovativeness of national financial systems vary sharply across economies. This study quantifies how the rule of law and the model of digital government relate to two dimensions of financial-sector development, banking-sector depth and digital financial innovation, across developed, developing, and transition economies, and tests whether digital government can substitute for institutional quality. Using a panel of 183 economies over 2000–2021 (estimation window 2003–2021) and a four-wave Global Findex panel, the analysis applies two-way fixed-effects and pooled wave-fixed-effects models with country-clustered standard errors. The rule of law is positively associated with banking-sector depth, but the association is heterogeneous: it is largest and most robust in transition economies ($\beta = 22.17$, $p = 0.020$) and insignificant in developing economies. Digital government, by contrast, is not significantly related to banking-sector depth ($p = 0.322$) yet is strongly associated with digital financial innovation, where the rule of law also matters; the e-government association is strongest for digital-payment adoption ($\beta = 51.99$, $p < 0.001$). In these cross-country estimates, the rule-of-law $\times$ e-government interaction is negative and significant ($\beta = -10.69$, $p = 0.018$), and the marginal association of the rule of law declines by almost half as digital government expands, a pattern consistent with partial substitution. These findings are robust to the 2025 revision of the governance data and to extending the sample through the 2024 Findex wave.

Keywords

financial development, financial innovation, digital government, rule of law, financial inclusion, panel data

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G20, O16, O43, O33

INTRODUCTION

Financial inclusion has become a cornerstone of development policy. According to the World Bank Global Findex, account ownership among adults rose from 51 percent in 2011 to 76 percent in 2021, among the fastest expansions of financial access on record (Demirgüç-Kunt et al., 2022). Much of this progress has been digital, driven by technology-enabled accounts and a pandemic-era surge in digital payments. Yet around 1.4 billion adults remain unbanked, concentrated among women, the poor, and rural populations in developing econo-

mies, and the depth of national financial systems still varies enormously. Why expanded access translates into deeper and more innovative financial systems in some economies but not in others is therefore a question of direct policy relevance.

Two forces are widely believed to shape this outcome, yet they are usually studied in isolation. The first is institutional quality, above all the rule of law: enforceable contracts and secure property rights underpin credit and investment. The second is the digital transformation of the state itself. The global average E-Government Development Index rose from 0.61 in 2022 to 0.64 in 2024, and the share of the population lagging in digital government fell from 45.0 to 22.4 percent, as identity, payments, and public services moved online (United Nations, 2024a). Digital government is thus increasingly viewed not as administrative convenience but as infrastructure capable of expanding financial access where banking networks are thin. How the two forces interact, however, remains poorly understood.

This gap matters because the policy implications differ sharply. If the two reinforce each other, economies should pursue both; if digital government substitutes for weak legal institutions, digital public infrastructure offers institutionally constrained economies a faster route to financial inclusion. Existing evidence rarely examines the two jointly, seldom separates traditional banking depth from digital financial innovation, and rarely asks whether the answer varies across developed, developing, and transition economies. The empirical answer is sought in two global panels read against three focal economies, the United States, Brazil, and Ukraine, selected *ex ante* as theoretically contrasting cases, one from each WESP group, on criteria formalized in Section 2.1; Ukraine is the motivating case of the wider research project. The study provides a group-comparative estimation of both levers within a single design, together with an explicit account of where their associations diverge.

1. LITERATURE REVIEW

The proposition that legal and institutional quality underpins financial-sector development is among the most durable in finance. Early cross-country evidence established that credit-market depth and capital accumulation depend on legal protection of investors and creditors and on enforcement quality (La Porta et al., 1998; King & Levine, 1993). More recent identification strategies exploiting exogenous shifts in legal jurisdiction confirm the causal direction, with financial development advancing where protective legal traditions reach further (Levine et al., 2023). The same institutional dependence extends to the credibility of corporate information: where disclosure regimes institutionalize integrated reporting, as in South Africa, its quality becomes measurable and forecastable at the firm level (Bondar et al., 2024). In this literature, the rule of law functions as a foundational public-governance good rather than a peripheral control, anchoring market confidence and the integrity of financial intermediation (Crowley & Mujtaba, 2026); the effectiveness and quality of governance institutions likewise shape development outcomes (Masyk et al., 2023). Its erosion is equally consequential, as declining accountability and rent-

seeking co-evolve within a single political equilibrium, so that institutional decay precedes and enables corruption rather than accompanying it (Ugulava, 2026). In European banking systems, modest declines in public trust have been shown to trigger rapid, non-linear destabilization, deposit flight, and rising non-performing loans (Lyeonov et al., 2024). At the firm level, corporate-governance quality and supervisory-board transparency translate directly into bank and insurer profitability and market value (Noor et al., 2024; Kuzior et al., 2023), while regulatory stringency and disclosure standards form a parallel institutional channel shaping the reporting quality on which creditor and investor confidence depends (To & Tran, 2025; Shafitranata et al., 2026). This body of work frames institutional quality as a precondition for financial depth and financial security (Klochan & Filipov, 2023), yet it largely predates the digital transformation now reshaping both government and finance.

A second strand turns to digital government as an emergent determinant of institutional and financial outcomes. A recurring finding is that e-government strengthens transparency, accountability, and administrative responsiveness, and, in evidence from

European economies, that digital maturity constrains corruption by narrowing discretionary human intervention (Yarovenko et al., 2025a; Yefimenko et al., 2025). At the organizational level, the same logic is institutionalized in dedicated anti-corruption audit frameworks (Bezverkhyi et al., 2024). The digitalization of public administration and financial-sector work processes is documented as a socio-economic force, reshaping service delivery (H. Saifi & F. Saifi, 2025; Yarovenko et al., 2025b), standardizing the digital formats, such as SAF-T and XBRL, in which financial information is produced and audited (Shygun et al., 2023), and encompassing smart-city and local digital infrastructure (Bashynska & Dyskina, 2018). Yet the evidence cautions against treating this effect as automatic. Analyses of post-crisis recovery and banking performance find digital government's influence on real outcomes mediated by institutional trust, administrative capacity, and governance quality rather than direct (Topazly et al., 2026; Nguyen, 2025). Its reach extends beyond finance into adjacent public-service domains, where the effect is similarly conditional. Digitalization improves the effectiveness of health expenditure and social outcomes only above thresholds of digital maturity (Hrytsenko et al., 2026; Tossekbayev et al., 2025), and data-governance frameworks that disregard local context and patient sovereignty can erode the trust they require (Sidii, 2025; Guseva et al., 2022). Even well-designed public financial-management reforms deliver little where institutional resistance and capacity gaps persist (Ntuli et al., 2025). The literature thus positions e-government as a powerful but institutionally contingent instrument whose transmission to financial outcomes cannot be assumed.

A third strand examines fintech and digital finance as engines of financial inclusion. Evidence converges on how mobile payments, LendTech, and buy-now-pay-later products overcome geographic and infrastructural barriers and draw excluded populations into the financial system (Del Sarto & Ozili, 2025; Demirgüç-Kunt et al., 2022). Digital finance also improves the traceability of money flows and thereby narrows the shadow economy (Bozhenko et al., 2024), and supplies counter-cyclical liquidity to firms and households during market disruptions (Sartamorn et al., 2025; Waliszewski et al., 2024). Adoption is governed by perceived usefulness, ease of use, and self-efficacy, and is reinforced where satisfaction mediates loyalty to digital channels (Hedau, 2025; Thi

Nguyen et al., 2026); parallel dynamics appear in the migration of banking onto social platforms and in the digital transformation of the finance and accounting function (Thach et al., 2025; Asare, 2025), including blockchain-based approaches to financial accounting and record-keeping (Prokopenko et al., 2024). Access is not automatic, however. In rural settings, take-up hinges on state-mandated identification and cashless reforms, and digital-inclusion gaps among vulnerable groups such as older adults persist without targeted intervention (Aladejebi et al., 2026; Ghorbanian Zolbin et al., 2025). The consequences also remain contested. Digital finance can stabilize the banking sector through client diversification even as poorly supervised mobile lending accumulates non-performing loans (Bozhenko et al., 2024), while the rapid diffusion of non-bank credit heightens the risk of household debt spirals (Waliszewski et al., 2024).

These strands intersect in the central, unresolved question of whether institutional quality and digitalization jointly shape financial outcomes as complements or as substitutes. The dominant position is complementarity, with digital government and digital finance amplifying institutional quality rather than acting as autonomous drivers, their payoff rising with governance strength. In the SADC region, the positive growth effect of digital financial inclusion is magnified where institutional quality is high, with a positive and significant interaction between the two (Meniago, 2025). The same logic recurs where digital tools require a robust institutional scaffold to curb corruption and cyber-risk, and where their developmental effect is transmitted only through mediators such as public trust and administrative capacity (Yarovenko et al., 2025a; Topazly et al., 2026). A competing view identifies substitution under specific, crisis-bound conditions. Where formal banking is constrained by regulatory frictions, non-bank LendTech and BNPL platforms assume the liquidity-provision role of impaired formal credit (Waliszewski et al., 2024) and decentralized or blockchain-based arrangements are theorized as compensating for deficient public registries and weak enforcement (Yefimenko et al., 2025; Sidii, 2025). This substitution logic has a darker variant in which digital governance under hybrid regimes displaces genuine democratic accountability rather than reinforcing it (Ugulava, 2026). Which mechanism dominates

remains empirically open and appears to depend on the institutional setting.

