“Digital governance, systemic shocks, and banking sector integrity in transition economies”

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DIGITAL GOVERNANCE, SYSTEMIC SHOCKS, AND BANKING SECTOR INTEGRITY IN TRANSITION ECONOMIES

Abstract

In transition economies, banking sector integrity is a critical prerequisite for economic resilience against exogenous shocks. This study evaluates the direct and indirect transmission channels through which public digital governance and systemic crisis shocks relate to banking stability and financial inclusion across 22 transition economies. Utilizing structural equation modeling (SEM) and path analysis based on annual panel data from 2003 to 2024 – supplemented by latent factor analysis, Dumitrescu-Hurlin causality tests, and post-estimation Wald tests – we analyze structural macro-level associations. Empirical results show that the static factor association between digital governance and banking stability is positive but marginally significant ($\beta = 4.102$, $p = 0.079$). In short-run dynamic first-difference specifications, no statistically significant immediate responsiveness is observed ($\beta = 0.027$, $p = 0.516$). Concurrently, improved banking stability significantly co-moves with financial inclusion ($\beta = 0.042$, $p = 0.008$), driven primarily by non-performing loan suppression ($\lambda = -3.684$, $p = 0.018$) and corruption control ($\lambda = 0.034$, $p = 0.006$). Systemic crisis shocks persistently depress both banking stability ($\beta = -0.130$, $p = 0.009$) and citizen financial engagement ($\beta = -0.027$, $p < 0.001$). Post-estimation Wald tests confirm cross-regional slope homogeneity ($\chi^2(1) = 0.48$, $p = 0.487$ for governance-to-stability; $\chi^2(1) = 0.03$, $p = 0.855$ for stability-to-inclusion). Contrary to conventional assumptions, public digital governance does not act as an immediate countercyclical shock absorber, highlighting the necessity of pairing digital reforms with long-term structural policies.

Keywords digital governance, banking, stability, systemic shocks, public trust, integrity, transition economies

JEL Classification G21 G32 O16 O38

INTRODUCTION

In modern financial architecture, transition economies exhibit heightened vulnerability to exogenous macroeconomic shocks, positioning banking sector integrity as a vital prerequisite for overall economic resilience (IMF, 2024b; World Bank, 2023). Systemic external crises disrupt macro-financial transmission channels, leading to elevated non-performing loans, liquidity strains, and a severe erosion of public confidence across financial markets (EBRD, 2023). Addressing these structural vulnerabilities requires robust institutional mechanisms capable of stabilizing the financial architecture during periods of intense economic uncertainty.

Digital governance reforms are increasingly implemented to optimize public administration, enhance regulatory transparency, and promote broader financial inclusion (World Bank, 2023). While digital infrastructure theoretically strengthens institutional quality, its real-time capacity to mitigate systemic shock transmission and shield banking systems during acute crises remains empirically debated (IMF, 2024b).

Understanding whether digital governance directly buffers financial institutions or indirectly reinforces systemic stability remains a central policy question for emerging market economies.

This study empirically evaluates the direct and indirect transmission channels connecting digital governance, systemic crisis shocks, banking stability, and revealed public trust across 22 transition economies over the period 2003–2024. Utilizing structural equation modeling (SEM), path analysis, and Dumitrescu–Hurlin causality tests, this paper clarifies whether digital governance functions as an immediate shock absorber during crises or operates primarily through long-term structural and institutional mediation.

1. LITERATURE REVIEW

The intersection of digital governance and financial stability is a critical domain of macroeconomic research, where public-sector technological advancement serves as a foundational pillar for institutional transparency and banking integrity. Strategic deployment of GovTech, electronic governance frameworks, and artificial intelligence (AI) enhances state apparatuses, optimizes public expenditure efficiency, and modernizes administrative delivery (Hrytsenko et al., 2026; Juhászová et al., 2026; Kafoe et al., 2026; Spivakovskyy et al., 2026). In turn, AI-driven public administration and e-government initiatives streamline regulatory oversight, improve quality of life, and catalyze long-term economic growth across integrated blocs (Ravšelj et al., 2026; Vasylieva et al., 2026; Zhidebekkyzy et al., 2026). Furthermore, state-level digital transparency stabilizes government revenue streams during severe shocks or armed conflicts, thereby strengthening overall administrative trust and mitigating structural risks within the banking sector (Lyeonov et al., 2026; Maisyarah, 2026; Masyk et al., 2023). Despite these valuable contributions, existing literature largely focuses on general macroeconomic performance or institutional efficiency, leaving the empirical transmission channels connecting digital governance, crisis shocks, banking sector stability, and revealed public trust insufficiently explored. To address this gap, our study empirically evaluates these direct and indirect structural pathways across 22 transition economies over the 2003–2024 period using structural equation modeling (SEM) and panel causality frameworks.

The rapid evolution of digital financial services and fintech ecosystems has emerged as a critical determinant of banking sector integrity, reshaping operational structures, public trust, and socio-economic equity. Global economic digitalization compels traditional banking systems to integrate advanced technologies for resilience, while strategic IT governance and financial development drive corporate modernization and facilitate targeted funding initiatives, such as green fund capitalization and infrastructure financing (Antoni et al., 2026; Bielialov et al., 2023; Pebruary et al., 2026). Simultaneously, the widespread proliferation of mobile devices and high-speed data democratizes access to mobile banking, fostering digital financial inclusion, reducing transaction frictions, and strengthening public trust within electronic payment ecosystems (Imanbayeva et al., 2026; Malaquias & Hwang, 2025). Furthermore, institutions leverage business analytics to address socio-economic challenges and promote long-term economic equity (Ruthvika & Hedau, 2025). However, existing research primarily emphasizes the broader benefits of digital inclusion and financial innovation, leaving the specific transmission mechanisms between fintech adoption, systemic risk absorption, and long-term public trust under crisis conditions insufficiently examined. To bridge this gap, our study empirically investigates these direct and indirect structural pathways across 22 transition economies over the period 2003–2024 using structural equation modeling (SEM) and panel causality frameworks.

The micro-level foundation of banking sector integrity in the digital era rests heavily on user-centric behavioral dynamics, where the transition from traditional to digital interfaces is governed by cognitive, psychological, and quality-driven factors. Initial adoption of electronic banking services depends on fundamental determinants such as perceived ease of use, usefulness, and individual technological self-efficacy (Hedau, 2025; Kadri,

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2025). As engagement deepens, long-term customer satisfaction and retention are shaped by high-quality electronic service delivery and personalized products tailored through modern digitalization technologies (Bui & Dam, 2026; Rysin et al., 2023; Thapaliya & Dongol, 2026). Furthermore, artificial intelligence (AI) accelerates this paradigm via hyper-personalization, automated feedback systems, and alignment with local cultural values (Kildei et al., 2025), ultimately generating the financial security and institutional trust required to sustain customer loyalty (Kiiko, 2026). However, existing studies concentrate heavily on individual consumer adoption and satisfaction metrics, leaving the structural connection between micro-level behavioral trust and macro-level banking sector resilience during systemic crises unexamined. To address this gap, our study empirically investigates how user-centric trust dynamics translate into macro-level banking stability across 22 transition economies over the 2003–2024 period using structural equation modeling (SEM) and panel causality frameworks.

The structural core of banking sector integrity within digital governance relies on a robust architecture of financial stability, institutional risk assessment, and regulatory surveillance. Scholars argue that financial stability in commercial banks directly depends on key regulatory indicators, while integrating advanced anti-crisis management systems and predictive modeling is crucial for absorbing external shocks (Mursalov et al., 2025; Vakhovych et al., 2023). This protection is further enhanced by innovative risk-profiling frameworks, such as Kohonen self-organizing maps to segment banks into structural-functional groups for early vulnerability detection (Zarutska & Sitnicki, 2026). However, the operational efficiency of these metrics remains vulnerable to systemic corruption, which distorts credit allocation and erodes profitability, resulting in significant performance disparities across Eastern European banking sectors (Sobol & Dopierała, 2025; Tarasenko et al., 2022). Ultimately, stabilizing micro-level banking acts as an indispensable pillar for enhancing national financial security during volatile periods of transition (Klochan & Filipov, 2023). Despite these insights, existing literature largely evaluates regulatory metrics and risk-profiling models in isolation, leaving the empirical interaction between digital governance, corruption control, and systemic stability during crises unaddressed. To fill this gap, our study empirically examines these direct and indirect transmission channels across 22 transition economies over 2003–2024 using structural equation modeling (SEM) and panel causality frameworks.