The joint effect is, moreover, strongly heterogeneous across levels of development. In advanced economies, institutional systems are saturated, so the marginal return to legal improvement diminishes and regulatory attention shifts toward emerging technological risks such as artificial intelligence and data privacy (Valaskova et al., 2025; Wieczorek & Postrzednik-Lotko, 2025). The very novelty of these risks, illustrated by the reframing of digital harms as safety and security threats, signals that the frontier in mature systems lies in governing digitalization rather than in deepening basic institutions (Burrell, 2026). Developing economies present a different configuration in which fintech enables institutional leapfrogging, and where GovTech-intensive middle-income countries reach banking-ecosystem digitalization on par with the wealthiest, blurring conventional income-based classifications (Abbasova et al., 2025; Del Sarto & Ozili, 2025). In these settings, the returns to institutional improvement are large and often multiplicative, yet weak legal protection can equally prevent digital and financial innovation from translating into real efficiency gains. This asymmetry between diminishing institutional returns at the frontier and amplifying returns in catching-up economies implies that neither the rule-of-law effect nor the digital-government effect on finance can be presumed uniform across country groups.

Transition economies occupy an intermediate, dynamic position, marked by simultaneous institutional convergence and turbulence. Cluster analyses of European management practices and digital transformation distinguish institutionally maturing states from those still engaged in reform-driven catch-up, with much of Eastern and Southern Europe constrained by limited innovation infrastructure (Kyzenko et al., 2026; Pakhnenko et al., 2025). Ukraine exemplifies this trajectory, sustaining accelerated digitalization of public and financial services under wartime shock even as energy-price shocks and inflationary pressure compound its macro-financial environment (Vasylieva et al., 2025), with external-trade activity adjusting under the same pressures (Malyarets et al., 2025), and as its economic security and demographic

potential are simultaneously reshaped (Tsymbal & Demediuk, 2025; Zahorodnia et al., 2026). The resilience of such economies is itself institutionally conditioned, depending on the prevailing model of capitalism and on continued investment in re-training and skills complementing digital and financial modernization (Yeremenko et al., 2025; Davlikanova, 2025); the same modernization agenda extends to behavioral and green-finance incentives (Yeremenko, 2026; Burrell et al., 2025) and to the responsible governance of technology-enabled development more broadly (Bappayo et al., 2026; Mshana & Postrzednik-Lotko, 2026). Despite this evidence, the literature remains fragmented, as studies either analyze institutions and financial depth in isolation from digitalization (La Porta et al., 1998; Levine et al., 2023) or assess digital financial services without systematically embedding the institutional context (Del Sarto & Ozili, 2025), while the few interaction-aware analyses are confined to single regions or to cross-sectional designs (Meniago, 2025; Nguyen, 2025). The present study addresses this fragmentation by reconciling the institutional and digital strands within a single panel framework, jointly modelling both dimensions of financial-sector development rather than treating banking depth and digital innovation in isolation, and by clarifying when digital government reinforces, rather than stands in for, the rule of law across structurally distinct economies.

This study aims to estimate how the rule of law and the model of digital government relate to banking-sector depth and to digital financial innovation across developed, developing, and transition economies, and to test whether digital government can substitute for institutional quality at the margin of financial inclusion.

2. METHOD

2.1. Data and sample

The empirical analysis rests on two country-level panels corresponding to the two dimensions of financial-sector development. The first panel measures the traditional depth of the banking sector at annual frequency over 2000–2021. The second panel measures digital financial innovation across the four Global Findex survey waves conducted in 2011, 2014, 2017, and 2021.

Data are drawn from established international sources. Banking-sector depth and private credit come from the World Bank Global Financial Development Database. The rule-of-law estimate comes from the Worldwide Governance Indicators. Digital government is measured by the United Nations E-Government Development Index. Financial-innovation outcomes come from the Global Findex database, and macroeconomic and structural controls from the World Development Indicators. Country groupings follow the United Nations classification in the World Economic Situation and Prospects into developed economies, economies in transition and developing economies (WESP, Statistical Annex, Tables A-C), retained here in its original terminology. WESP is used because it covers the full country universe of the study and defines a separate transition category, which is central to the design and to the focal case of Ukraine; classifications of emerging markets used by index providers cover only a subset of investable markets and contain no transition category. The classification is taken from a single recent WESP annex and held fixed over the sample period, so no economy changes group within the panel. The three categories are mutually exclusive by construction; the classification acknowledges that several transition economies have characteristics that could place them in more than one group but assigns each to a single category.

The developing group is deliberately broad, spanning low-income economies and high-income jurisdictions; Appendix A therefore reports each economy's World Bank income group alongside its WESP category, and the developing-group coefficients are interpreted as averages over this heterogeneous set (Sections 3.3 and 4).

The three focal economies are theoretically selected contrasting cases rather than a probability sample, following the diverse-case logic of Seawright and Gerring (2008): one case per WESP group, chosen *ex ante* on four observable criteria, the WGI rule-of-law estimate, the e-government index, banking-sector depth, and Findex digital-payment adoption, read at the 2021 wave (the EGDI matched to the 2020 survey, Section 2.2; bank depth from the GFDD for 2021, with 2020 the latest value reported for the United States). The

United States, with a rule-of-law estimate of 1.39, an EGDI of 0.93, bank depth of 74.2% of GDP, and digital-payment adoption of 93.0% of adults, pairs strong institutions and mature financial markets with comparatively decentralized digital provision. Brazil (−0.30; 0.77; 125.8%; 76.5%) combines intermediate institutional quality with intensive centralized digital public-financial infrastructure and high digital-payment adoption. Ukraine (−0.68; 0.71; 30.4%; 81.3%) combines an institutionally stressed environment with rapid centralized GovTech development under crisis and is also the motivating case of the wider research project; its selection is theoretical rather than data-driven. The cases interpret the panel estimates; they do not identify them.

The samples are constructed as follows. Appendix A lists the 185 WESP-classified economies that enter at least one of the two analytical samples (39 developed, 17 transition, 129 developing). The raw depth panel provides descriptive coverage of 183 economies over 2000–2021 (Table 1). After listwise deletion on the regression variables, the depth estimation sample comprises 3,047 country-year observations for 177 economies over 2003–2021, the start year reflecting the first edition of the e-government index and the end year the coverage of the Global Financial Development Database, whose most recent vintage, released in September 2022, extends through 2021. The group-specific analyses cover the 175 economies of this sample with a WESP assignment: 39 developed (715 observations), 120 developing (2,048), and 16 transition (272). Turkmenistan is the only classified transition economy absent from the depth panel, as the source database reports no banking-depth series for it; two further economies enter the pooled specifications only (12 observations; see the note to Appendix A). The innovation panel comprises 519 country-wave observations for account ownership (152 economies) and 383 for digital-payment adoption (147 economies). The 2024 wave, released in mid-2025, is not part of the main sample because the Worldwide Governance Indicators vintage used throughout the study ends in 2023; it is instead incorporated in a dedicated robustness exercise based on the 2025 WGI revision (Section 3.6, Appendix G). The partial 2022 wave is not used.

2.2. Variables and measurement

2.2.1. Dependent variables

For the depth dimension, the dependent variable is deposit money bank assets relative to GDP; private credit is used in robustness checks. For the innovation dimension, the dependent variables are account ownership and digital-payment adoption, each expressed as the share of adults aged 15 and over. Digital-payment adoption is the most direct proxy for the uptake of digital financial services and serves as the headline innovation indicator.

2.2.2. Key explanatory variables

Institutional quality is captured by the rule-of-law estimate from the Worldwide Governance Indicators, a standardized measure with an approximate mean of zero and unit standard deviation. Digital government is captured by the E-Government Development Index, a composite of online-service provision, telecommunication infrastructure, and human capital. Because the index is compiled in biennial waves, it is carried forward to annual frequency in the depth panel; in the innovation panel, each Findex wave is matched to the most recent E-Government Survey published at or before it (the 2010, 2014, 2016 and 2020 surveys), so the index is predetermined with respect to the outcome wave. Robustness to this temporal construction is examined in Section 3.6 and Appendix I. The carry-forward removes high-frequency variation from the index, so its within-country coefficients are interpreted conservatively.

2.2.3. Controls

All specifications include log GDP per capita in constant terms, inflation measured by the consumer price index and winsorized at the 1st and 99th percentiles, the share of internet users, the urban population share, log population and mobile-cellular subscriptions per 100 people.

2.2.4. Interaction

The rule-of-law and e-government variables are mean-centered before forming their interaction.

Centering limits collinearity with the interaction term and allows the constituent coefficients to be read at the sample mean of the other variable.