The institutional alignment of digital governance and banking sector integrity requires a rigorous framework of ethical leadership, compliance protocols, and security measures to mitigate emerging vulnerabilities. In rapidly changing environments, classical governance models face complex anomie trends in business ethics, demanding adaptive corporate structures and clear ethical-friction threshold models for AI-driven leadership to bridge technical compliance with genuine accountability (Hakobyan et al., 2025; Szeberényi, 2026). To effectively suppress financial crimes, modern digital governance must serve as an active cross-country tool against money laundering and illicit capital flight, supported by strong political will, IT integration, and high-quality financial reporting (Haliah et al., 2025; Lygina et al., 2026). However, existing research mainly examines ethical compliance and anti-fraud mechanisms from an administrative perspective, leaving the direct dynamic link between institutional ethical frameworks, digital governance, and banking stability under macroeconomic stress underexplored. To address this gap, our study empirically investigates these direct and indirect structural pathways across 22 transition economies over the period 2003–2024 using structural equation modeling (SEM) and panel causality frameworks.

The micro- and meso-economic foundations of banking sector integrity within modern digital governance frameworks are deeply rooted in internal control optimization, digital accounting, and technological adoption. Comprehensive digital transformation significantly enhances internal control systems, agency cost mitigation, and government accounting accuracy, while digital formats for financial information provide a robust foundation for modern business analysis and auditing (Al Hayek, 2026; Altawalbeh, 2026; Dao & Nguyen, 2026; Shygun et al., 2023). Complementing these digital reporting practices, conceptual frameworks for anti-corruption au-

diting act as vital institutional mechanisms to restrain financial crimes, curb systemic corruption, and bolster regulatory oversight (Bezverkhyi et al., 2024). At the operational and supply-chain levels, value-chain digital control models, supply-chain sustainability, and blockchain applications optimize capital investments, cryptographic verification, and real-sector efficiency (Goguadze, 2026; Prokopenko et al., 2024). Furthermore, integrating artificial intelligence (AI) and predictive analytics boosts employee performance, elevates financial system capabilities, and strengthens corporate reputation when paired with effective leadership and targeted digital engagement (Alsammak et al., 2026; Alzubi, 2026; Bashynska et al., 2023; Krap et al., 2024; Morshed & Khrais, 2026; Saifi & Saifi, 2025; Tran & Phan, 2026). However, existing research concentrates heavily on internal firm-level efficiency, accounting formats, and supply-chain controls, leaving the macro-level transmission channels between corporate digital controls, systemic crisis absorption, and public banking trust unexamined. To bridge this gap, our study empirically investigates these direct and indirect structural pathways across 22 transition economies over the period 2003–2024 using structural equation modeling (SEM) and panel causality frameworks.

The macroeconomic backdrop of banking sector integrity within modern digital governance frameworks is defined by a complex interplay of technological innovation, regulatory adaptations, and market resilience. Scholars argue that long-term growth in emerging economies is driven by foreign direct investment, technology transfer, and AI ecosystem development, which altogether enhance market efficiency and financial integration (Abdullayev et al., 2026; Putri et al., 2026; Tsaurai, 2026). Concurrently, cognitive and behavioral impulses shape macro-financial stability, while digital entrepreneurship, institutional freedom, and quasi-viral technologies foster industrial resilience and energy justice (Brychko et al., 2025; Melnyk et al., 2025; Sitnicki et al., 2026a; Sitnicki et al., 2026b). In times of severe geopolitical crises, maintaining economic continuity requires supporting displaced businesses and leveraging financial systems to sustain entrepreneurial ecosystems (Polishchuk et al., 2024; Prokopenko et al., 2025). However, existing research mainly examines macro-technological growth drivers and general market resilience, leaving the specific transmission mechanisms connecting macro-level digital governance, crisis shocks, and public banking trust insufficiently explored. To address this gap, our study empirically evaluates these direct and indirect structural pathways across 22 transition economies over the 2003–2024 period using structural equation modeling (SEM) and panel causality frameworks.

The aim of this research is to empirically evaluate the direct and indirect transmission channels through which digital governance and systemic crisis shocks affect banking stability and revealed public confidence across 22 transition economies.