2.2.5. Alternative institutional indices

Three further indices from the Quality of Government database, the WJP Rule of Law Index, the V-Dem electoral-democracy index and the Freedom House rule-of-law measure, are used in robustness checks; being on different scales, only their sign and significance are compared with the baseline.

2.3. Empirical specification

For the depth panel, the baseline is a two-way fixed-effects model in which country fixed effects absorb time-invariant unobserved heterogeneity and year fixed effects absorb shocks common to all economies in a given year. A Hausman test rejects the random-effects specification in favor of fixed effects ($\chi^2(8) = 22.65$, $p = 0.004$). The baseline and the interaction model are given by equations (1) and (2):

$$Y_{it} = \alpha_i + \lambda_t + \beta RoL_{it} + \gamma EGDI_{it} + Z_{it}'\theta + \varepsilon_{it}, \quad (1)$$

$$Y_{it} = \alpha_i + \lambda_t + \beta_1 RoL_{it} + \beta_2 EGDI_{it} + \beta_3 (RoL_{it} \cdot EGDI_{it}) + Z_{it}'\theta + \varepsilon_{it}, \quad (2)$$

where i indexes economies and t indexes years; α_i and λ_t are country and year fixed effects; RoL is the rule-of-law estimate; $EGDI$ is the e-government index; Z is the row vector of controls, the prime denoting transposition, and θ the corresponding coefficient vector; and ε_{it} is the idiosyncratic error. In equation (1), β and γ are the coefficients on the rule-of-law estimate and the e-government index, respectively; in equation (2), β_1 and β_2 are their coefficients when the interaction is included, and β_3 is the coefficient on the interaction term. Standard errors are clustered by country throughout. Inflation aside, no other variable is transformed.

Heterogeneity across economy types is examined in two ways: by estimating the depth model separately within each group, and by formally interact-

ing the rule-of-law variable with economy-type indicators in the pooled two-way fixed-effects model. The robustness of the heterogeneous coefficients is assessed against 1%/99% winsorization of the dependent variable, exclusion of financial centers, and a leave-one-country-out procedure for the transition group.

For the innovation panel, the four Findex waves provide little within-country variation, so country fixed effects would absorb almost all of the identifying variation in the slowly-moving regressors. The innovation models are therefore estimated in pooled form with wave fixed effects, retaining the cross-country variation that identifies the association, with standard errors clustered by country, as in equation (3):

$$Y_{iw} = \lambda_w + \beta RoL_{iw} + \gamma EGD I_{iw} + Z_{iw}'\theta + \varepsilon_{iw}, \quad (3)$$

where w indexes Findex waves and λ_w are wave fixed effects; the remaining symbols are as defined for equations (1) and (2). In the interaction specification for the innovation panel, the marginal association of rule of law with the outcome depends on the level of digital government, obtained as the partial derivative in equation (4):

$$\frac{\partial Y_{iw}}{\partial RoL_{iw}} = \beta_1 + \beta_3 EGD I_{iw}. \quad (4)$$

This expression is evaluated at the 10th, 50th, and 90th percentiles of the e-government index to trace how the institutional effect varies with the level of digital government. All models are estimated with fixed-effects estimators and cluster-robust standard errors. Because identification in the innovation panel rests predominantly on cross-country variation, its coefficients, including the interaction term, are interpreted as conditional associations rather than causal effects.

3. RESULTS

3.1. Descriptive statistics

The analysis draws on two panels that capture two complementary dimensions of financial-sector development. The first dimension is the traditional depth of the banking sector, proxied by deposit money bank assets relative to GDP over 2000–2021. The second dimension is digital financial innovation, proxied by Findex indicators of account ownership and, most directly, the adoption of digital

Table 1. Descriptive statistics by economy type (raw depth panel, 2000–2021)

Variable	Group	Mean	SD	Min	Max	N
Financial development (bank assets/GDP, %)	Full	58.41	44.96	0.44	305.24	3785
	Developed	101.07	43.36	12.39	305.24	822
	Developing	47.76	39.29	0.44	283.91	2612
	Transition	38.58	19.76	4.41	88.64	327
Rule of law (WGI)	Full	−0.06	0.96	−2.01	2.12	3202
	Developed	1.22	0.59	−0.21	2.12	717
	Developing	−0.40	0.72	−2.01	1.62	2179
	Transition	−0.60	0.38	−1.38	0.34	288
E-Government Index (EGDI)	Full	0.48	0.22	0.00	0.98	3195
	Developed	0.75	0.11	0.47	0.98	717
	Developing	0.38	0.17	0.00	0.86	2174
	Transition	0.52	0.15	0.00	0.84	286
Log GDP per capita	Full	8.61	1.42	5.49	11.63	3260
Inflation (CPI, %)	Full	6.03	19.63	−16.86	557.20	3669
Internet users (% pop)	Full	35.27	30.46	0.00	100.00	3717
Urban population (%)	Full	56.66	23.06	8.04	100.00	3785
Mobile subscriptions (per 100)	Full	78.93	51.18	0.00	416.26	3759

Note: WGI rule of law is a standardized estimate (mean ≈ 0 , SD ≈ 1). Groups follow the UN WESP classification (Statistical Annex, Tables A–C). Descriptive statistics refer to the raw panel; the estimation sample covers 2003–2021 with 3,047 observations for 177 economies (Section 2.1). The Full row includes two economies without a WESP assignment (Appendix A, note).

payments across the survey waves of 2011, 2014, 2017 and 2021. Table 1 reports summary statistics for the depth panel, and Table 2 for the innovation panel, both disaggregated by economy type.

Across the 183 economies of the raw depth panel, banking-sector depth averages 58.4% of GDP (SD 45.0), and the rule-of-law estimate averages -0.06 (SD 0.96) on the standard WGI scale. The three economy groups differ markedly. Developed economies record the highest mean depth (101.1% of GDP) and the highest rule-of-law estimate (1.22), while transition economies record the lowest mean depth (38.6% of GDP). Notably, transition economies report a higher mean e-government index (0.52) than developing economies (0.38), despite their lower financial depth.

Table 2 summarizes the innovation panel. Account ownership averages 57.9% of adults across the four waves, and digital-payment adoption averages 54.2%. The group gradient is pronounced: devel-

oped economies are near saturation (92.2% account ownership, 89.6% digital payments), whereas developing and transition economies remain well below (44.2% and 49.4% account ownership, respectively). Within-group dispersion is largest among developing economies ($SD \approx 25$).

Figure 1 traces the two dimensions for the three focal economies. The two dimensions move differently: Ukraine's banking depth contracts after 2014, whereas its account ownership rises steadily from 41.3% (2011) to 83.6% (2021). Brazil records the highest depth of the three focal cases, and the United States exhibits near-saturated account ownership throughout.

3.2. Rule of law, digital government and banking-sector depth

Table 3 reports two-way fixed-effects estimates for the depth panel. All specifications include country and year fixed effects, with standard errors clus-

Table 2. Descriptive statistics by economy type (digital financial innovation panel, 2011–2021)

Variable	Group	Mean	SD	Min	Max	N
Account ownership (% age 15+)	Full	57.9	30.2	0.4	100.0	554
	Developed	92.2	10.2	44.6	100.0	150
	Developing	44.2	24.9	1.5	98.5	335
	Transition	49.4	23.1	0.4	89.7	63
Digital payment adoption (% age 15+)	Full	54.2	29.9	4.2	100.0	410
	Developed	89.6	11.6	43.3	100.0	114
	Developing	39.2	22.7	4.2	97.4	245
	Transition	48.0	20.6	8.7	87.5	46

Note: Findex indicators, share of adults aged 15+. Digital-payment adoption is available for three waves (2014–2021). The Full row covers the 162 economies of the innovation panel, including two without a WESP assignment (Appendix A, note).

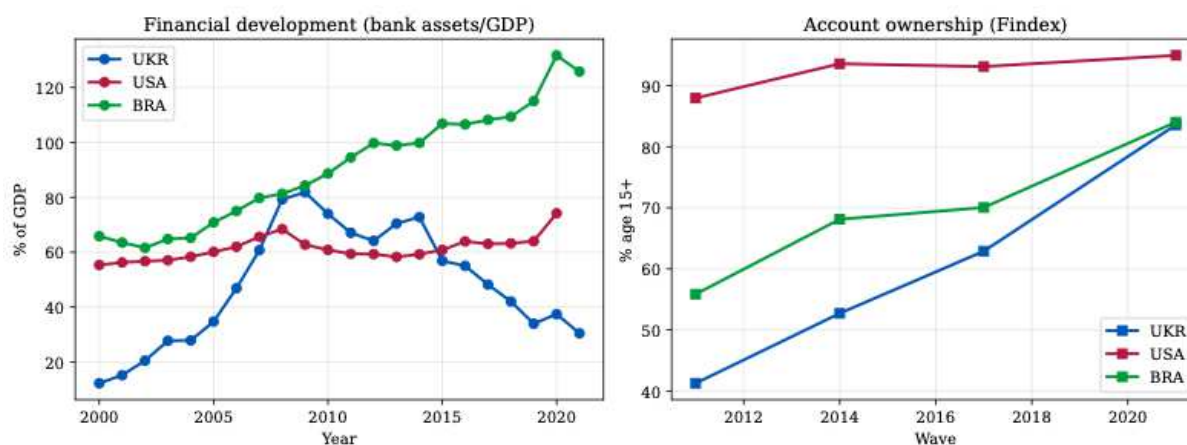


Figure 1. Focal-economy dynamics: banking-sector depth (left) and account ownership (right)

Table 3. Rule of law, digital government and banking-sector depth (Panel 1)

Variable	(1)	(2)	(3)
Rule of law	9.809*** (3.718)	9.632** (3.737)	–
E-government (EGDI)	–	8.995 (9.049)	–
Rule of law (centered)	–	–	10.040*** (3.851)
EGDI (centered)	–	–	9.141 (9.204)
Rule of law × EGDI	–	–	5.745 (8.801)
Log GDP per capita	1.069 (9.741)	1.173 (9.706)	1.511 (9.885)
Inflation (winsorized)	0.080 (0.098)	0.079 (0.096)	0.079 (0.096)
Internet users	0.297*** (0.102)	0.280*** (0.098)	0.281*** (0.098)
Urban population	0.753 (0.548)	0.756 (0.548)	0.782 (0.536)
Log population	20.858 (16.657)	21.151 (16.556)	22.088 (17.114)
Mobile subscriptions	0.110** (0.043)	0.108** (0.043)	0.110*** (0.042)
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	3,047	3,047	3,047
R ²	0.878	0.878	0.878

Note: Dependent variable – bank assets/GDP (%). Clustered (country) SE in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

tered by country. A Hausman test rejects the random-effects specification in favor of fixed effects ($\chi^2(8) = 22.65$, $p = 0.004$). Column (1) enters rule of law with controls; column (2) adds the e-government index; column (3) adds their interaction (both terms mean-centered).

Rule of law enters positively and is statistically significant across specifications ($\beta = 9.63$ to 10.04 , $p < 0.01$ in columns 1 and 3, $p < 0.05$ in column 2). The e-government index is not statistically significant, whether entered additively ($\beta = 9.00$, $p = 0.322$) or interacted. The rule-of-law $\times$ e-government interaction is not significant ($\beta = 5.75$, $p = 0.515$), so the moderation hypothesis is not supported for banking-sector depth. Among the controls, internet users and mobile subscriptions are consistently significant.

3.3. Heterogeneity of the rule-of-law effect by economy type

Table 4 re-estimates the depth specification separately for each economy group and reports the robustness of the rule-of-law coefficient to the

treatment of outliers. Three treatments of the dependent variable are shown: the original series, a 1%/99% winsorized series, and a series excluding financial centers (bank assets/GDP > 200%).

The final row reports the interaction of rule of law with a developed-economy indicator (developing as base) in the pooled two-way FE model. The transition group covers 16 of the 17 WESP transition economies; Turkmenistan is absent from the depth panel (Section 2.1). The transition coefficient is identical across columns to two decimals because neither outlier treatment affects any transition observation: the winsorization bounds are 4.1 and 187.6% of GDP, and no transition economy exceeds the 200% financial-center threshold.

The rule-of-law coefficient is largest in developed economies ($\beta = 34.17$, $p = 0.067$) and statistically significant in transition economies ($\beta = 22.17$, $p = 0.020$), but small and not significant in developing economies ($\beta = 3.30$, $p = 0.226$). The formal interaction confirms that the effect in developed economies is significantly larger than in developing economies in the baseline ($\beta = 34.92$, $p = 0.034$),

Table 4. Rule-of-law coefficient by economy type and outlier treatment

Group (N; countries)	Original	Winsorized 1/99	Excl. fin. centers
Developed (715; 39)	34.17* (18.09)	30.37*	26.81
Developing (2048; 120)	3.30 (2.71)	3.07	3.07
Transition (272; 16)	22.17** (8.55)	22.17**	22.17**
Formal test: RoL $\times$ Developed	34.92** ($p = 0.034$)	31.27** ($p = 0.038$)	27.45* ($p = 0.056$)

Note: Cell entries are the rule-of-law coefficient (clustered SE for the original series). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

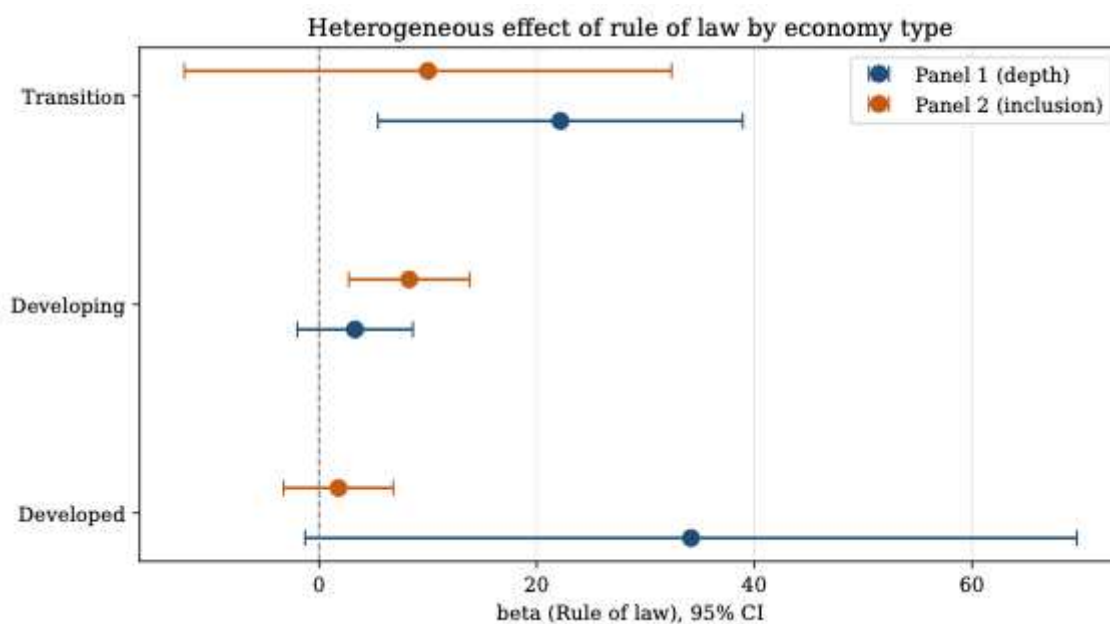


Figure 2. Heterogeneous effect of rule of law by economy type, both panels

a difference that remains at the 10% level when financial centers are excluded ($\beta = 27.45$, $p = 0.056$). The transition-economy coefficient is invariant to the outlier treatments and, in a leave-one-country-out exercise, ranges from 13.90 to 27.73 (median 22.07), so it does not depend on any single

country. Given the breadth of the WESP developing category, the developing-group coefficient is read as an average over a heterogeneous set of economies rather than as a parameter common to all of them (Section 2.1). Finer income-based splits within this category are not estimated: with two-

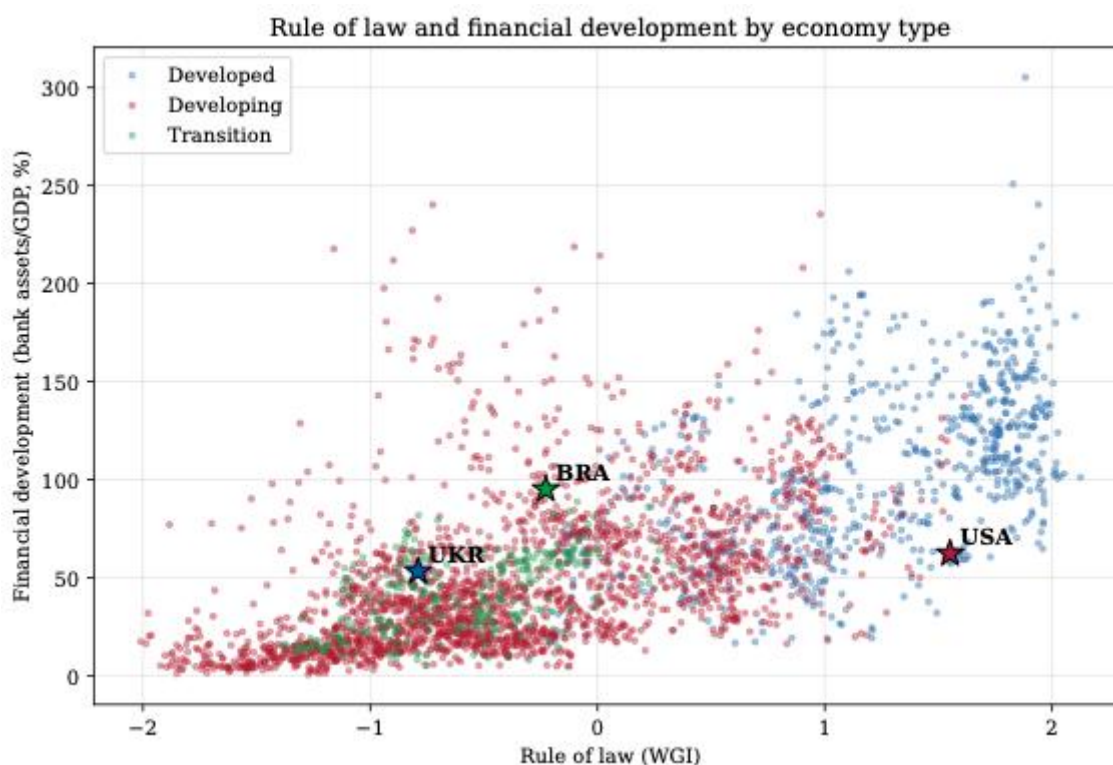


Figure 3. Rule of law and banking-sector depth by economy type, with focal economies

way fixed effects and slow-moving institutional regressors, subgroup coefficients lose precision quickly, and the transition group, at 16 economies, already marks the practical minimum. Figure 2 plots these coefficients with 95% confidence intervals; Figure 3 shows the underlying scatter with the focal economies highlighted.