2. METHODOLOGY

The methodological architecture of this study rests on a comparative analysis of 22 countries across Central and Eastern Europe, the Baltics, the Balkans, the Caucasus, and Central Asia (namely, Ukraine, Moldova, Belarus, Estonia, Latvia, Lithuania, Bulgaria, Romania, Poland, the Czech Republic, Slovakia, Hungary, Serbia, Croatia, Slovenia, North Macedonia, Montenegro, Bosnia and Herzegovina, Kazakhstan, Armenia, Georgia, and Albania). This representative sample is scientifically sound, as all state entities share a common legacy of transformation from planned to market economies while demonstrating highly diversified development trajectories. Encompassing full European Union members, accession candidate countries, and non-aligned states enables a comprehensive evaluation of differing regulatory models, external institutional incentives, and digital governance maturity levels in reinforcing transparency, banking stability, and anti-corruption performance.

The 2003–2024 timeframe covers a 22-year retrospective cycle tracing institutional evolution from early e-services to post-COVID digital public administration, while capturing major macroeconomic stress events-such as the 2008 Global Financial Crisis, the Eurozone debt crisis, the pandemic, and recent geopolitical shocks. Moreover, selecting 2003 as a baseline guarantees full methodological compatibility and verified World Bank data availability.

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Three composite indices were constructed using harmonized international statistics. The Digital Governance Index (DGI) aggregates the E-Participation Index, Online Service Index, and Government Effectiveness Index to measure digital maturity and public service availability (United Nations, 2024; World Bank, 2024a). The Banking Stability and Integrity Index (BSII) synthesizes core financial health indicators – Tier 1 capital ratio, Non-performing loans (NPL), and Return on Assets (ROA) – alongside Control of Corruption to capture institutional resilience and anti-corruption monitoring (International Monetary Fund, 2025; World Bank, 2024a, 2024b). The Revealed Financial Inclusion and Engagement Index (RFIEI) measures actual citizen behavioral participation, banking sector penetration, and digital payment adoption through depositors per 1,000 adults, deposit accounts per 1,000 adults, bank deposits to GDP (%), and debit cards per 1,000 adults (International Monetary Fund, 2024a; World Bank, 2024b). We operationalize this construct specifically as revealed behavioral financial inclusion and engagement rather than subjective public trust, recognizing that systemic account expansion and card usage are driven by a combination of digitalization, infrastructure expansion, regulatory mandates, and compulsory salary-payment systems.

To capture both balance-sheet resilience and administrative execution within the financial framework, the composite metrics integrate targeted institutional dimension controls without losing empirical specificity. The dependent Banking Stability and Integrity Index (BSII) combines macroprudential solvency ratios (NPL, ROA, Tier 1 capital) with Control of Corruption to reflect supervisory enforcement integrity, which conditions credit quality in transition economies. Conversely, the Digital Governance Index (DGI) pairs UN-based e-government metrics (Online Service Index and E-Participation Index) with Government Effectiveness to account for the administrative execution needed to operationalize digital infrastructure.

To prevent cross-institutional confounding between broader country-level governance indicators across constructs, both indices remain empirically anchored by their core domains: BSII is predominantly driven by bank balance-sheet solvency (primarily non-performing loan suppression, $\lambda = -3.684$), while DGI variation is governed by direct e-governance deployment metrics rather than general non-digital institutional quality.

To address missing values stemming from the two-year UN survey publication cycles for the E-Participation and Online Service indices, linear interpolation and moving averages were applied to ensure dataset continuity. Prior to econometrics, descriptive statistics were performed to evaluate sample variation and detect anomalous values. Finally, correlation matrix inspection and Variance Inflation Factor testing (mean VIF = 1.37, all individual VIFs < 2) confirmed the absence of severe multicollinearity, validating the dataset for panel regression and structural modeling.

To compute integral indicators, initial variables were first normalized using z-score scaling to ensure comparability. The primary specification formed composite indices – Digital Governance Index (DGI), Banking Stability and Integrity Index (BSII), and Revealed Financial Inclusion and Engagement Index (RFIEI) – based on simple mean values across their respective sub-indicators. This transparent approach avoids complex assumptions while providing intuitive interpretation for practical applications. For robustness, an alternative specification derived integral indices via factor analysis, using empirical weighting coefficients to capture latent variables across time.

Data stationarity was evaluated using standard panel unit root procedures, including Levin–Lin–Chu (LLC), Im-Pesaran-Shin (IPS), and Fisher-type ADF tests. Detecting unit roots dictated necessary transformations (such as first-differencing) to prevent spurious regression and guarantee valid panel inferences.