3.4. Rule of law, digital government and digital financial innovation

Table 5 turns to the second, innovation dimension. The dependent variables are account ownership and, most directly, digital-payment adoption (the share of adults who made or received a digital payment). Because the Findex data comprise only four waves (three for digital-payment adoption, unavailable in 2011), the specifications are estimated in a pooled form with wave fixed effects and standard errors clustered by country; this preserves the cross-country variation that identifies the association. The estimates are therefore read as cross-country associations rather than within-country effects. Column (1) is the additive model for account ownership, column (2) adds the rule-of-law $\times$ e-government interaction, and column (3) reports the additive model for digital-payment adoption.

For digital financial innovation, both rule of law and digital government are strongly significant. In the account-ownership model, rule of law enters at $\beta = 8.81$ ($p < 0.001$) and the e-government index at $\beta = 42.17$ ($p < 0.01$). For digital-payment adoption,

the pattern is stronger, with the e-government coefficient rising to $\beta = 51.99$ ($p < 0.001$). This contrasts with the depth panel, where the e-government index was not significant.

The rule-of-law $\times$ e-government interaction is negative and significant ($\beta = -10.69$, $p = 0.018$), the opposite of complementarity. Evaluated across the observed range of the e-government index, the marginal association of rule of law with account ownership declines from 13.52 at a low level of digital government (10th percentile, EGDI = 0.24) to 10.31 at the median (EGDI = 0.54) and 7.08 at a high level (90th percentile, EGDI = 0.84). The marginal association thus weakens with digital government but remains positive across the observed range of the index. This attenuation is consistent with partial substitution between the two, although it does not by itself establish that digital government functionally replaces legal institutions; that stronger claim would require exogenous variation. Read at the focal configurations of the 2021 wave (Appendix H), the marginal association declines along the e-government gradient, from 8.5 in Ukraine (EGDI = 0.71) to 7.9 in Brazil (0.77) and 6.1 in the United States (0.93). Fitted values from the same equation understate observed account ownership by about 12 percentage points in Brazil and 26 in Ukraine, the two focal cases with intensive centralized digital government, while the unbounded linear specification overshoots for the United States; the focal cases thus illustrate, but do not identify, the interaction. In the group-specific estimates, the e-government

Table 5. Rule of law, digital government and digital financial innovation (Panel 2)

Variable	Account (1)	Account + int. (2)	Digital pay. (3)
Rule of law	8.813*** (1.823)	–	10.155*** (1.888)
E-government (EGDI)	42.171*** (14.314)	–	51.992*** (15.299)
Rule of law (centered)	–	10.294*** (1.970)	–
EGDI (centered)	–	39.085*** (13.576)	–
Rule of law $\times$ EGDI	–	–10.687** (4.448)	–
Log GDP per capita	8.651*** (2.337)	9.173*** (2.334)	6.426** (2.510)
Inflation (winsorized)	0.220 (0.187)	0.216 (0.187)	0.191 (0.195)
Internet users	0.020 (0.117)	–0.016 (0.118)	–0.051 (0.117)
Urban population	–0.182* (0.098)	–0.177* (0.099)	–0.084 (0.096)
Log population	0.157 (0.817)	0.245 (0.789)	–0.264 (0.782)
Wave FE	Yes	Yes	Yes
Observations	519	519	383
R ²	0.794	0.798	0.801

Note: Dependent variables: account ownership (col. 1–2) and digital-payment adoption (col. 3), % of adults aged 15+. Pooled with wave FE; clustered (country) SE. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

coefficient is significant in both developed ($\beta = 44.9$, $p < 0.01$) and developing economies ($\beta = 55.3$, $p < 0.05$), whereas rule of law is significant only in developing economies ($\beta = 8.3$, $p < 0.01$) and insignificant in developed economies; the transition group ($N = 59$) yields imprecise estimates for both terms.

3.5. Diagnostics

Multicollinearity is within accepted bounds: the largest variance inflation factor among the depth-panel regressors is 6.79 (e-government), followed by log GDP per capita (6.59) and internet users (5.75), all below the conventional threshold of 10 (Appendix C). The correlation matrix (Appendix B) shows that the e-government index is highly correlated with internet users (0.87) and with log GDP per capita (0.82), which is consistent with the limited independent association of the e-government index in the depth panel. Rule of law remains significant despite its correlation with log GDP per capita (0.81). A leave-one-control-out exercise confirms this reading: omitting internet users roughly doubles the e-government coefficient in the depth model (to 20.6, $p \approx 0.06$) while leaving the rule-of-law coefficient essentially unchanged, and no exclusion alters the sign or significance pattern of the main estimates (Appendix I).

3.6. Robustness

Four further checks assess the robustness of the findings; the first two concern the depth panel and are summarized in Table 6. First, replacing the dependent variable with private credit by deposit money banks (% of GDP) leaves the pattern intact: rule of law remains positive and significant ($\beta = 7.47$, $p = 0.021$), and the heterogeneity re-appears, with the largest coefficient in developed economies ($\beta = 36.57$, $p = 0.037$), a positive coefficient in transition economies ($\beta = 16.10$, $p = 0.053$), and a small, non-significant coefficient in developing economies ($\beta = 2.56$).

Second, the rule-of-law association is corroborated by alternative institutional indices. In the same two-way fixed-effects specification, the Freedom House rule-of-law measure enters positively and significantly (standardized $\beta = 5.73$, $p = 0.023$), and the V-Dem electoral-democracy index is

positive and marginally significant ($\beta = 3.21$, $p = 0.063$). The WJP Rule of Law Index is positive in a cross-country (pooled) specification, but its within-country variation over 2011–2021 is too small (within-standard-deviation ≈ 0.017) to identify a coefficient once country fixed effects are included; it is therefore not informative in this design. These checks establish robustness across the alternative indices that retain usable within-country variation in this window, Freedom House and V-Dem; they do not support the stronger claim that the choice of institutional index is inconsequential. The WJP index, with near-zero within-country variation, yields an artefactual sign reversal under fixed effects, and the BTI covers less than a third of the estimation sample with an uninformative within estimate (Appendix E); robustness is claimed across measures, not independence from measurement.

Third, the innovation-panel estimates of Table 5 are re-examined beyond the 2021 endpoint. The 2024 Global Findex wave, released in mid-2025, is added to the sample, and the rule of law is drawn from the 2025 revision of the Worldwide Governance Indicators, which extends coverage to 2024 and recalculates the historical series under a changed methodology (World Bank, 2025). Appendix G reports three variants: the four-wave baseline, the four-wave panel on the revised institutional series, which isolates the effect of the revision itself, and the full five-wave panel of 649 country-wave observations for account ownership and 473 for digital payments. Every estimate retains its sign and significance, the group pattern of Section 3.4 is preserved, and the central result sharpens: the negative rule-of-law $\times$ e-government interaction strengthens from $\beta = -10.69$ ($p = 0.018$) to $\beta = -12.70$ ($p = 0.003$), with the marginal association of the rule of law falling from 14.50 at low levels of digital government to 6.71 at high levels. The conclusions therefore depend neither on the 2021 endpoint nor on the institutional-data vintage.

Fourth, the innovation-panel interaction is not an artefact of the temporal construction of the e-government index. Re-estimating equation (4) with the index lagged by one further survey wave leaves the interaction negative and significant ($\beta = -9.22$, $p = 0.043$), and linear interpolation of the index to the Findex year yields $\beta = -8.11$ ($p = 0.065$);

Table 6. Robustness: alternative dependent variable and institutional indices (Panel 1)

Specification	Institutional coef.	EGDI coef.	N
Baseline: bank assets/GDP, WGI	9.63** (rule of law)	9.00	3,047
Alt. Y: private credit/GDP, WGI	7.47** (rule of law)	4.73	3,033
Alt. index: Freedom House (z)	5.73** (FH rule of law)	–	2,733
Alt. index: V-Dem polyarchy (z)	3.21* (V-Dem)	–	2,823
Alt. index: WJP, pooled	+ (n.s., low within var.)	–	827

Note: Two-way FE (country + year), clustered (country) SE. Institutional indices standardized where marked (z). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. WGI, WJP, Freedom House and V-Dem measure institutional quality on different scales; only sign and significance are comparable across indices.

in the depth panel, a one-year-lagged index reproduces the baseline null for e-government ($\beta = 8.93$ against 9.00). Appendix I reports the full set, together with the leave-one-control-out estimates of Section 3.5.