To ensure methodological clarity and eliminate ambiguity regarding model architectures, the empirical estimation is structured around two complementary specifications. The baseline specification operates on latent construct scores derived via exploratory factor analysis in levels to evaluate long-run structural linkages among digital governance (DGI), banking resilience (*BSII*), and revealed financial engagement (RFIEI), uti-

lizing Huber-White cluster-robust standard errors alongside country and year fixed effects. To evaluate immediate shock dynamics, account for time-series persistence, and address unit roots, a robustness specification transforms mean-based composite indices into first differences ($I(1)$) across multiple lag structures (L_0–L_3). Before conducting SEM path analysis, predictive directions were verified to mitigate endogeneity and reverse causality, allowing the comparative time-series framework to evaluate immediate and lagged transmission channels while confirming parameter robustness across construct methodologies.

Subgroup Specification and Cross-Group Parameter Testing: To test for regional heterogeneity across transition economies ($N \times T = 198$), the sample is grouped into: (1) Baltics & CEE ($n = 81$), (2) Balkans & Adriatic ($n = 63$), and (3) Eastern Partnership & Central Asia ($n = 54$). Following multi-group SEM with country-clustered standard errors, cross-group parameter invariance (H_0: $\beta_{GroupA} = \beta_{GroupB}$) is evaluated via post-estimation Wald tests. This provides a formal statistical baseline for slope comparison across institutional subsamples.

To capture the stress resistance of banking systems across different phases of macroeconomic instability, a country-specific crisis dummy variable (D_Crisis_{it}) was integrated into the empirical framework. To eliminate potential discretionary coding bias, the classification of stress periods follows a standardized, rule-based *ex-ante* criterion grounded in authoritative institutional data-specifically the IMF Systemic Banking Crises Database (Laeven & Valencia, 2020), World Bank Financial Development Indicators, and EBRD Transition Reports. A country-year observation is objectively coded $D\_Crisis_{it} = 1$ if it meets at least one of the following formal criteria: Real GDP Contraction: Annual real GDP growth rate falls below zero

Table 1. Periodization of macroeconomic and local shocks and their classification in the stress resilience assessment model

Country	Crisis years	Crisis type
Ukraine	2008–2009; 2014–2015; 2020–2024	global crisis, banking restructuring, COVID-19, war
Moldova	2008–2009; 2014–2015; 2020–2024	global crisis, banking fraud crisis, COVID-19, energy/security shock
Belarus	2008–2009; 2011; 2015; 2020–2024	global crisis, currency shocks, COVID-19, energy/security shock
Estonia	2008–2010; 2020–2023	global crisis, COVID-19, energy shock
Lithuania	2008–2010; 2020–2023	global crisis, COVID-19, energy shock
Latvia	2008–2010; 2020–2023	global crisis, COVID-19, energy shock
Bulgaria	2008–2009; 2020–2023	global crisis, COVID-19, energy shock
Romania	2008–2009; 2020–2023	global crisis, COVID-19, energy shock
Poland	2008–2009; 2020–2023	global crisis, COVID-19, energy shock
Czechia	2008–2009; 2012–2013; 2020–2023	global crisis, European debt crisis, COVID-19, energy shock
Slovakia	2008–2009; 2020–2023	global crisis, COVID-19, energy shock
Hungary	2008–2010; 2012; 2020–2022	global crisis, European debt crisis, COVID-19, energy shock
Serbia	2008–2009; 2012–2013; 2020–2023	global crisis, European debt crisis, COVID-19, energy shock
Croatia	2008–2009; 2012; 2020–2023	global crisis, European debt crisis, COVID-19, energy shock
Slovenia	2008–2009; 2012; 2020–2023	global crisis, European debt crisis, COVID-19, energy shock
North Macedonia	2008–2009; 2012; 2020–2023	global crisis, European debt crisis, COVID-19, energy shock
Montenegro	2008–2009; 2012; 2020–2022	global crisis, European debt crisis, COVID-19, energy shock
Bosnia and Herzegovina	2008–2009; 2012–2013; 2020–2023	global crisis, European debt crisis, COVID-19, energy shock
Albania	2008–2009; 2012–2013; 2020–2023	global crisis, European debt crisis, COVID-19, energy shock
Kazakhstan	2007–2009; 2015–2016; 2020–2022	global crisis, currency shocks, COVID-19, energy shock
Armenia	2008–2009; 2020–2021	global crisis, COVID-19
Georgia	2008–2009; 2020–2021	war, global crisis, COVID-19

Note: Stress periods (D_Crisisit = 1) are determined via formal ex-ante criteria using data from the IMF Systemic Banking Crises Database (Laeven & Valencia, 2020), World Bank, and EBRD Transition Reports. A year is classified as a crisis period if a country experiences real GDP contraction (ΔGDPit < 0), systemic banking restructuring, or major exogenous geopolitical/energy disruptions. Robustness tests using an alternative strictly macroeconomic criterion (D_Crisis_Macroit = 1 if ΔGDPit < 0) confirm parameter invariance across specifications.

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($\Delta GDP_{it} < 0$); Systemic Banking Stress: Documented systemic bank runs, acute liquidity constraints, or large-scale restructuring/recapitalization interventions (e.g., Ukraine 2014–2015, Moldova 2014–2015); Exogenous Security or Terms-of-Trade Shocks: Major military conflicts, regional geopolitical crises, or acute energy shocks explicitly identified in official IMF/EBRD country assessments. Full country-specific periodization and shock classifications are summarized in Table 1.

To increase the reliability of empirical inferences, a subgroup analysis was conducted by country clusters to account for institutional and regional heterogeneity. This comparative framework tests whether the structural pathways linking digital governance, banking resilience, and revealed financial engagement differ across regulatory regimes, integration stages, and reform trajectories.

To account for the panel structure ($N = 22$, $T = 22$, $N \times T = 484$) and prevent distorted statistical inference arising from serial correlation, cross-sectional dependence, and within-country error clustering, the structural equation model is estimated using panel-adjusted covariance specifications. Specifically, standard errors across all measurement and structural equations are computed using Huber-White cluster-robust sandwich estimators aggregated at the country level (22 clusters), relaxing the assumption of independent observations within panels. Furthermore, unobserved time-varying common shocks are controlled by incorporating year fixed effects alongside exogenous rule-based crisis dummies (D_Crisis_{it}). Pre-estimation panel diagnostics-including Pesaran's cross-sectional dependence test and Dumitrescu–Hurlin causality tests-confirm that path coefficients (β) and associated p-values remain empirically robust under clustered spatial and temporal variance structures (Dumitrescu & Hurlin, 2012).

3. RESULTS

The empirical analysis begins with a descriptive statistical evaluation of the dataset to assess variable structure, quality, internal dynamics, distributional asymmetry, and potential outliers. Decomposing complex integral metrics into primary indicators reveals fundamental patterns in digital governance, financial stability, and revealed financial inclusion and engagement across the 22 transition economies over the 2003–2024 period. Table 2 presents summary statistics, including the arithmetic mean, median, standard deviation, skewness, kurtosis, minimum, and maximum values for each indicator, providing a reliable foundation for subsequent econometric modeling and highlighting regional convergence or divergence dynamics.

Distribution parameters confirm significant institutional and financial heterogeneity across the 22 transition economies (N = 484). Tier 1 capital averages 16.59%, well above Basel minimums. However, non-performing loans (NPL) show high right-skewness (2.48) and kurtosis (10.39), peaking at 54.5% during severe localized crises against a 5.20% median. Return on assets (ROA) displays left-skewness (–1.49, Min = –5.6%) from restructuring losses. Control of corruption ranges widely (–1.15 to 1.55, mean = 0.054), illustrating the gap between transparent Baltic states and lower-performing post-Soviet regimes.

Table 2. Descriptive statistics of key financial and governance indicators (2003–2024)

Variable	Obs	Mean	Median	SD	Min	Max	Skewness	Kurtosis
Tier	484	16.59	16.25	4.11	7.52	35.6	0.75	4.49
NPL	484	8.00	5.25	7.55	0.2	54.5	2.48	10.39
ROA	484	1.15	1.25	1.26	–5.6	6.2	–1.49	10.25
Cntrl_Corrup	484	0.054	0.025	0.678	–1.15	1.55	0.15	1.89
Depositors	484	943.45	940	371.70	150	1870	0.03	2.32
Dep_ accounts	484	1876.82	1810	823.61	250	4080	0.20	2.39
bank_dep	484	46.68	46.15	15.98	9.4	88	0.12	2.48
debit_cards	484	1003.57	1020	480.17	30	2600	0.04	2.57
E_PI	484	0.428	0.452	0.277	0	1	0.04	1.74
OSI	484	0.523	0.528	0.221	0	1	–0.12	2.34
Gov_Effect	484	0.202	0.14	0.573	–1.13	1.45	0.15	1.86

Financial inclusion and engagement metrics demonstrate steady financial deepening: depositors and deposit accounts are symmetrically distributed, debit cards average 1,003.57 per 1,000 adults, and bank deposits average 46.68% of GDP. Digital indicators span 0 to 1, with online service delivery (OSI = 0.523) outstripping e-participation (*E_PI* = 0.428). Government effectiveness dispersion (SD = 0.573) confirms lingering structural divides.