4. DISCUSSION

The finding that the rule of law deepens banking mainly in transition, not developing, economies sits in tension with prior work. The transition pattern fits accounts of institutional convergence, where economies closing the gap toward common standards gain large returns from each increment of legal quality (Kyzenko et al., 2026). Its developing-economy null, however, runs counter to evidence that governance independently propels financial development (Meniago, 2025) and that corporate-governance quality lifts bank performance even where legal institutions are weak (Noor et al., 2024). The divergence is one of identification: within-country estimation absorbs the slow-moving institutional differences that cross-sectional designs attribute to the rule of law, so the null reflects limited within-country variation, not irrelevance. The developing-group average also spans a deliberately broad WESP category, from low-income economies to high-income jurisdictions, and is read as a group mean rather than a parameter common to its members.

The second result, that digital government leaves banking depth unchanged while advancing digital financial innovation, clarifies a channel approached from opposite directions. It is consistent with evidence that public-sector digital maturity redirects activity toward mobile and online transactions rather than private credit (Abbasova et al., 2025), yet in partial tension with findings that

the telecommunications component of e-government raises bank profitability in ASEAN (Nguyen, 2025). The reconciliation lies in what each measure captures: e-government indices load on service delivery and connectivity, lowering the cost of digital access without expanding intermediated credit. The United States, combining deep financial markets with fragmented digital government, and Brazil, where intensive GovTech has coincided with digital-service growth rather than banking depth, both illustrate the point.

The third result, the mutual attenuation of the rule-of-law and digital-government associations with digital financial innovation, a pattern consistent with partial substitution, is the most contested. It fits the leapfrogging logic in which digitalization partially compensates for weak institutions, and crisis-period evidence that non-bank channels substitute for impaired credit where regulatory frictions bind (Waliszewski et al., 2024). It is harder to square with the complementarity thesis, in which digital tools deliver gains only atop a robust institutional scaffold (Yarovenko et al., 2025a). The two reconcile if the interaction is domain-specific: institutions and digitalization complement each other for the safe deepening of credit, but substitute for extending digital access, where a capable digital state carries inclusion forward amid institutional strain. Ukraine's wartime experience is the sharpest case, its Diia platform sustaining financial-service access as institutional capacity came under stress. This conditional reading, not a blanket verdict, is the study's central contribution. It is, moreover, an interpretive reading of cross-country associations: establishing that digital government functionally compensates for weak legal institutions would require exogenous variation beyond this panel.

CONCLUSION

This study set out to establish how the rule of law and the model of digital government relate to two dimensions of financial-sector development, banking-sector depth and digital financial innovation, across developed, developing, and transition economies.

Three findings emerge. The rule of law is associated with deeper banking systems chiefly where institutional orders are still consolidating: the association is strongest and most robust in transition economies, larger in developed than in developing economies, and absent on average within the broad developing group. Digital government shows no comparable association with banking depth, yet both factors are strongly associated with digital financial innovation, where their negative interaction implies that the marginal rule-of-law association weakens, without vanishing, as digital government expands.

Three conclusions follow. First, institutional reform is not a uniform lever for financial deepening; its payoff concentrates in converging institutional environments, so reform sequencing should differ by economy type. Second, digital government operates on the inclusion margin rather than the depth margin, and the attenuation pattern is consistent with digital public infrastructure partially substituting for weak legal institutions there; because the innovation-panel estimates are cross-country associations, this reading supports prioritization, not causal guarantees. Third, the two levers are therefore best treated as complementary tracks: digital-government investment aligned with early inclusion gains, institutional reform with the deeper financial development that digital tools alone are not associated with.

These conclusions inherit the design's limits, cross-country identification in the innovation panel, an internally heterogeneous developing group and a biennial composite e-government index; income-group disaggregation and quasi-experimental identification are natural extensions.

DATA AVAILABILITY

All data analyzed in this study derive from publicly available sources and can be obtained without restriction. Banking-sector depth and private credit are from the World Bank Global Financial Development Database (World Bank, 2022). Institutional quality is measured by the rule-of-law estimate and other governance dimensions from the Worldwide Governance Indicators (Kaufmann & Kraay, 2024), with the revised 2025 vintage used in the robustness analysis of Appendix G (World Bank, 2025). Digital government is measured by the E-Government Development Index from the United Nations E-Government Survey (United Nations, 2024a). Financial-innovation outcomes are from the Global Findex Database (Demirgüç-Kunt et al., 2022). Macroeconomic and structural controls are from the World Development Indicators (World Bank, 2023), and the economy classification follows the United Nations World Economic Situation and Prospects (United Nations, 2024b). The alternative institutional indices used in robustness checks are the World Justice Project Rule of Law Index (World Justice Project, 2024), the Varieties of Democracy indices (Coppedge et al., 2024) and the Freedom in the World measures (Freedom House, 2024), accessed through the Quality of Government database.

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APPENDIX A. Economies included in the analysis

Table A1 lists the 185 WESP-classified economies that enter at least one of the two analytical samples, the depth-panel estimation sample and/or the digital-financial-innovation panel (Section 2.1), alphabetically within each WESP group. “Group” denotes the United Nations WESP classification (Dev = developed, Tr = transition, Dvg = developing); “Income” denotes the World Bank income group.

Table A1. Economies included in the analysis

Economy	ISO3	Group	Income	Economy	ISO3	Group	Income
Australia	AUS	Dev	High	Equatorial Guinea	GNQ	Dvg	Upper-mid
Austria	AUT	Dev	High	Eswatini	SWZ	Dvg	Lower-mid
Belgium	BEL	Dev	High	Fiji	FJI	Dvg	Upper-mid
Bulgaria	BGR	Dev	High	Gabon	GAB	Dvg	Upper-mid
Canada	CAN	Dev	High	Gambia	GMB	Dvg	Low
Croatia	HRV	Dev	High	Ghana	GHA	Dvg	Lower-mid
Cyprus	CYP	Dev	High	Grenada	GRD	Dvg	Upper-mid
Czech Republic	CZE	Dev	High	Guatemala	GTM	Dvg	Upper-mid
Denmark	DNK	Dev	High	Guinea	GIN	Dvg	Lower-mid
Estonia	EST	Dev	High	Guinea-Bissau	GNB	Dvg	Low
Finland	FIN	Dev	High	Guyana	GUY	Dvg	High
France	FRA	Dev	High	Haiti	HTI	Dvg	Lower-mid
Germany	DEU	Dev	High	Honduras	HND	Dvg	Lower-mid
Greece	GRC	Dev	High	Hong Kong SAR	HKG	Dvg	High
Hungary	HUN	Dev	High	India	IND	Dvg	Lower-mid
Iceland	ISL	Dev	High	Indonesia	IDN	Dvg	Upper-mid
Ireland	IRL	Dev	High	Iran	IRN	Dvg	Upper-mid
Israel	ISR	Dev	High	Iraq	IRQ	Dvg	Upper-mid
Italy	ITA	Dev	High	Jamaica	JAM	Dvg	Upper-mid
Japan	JPN	Dev	High	Jordan	JOR	Dvg	Lower-mid
Korea, Rep.	KOR	Dev	High	Kenya	KEN	Dvg	Lower-mid
Latvia	LVA	Dev	High	Kosovo	XKX	Dvg	Upper-mid
Lithuania	LTU	Dev	High	Kuwait	KWT	Dvg	High
Luxembourg	LUX	Dev	High	Laos	LAO	Dvg	Lower-mid
Malta	MLT	Dev	High	Lebanon	LBN	Dvg	Lower-mid
Netherlands	NLD	Dev	High	Lesotho	LSO	Dvg	Lower-mid
New Zealand	NZL	Dev	High	Liberia	LBR	Dvg	Low
Norway	NOR	Dev	High	Libya	LBY	Dvg	Upper-mid
Poland	POL	Dev	High	Madagascar	MDG	Dvg	Low
Portugal	PRT	Dev	High	Malawi	MWI	Dvg	Low
Romania	ROU	Dev	High	Malaysia	MYS	Dvg	Upper-mid
Singapore	SGP	Dev	High	Maldives	MDV	Dvg	Upper-mid
Slovak Republic	SVK	Dev	High	Mali	MLI	Dvg	Low
Slovenia	SVN	Dev	High	Mauritania	MRT	Dvg	Lower-mid
Spain	ESP	Dev	High	Mauritius	MUS	Dvg	Upper-mid
Sweden	SWE	Dev	High	Mexico	MEX	Dvg	Upper-mid
Switzerland	CHE	Dev	High	Micronesia	FSM	Dvg	Lower-mid
United Kingdom	GBR	Dev	High	Mongolia	MNG	Dvg	Upper-mid
United States	USA	Dev	High	Morocco	MAR	Dvg	Lower-mid
Albania	ALB	Tr	Upper-mid	Mozambique	MOZ	Dvg	Low
Armenia	ARM	Tr	Upper-mid	Myanmar	MMR	Dvg	Lower-mid
Azerbaijan	AZE	Tr	Upper-mid	Namibia	NAM	Dvg	Lower-mid
Belarus	BLR	Tr	Upper-mid	Nepal	NPL	Dvg	Lower-mid
Bosnia and Herzegovina	BIH	Tr	Upper-mid	Nicaragua	NIC	Dvg	Lower-mid
Georgia	GEO	Tr	Upper-mid	Niger	NER	Dvg	Low
Kazakhstan	KAZ	Tr	Upper-mid	Nigeria	NGA	Dvg	Lower-mid
Kyrgyzstan	KGZ	Tr	Lower-mid	Oman	OMN	Dvg	High
Moldova	MDA	Tr	Upper-mid	Pakistan	PAK	Dvg	Lower-mid

Table A1 (cont.). Economies included in the analysis

Economy	ISO3	Group	Income	Economy	ISO3	Group	Income
Montenegro	MNE	Tr	Upper-mid	Palestine	PSE	Dvg	Lower-mid
North Macedonia	MKD	Tr	Upper-mid	Panama	PAN	Dvg	High
Russian Federation	RUS	Tr	High	Papua New Guinea	PNG	Dvg	Lower-mid
Serbia	SRB	Tr	Upper-mid	Paraguay	PRY	Dvg	Upper-mid
Tajikistan	TJK	Tr	Lower-mid	Peru	PER	Dvg	Upper-mid
Turkmenistan	TKM	Tr	Upper-mid	Philippines	PHL	Dvg	Lower-mid
Ukraine	UKR	Tr	Upper-mid	Puerto Rico	PRI	Dvg	High
Uzbekistan	UZB	Tr	Lower-mid	Qatar	QAT	Dvg	High
Afghanistan	AFG	Dvg	Low	Rwanda	RWA	Dvg	Low
Algeria	DZA	Dvg	Upper-mid	Samoa	WSM	Dvg	Upper-mid
Angola	AGO	Dvg	Lower-mid	San Marino	SMR	Dvg	High
Antigua and Barbuda	ATG	Dvg	High	Sao Tome and Principe	STP	Dvg	Lower-mid
Argentina	ARG	Dvg	Upper-mid	Saudi Arabia	SAU	Dvg	High
Bahamas	BHS	Dvg	High	Senegal	SEN	Dvg	Lower-mid
Bahrain	BHR	Dvg	High	Seychelles	SYC	Dvg	High
Bangladesh	BGD	Dvg	Lower-mid	Sierra Leone	SLE	Dvg	Low
Barbados	BRB	Dvg	High	Solomon Islands	SLB	Dvg	Lower-mid
Belize	BLZ	Dvg	Upper-mid	Somalia	SOM	Dvg	Low
Benin	BEN	Dvg	Lower-mid	South Africa	ZAF	Dvg	Upper-mid
Bhutan	BTN	Dvg	Lower-mid	South Sudan	SSD	Dvg	Low
Bolivia	BOL	Dvg	Lower-mid	Sri Lanka	LKA	Dvg	Lower-mid
Botswana	BWA	Dvg	Upper-mid	St. Kitts and Nevis	KNA	Dvg	High
Brazil	BRA	Dvg	Upper-mid	St. Lucia	LCA	Dvg	Upper-mid
Brunei	BRN	Dvg	High	St. Vincent and the Grenadines	VCT	Dvg	Upper-mid
Burkina Faso	BFA	Dvg	Low	Sudan	SDN	Dvg	Low
Burundi	BDI	Dvg	Low	Suriname	SUR	Dvg	Upper-mid
Cabo Verde	CPV	Dvg	Upper-mid	Syria	SYR	Dvg	Low
Cambodia	KHM	Dvg	Lower-mid	Taiwan	TWN	Dvg	High
Cameroon	CMR	Dvg	Lower-mid	Tanzania	TZA	Dvg	Lower-mid
Central African Republic	CAF	Dvg	Low	Thailand	THA	Dvg	Upper-mid
Chad	TCO	Dvg	Low	Timor-Leste	TLS	Dvg	Lower-mid
Chile	CHL	Dvg	High	Togo	TGO	Dvg	Low
China	CHN	Dvg	Upper-mid	Tonga	TON	Dvg	Upper-mid
Colombia	COL	Dvg	Upper-mid	Trinidad and Tobago	TTO	Dvg	High
Comoros	COM	Dvg	Lower-mid	Tunisia	TUN	Dvg	Lower-mid
Congo	COG	Dvg	Lower-mid	Turkiye	TUR	Dvg	Upper-mid
Costa Rica	CRI	Dvg	High	Uganda	UGA	Dvg	Low
Cote d'Ivoire	CIV	Dvg	Lower-mid	United Arab Emirates	ARE	Dvg	High
DR Congo	COD	Dvg	Low	Uruguay	URY	Dvg	High
Djibouti	DJI	Dvg	Lower-mid	Vanuatu	VUT	Dvg	Lower-mid
Dominica	DMA	Dvg	Upper-mid	Vietnam	VNM	Dvg	Lower-mid
Dominican Republic	DOM	Dvg	Upper-mid	Yemen	YEM	Dvg	Low
Ecuador	ECU	Dvg	Upper-mid	Zambia	ZMB	Dvg	Lower-mid
Egypt	EGY	Dvg	Lower-mid	Zimbabwe	ZWE	Dvg	Lower-mid
El Salvador	SLV	Dvg	Upper-mid				

Note: Classification follows UN WESP (Statistical Annex, Tables A–C). Income groups follow the World Bank classification. Dev = developed (n = 39), Tr = transition (n = 17), Dvg = developing (n = 129). Turkmenistan is classified as a transition economy but reports no banking-depth series in the source database; it therefore appears only in the innovation panel, and the depth analyses cover 16 transition economies. Five further economies appear in the depth data but not in this table: Aruba, Eritrea and Macao SAR enter only the descriptive coverage of Table 1, while Ethiopia and Venezuela (12 observations combined, 0.4% of the estimation sample) enter the pooled depth estimations but, carrying no WESP assignment in the classification file, are excluded from the group-specific analyses; given their weight, this cannot materially affect the group estimates.

APPENDIX B. Correlation matrix

Pairwise Pearson correlations among the regressors used in the depth panel.

Table B1. Correlation matrix

	RoL	EGDI	lnGDPpc	Infl.	Internet	Urban	lnPop	Mobile
Rule of law	1.00							
E-government (EGDI)	0.74	1.00						
Log GDP per capita	0.81	0.82	1.00					
Inflation (winsorized)	-0.36	-0.28	-0.32	1.00				
Internet users	0.68	0.87	0.79	-0.34	1.00			
Urban population	0.51	0.66	0.74	-0.18	0.64	1.00		
Log population	-0.21	0.08	-0.18	0.18	-0.08	0.07	1.00	
Mobile subscriptions	0.44	0.65	0.60	-0.28	0.74	0.51	-0.08	1.00

Note: Lower-triangular Pearson correlation coefficients. RoL = rule of law; EGDI = e-government index; lnGDPpc = log GDP per capita; lnPop = log population.

APPENDIX C. Variance inflation factors

Variance inflation factors (VIF) for the regressors of the depth-panel model. All values are below the conventional threshold of 10.

Table C1. Variance inflation factors

Variable	VIF
E-government (EGDI)	6.79
Log GDP per capita	6.59
Internet users	5.75
Rule of law	3.64
Urban population	2.60
Mobile subscriptions	2.33
Log population	1.47
Inflation (winsorized)	1.21

Note: VIF computed on the pooled cross-section of regressors. Maximum VIF = 6.79 < 10.

APPENDIX D. LEAVE-ONE-COUNTRY-OUT ROBUSTNESS (TRANSITION ECONOMIES)

Because the transition group is small (16 economies), the rule-of-law coefficient in the depth model is re-estimated 16 times, each time omitting one country. The group comprises 16 of the 17 WESP transition economies; Turkmenistan is absent from the depth panel because the source database reports no banking-depth series for it (Section 2.1). The coefficient remains positive and of similar magnitude throughout, confirming that it does not depend on any single economy.

Table D1. Leave-one-country-out robustness

Specification	β (rule of law)	p-value
Full transition sample	22.17	0.0071***
Omit Albania	22.89	0.0174**
Omit Armenia	21.25	0.0065***
Omit Azerbaijan	23.29	0.0110**
Omit Bosnia and Herzegovina	21.53	0.0154**

Table D1 (cont.). Leave-one-country-out robustness

Specification	β (rule of law)	p-value
Omit Belarus	23.11	0.0073***
Omit Georgia	19.61	0.0607*
Omit Kazakhstan	27.73	0.0008***
Omit Kyrgyzstan	22.51	0.0179**
Omit Moldova	13.90	0.0130**
Omit North Macedonia	22.77	0.0081***
Omit Montenegro	21.36	0.0137**
Omit Russian Federation	23.32	0.0042***
Omit Serbia	20.36	0.0274**
Omit Tajikistan	20.59	0.0224**
Omit Ukraine	25.53	0.0021***
Omit Uzbekistan	21.62	0.0080***

Note: Two-way FE (country + year), clustered (country) SE. Range of the coefficient across omissions: [13.90, 27.73]; median 22.07. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

APPENDIX E. Alternative measures of institutional quality (depth panel)

The rule-of-law association is re-estimated with alternative institutional indices in the same two-way fixed-effects specification. Freedom House and V-Dem confirm the positive sign. The WJP Rule of Law Index is positive in the cross-country (pooled) specification but yields an artefactual negative coefficient once country fixed effects are included, because its within-country variation is extremely small; the within- and between-country standard deviations reported below make this explicit.

Table E1. Alternative measures of institutional quality (depth panel)

Measure / specification	β	p	N
WGI rule of law – baseline (raw)	9.63**	0.010	3,047
Freedom House rule of law – two-way FE (z)	5.73**	0.023	2,733
V-Dem polyarchy – two-way FE (z)	3.21*	0.063	2,823
BTI rule of law – two-way FE (z)	1.40	0.572	968
WJP Rule of Law – two-way FE (z)	-12.98	0.002	827
WJP Rule of Law – pooled, year FE (raw)	+51.68	0.161	827

Note: Indices are on different scales; (z) denotes standardization. Only sign and significance are comparable. WJP within-country SD = 0.017 vs between-country SD = 0.138; WGI within-country SD = 0.100 vs between-country SD = 0.920. The near-zero within-group variation of WJP explains its unstable sign under country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

APPENDIX F. Heterogeneity of the rule-of-law effect: full robustness

Panel A reports the rule-of-law coefficient estimated separately within each economy group, under three treatments of the dependent variable. Panel B reports the formal interaction of rule of law with economy-type indicators (developing as the base group) in the pooled two-way fixed-effects model.

Table F1. Heterogeneity of the rule-of-law effect**Panel A.** Group-specific coefficient by outlier treatment

Group (N; countries)	Original	Winsorized 1/99	Excl. fin. centers
Developed (715; 39)	34.17*	30.37*	26.81
Developing (2048; 120)	3.30	3.07	3.07
Transition (272; 16)	22.17**	22.17**	22.17**

Table F1 (cont.). Heterogeneity of the rule-of-law effect**Panel B.** Formal interaction test (developing = base)

Interaction term	Original	Winsorized 1/99	Excl. fin. centers
Rule of law × Developed	34.92** (0.034)	31.27** (0.038)	27.45* (0.056)
Rule of law × Transition	8.08 (0.561)	8.87 (0.515)	9.05 (0.498)

Note: Two-way FE (country + year), clustered (country) SE. Panel A cells are the rule-of-law coefficient within each group. Panel B cells are the interaction coefficient with p-value in parentheses. Financial centers are economies with bank assets/GDP > 200%. * p < 0.10, ** p < 0.05, *** p < 0.01.

APPENDIX G. Robustness of the innovation panel: the 2025 WGI revision and the 2024 Findex wave

This appendix re-estimates the innovation-panel specifications of Table 5 under two updates of the underlying data. Variant A reproduces the baseline: four Findex waves (2011–2021) with the rule of law from the Worldwide Governance Indicators vintage used in the main analysis. Variant B keeps the same four waves but draws the rule of law from the 2025 WGI revision, isolating the effect of the data revision from that of the additional wave. Variant C adds the 2024 Findex wave, extending the panel to five waves (2011–2024). Across all three variants, every coefficient retains its sign and statistical significance, the group pattern reported in Section 3.4 is preserved, and the negative rule-of-law × e-government interaction – the study's central result – strengthens rather than weakens.

Table G1. Robustness of the innovation panel under the 2025 WGI revision and the 2024 Findex wave

Parameter	A: 4 waves, WGI-2024 (baseline)	B: 4 waves, WGI-2025	C: 5 waves, WGI-2025
Account (1): Rule of law	8.81*** (1.82)	8.08*** (1.80)	8.78*** (1.67)
Account (1): E-government (EGDI)	42.17*** (14.31)	42.26*** (14.41)	42.65*** (13.60)
Account (2): Rule of law (centered)	10.29*** (1.97)	9.61*** (1.95)	10.49*** (1.80)
Account (2): EGDI (centered)	39.09*** (13.58)	39.13*** (13.62)	37.72*** (12.58)
Account (2): Rule of law × EGDI	−10.69** (4.45)	−10.99** (4.40)	−12.70*** (4.25)
Digital pay. (3): Rule of law	10.15*** (1.89)	9.71*** (1.80)	11.29*** (1.91)
Digital pay. (3): E-government (EGDI)	51.99*** (15.30)	51.21*** (15.18)	51.28*** (15.33)
ME of rule of law at EGDI p10	13.52*** (2.77)	12.93*** (2.73)	14.50*** (2.61)
ME of rule of law at EGDI p90	7.08*** (1.93)	6.31*** (1.92)	6.71*** (1.78)
Observations (account / digital pay.)	519 / 383	519 / 383	649 / 473

Note: Pooled OLS with wave fixed effects; standard errors clustered by country in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01. ME denotes the marginal association of the rule of law on account ownership, evaluated at the 10th and 90th percentiles of the e-government index within each estimation sample (0.24 and 0.84 in variants A and B; 0.26 and 0.87 in variant C). The digital-payment indicator is unavailable for most high-income economies in the 2024 wave, which reduces the 2024 sample in the digital-payment specification. The 2025 WGI revision recalculates the historical series under a changed methodology, so coefficient magnitudes are indicative; sign and significance are the primary basis of comparison.

APPENDIX H. Focal cases evaluated in the innovation model

Table H1 evaluates the interaction model of equation (4) at the focal economies' 2021 configurations.

Table H1. Focal cases in the innovation model, 2021 wave

Economy	Rule of law	EGDI	Account ownership, observed (%)	Account ownership, predicted (%)	Marginal rule-of-law association
United States	1.39	0.93	95.0	107.6	6.1
Brazil	−0.30	0.77	84.0	71.9	7.9
Ukraine	−0.68	0.71	83.6	57.5	8.5

Note: Coefficients from Table 5, column (2). The marginal association equals $\beta_1 + \beta_3(\text{EGDI} - \text{sample mean})$; predicted values are in-sample fitted values of the same equation. The linear specification is unbounded, so fitted values can exceed 100. Observed ownership exceeds the fitted value by about 12 percentage points in Brazil and 26 in Ukraine; the focal cases illustrate, not identify, the interaction.

APPENDIX I. Temporal construction of the EGDI and overlapping controls

Table I1 re-estimates the interaction model (equation 4) under alternative temporal constructions of the e-government index and, for the depth panel, with a one-year-lagged index; Table I2 reports leave-one-control-out estimates for the overlapping controls of Section 3.5. Cell entries are coefficients with p-values in parentheses; standard errors are clustered by country.

Table I1. Alternative temporal constructions of the e-government index

Specification	Rule of law	E-government	Interaction	N
Innovation: baseline timing	10.29 (0.000)	39.08 (0.005)	-10.69 (0.018)	519
Innovation: EGDI lagged one survey wave	9.90 (0.000)	38.42 (0.005)	-9.22 (0.043)	519
Innovation: EGDI interpolated to wave year	9.76 (0.000)	45.91 (0.003)	-8.11 (0.065)	519
Depth: EGDI lagged one year	9.59 (0.016)	8.93 (0.325)	—	2,885

Table I2. Leave-one-control-out estimates

Specification	Rule of law	E-government	Interaction	N
Innovation: full control set	10.29 (0.000)	39.08 (0.005)	-10.69 (0.018)	519
Innovation: without internet users	10.28 (0.000)	39.17 (0.001)	-10.79 (0.010)	522
Innovation: without log GDP per capita	13.34 (0.000)	55.33 (0.000)	-8.43 (0.066)	521
Innovation: without both	13.59 (0.000)	67.60 (0.000)	-9.00 (0.032)	525
Depth: full control set	9.63 (0.010)	9.00 (0.322)	—	3,047
Depth: without internet users	9.82 (0.011)	20.59 (0.056)	—	3,047
Depth: without mobile subscriptions	9.67 (0.011)	11.43 (0.226)	—	3,047
Depth: without log GDP per capita	9.82 (0.003)	8.95 (0.322)	—	3,047

Note: Innovation rows: pooled OLS with wave fixed effects, dependent variable account ownership, rule-of-law and e-government terms mean-centered, interaction as in equation (4); the sample varies with listwise deletion of the omitted control. Depth rows: two-way fixed effects as in Table 3, column (2). Baseline timing matches each Findex wave to the most recent E-Government Survey published at or before it (Section 2.2).