These distributional properties validate the moving-average interpolation and composite index calculations. Low variance inflation factors (mean VIF = 1.37, all VIFs < 2) rule out multicollinearity. Primary integral indices (DGI, BSII, RFIEI) were derived from normalized arithmetic means for direct interpretation, while alternative indices were constructed via factor analysis for robustness testing (Table 3).

Table 3. Results of factor analysis for constructing latent indicators

Variable	Factor1	Uniqueness
Banking Stability & Integrity Index (BSII), eigenvalue (λ_1) = 0.5569, LR-test $\chi^2(6) = 69.28$ ($p < 0.0001$)		
z_d_Tier	−0.2115	0.9553
z_NPL	−0.3686	0.8642
z_ROA	0.4680	0.7810
z_d_Cntrl_Corrup	0.3966	0.8427
Revealed Financial Inclusion and Engagement Index (*RBCI*) eigenvalue (λ1) = 3,1707, LR-test $\chi^2(6) = 2,959.59$ ($p < 0.0001$)		
z_Depositors	0.9969	0.0060
z_Dep_accounts	0.9936	0.0073
z_ln_bank_dep	0.6788	0.5385
z_ln_debit_cards	0.8538	0.2614
Digital Governance Index (DGI) eigenvalue (λ_1) = 0.5814, LR-test $\chi^2(3) = 86.31$ ($p < 0.0001$)		
z_Gov_Effect	0.0209	0.9911
z_d_OSI	0.5379	0.7105
z_d_E_PI	0.5400	0.7083

Principal Factor Analysis ($N = 484$) was conducted using Iterated Principal Factors (IPF) without rotation to derive empirical weighting coefficients for latent constructs (Table 3). Although primary factor eigenvalues for the Digital Governance Index ($\lambda_1 = 0.5814$) and Banking Stability and Integrity Index ($\lambda_1 = 0.5569$) fall below the Kaiser criterion threshold of 1.0 due to component-specific variance after z-score normalization and differencing, Likelihood Ratio (LR) independence tests confirmed highly significant empirical inter-correlation across all construct indicators ($\chi^2(3) = 86.31$ for *DGI*; $\chi^2(6) = 69.28$ for BSII; $\chi^2(6) = 2959.59$ for *RFIEI*; all $p < 0.0001$).

For DGI, the primary factor was driven by online service delivery ($\lambda = 0.5379$) and e-participation ($\lambda = 0.5400$), reflecting direct digital interaction metrics rather than broad administrative effectiveness ($\lambda = 0.0209$). For BSII, the dominant factor loaded positively on return on assets ($\lambda = 0.4680$) and corruption control ($\lambda = 0.3966$), with negative loadings for non-performing loan accumulations ($\lambda = -0.3686$).

For the Revealed Financial Inclusion and Engagement Index, the first factor ($\lambda_1 = 3.1707$) explained 99.8% of system variance, driven heavily by depositors ($\lambda = 0.9969$) and deposit accounts ($\lambda = 0.9936$). However, near-unity loadings for these core account metrics created a Heywood case (uniqueness < 0.007) due to near-perfect structural redundancy between scale-based banking penetration indicators. To address this empirical boundary condition, the factor-derived index ($RFIEI_{\_Factor}$) is strictly reserved for secondary robustness checks, establishing the simple normalized arithmetic mean (*RFIEI_Mean*) as the primary baseline operationalization. To evaluate integration properties prior to SEM modeling, all constructed metrics were subjected to panel unit root testing via Levin-Lin-Chu (LLC), Im-Pesaran-Shin (IPS), and Fisher-type ADF procedures (Table 4).

The panel unit root test results (Table 4) revealed mixed stationarity properties across the constructed indices. The mean-derived metrics *DGI_mean* and *BSII_mean*, alongside *RFIEI_factor*, rejected the null hypothesis of a unit root across all three procedures – Levin–Lin–Chu (LLC), Im–Pesaran-Shin (IPS), and Fisher-ADF tests ($p < 0.01$) – confirming their level stationarity ($I(0)$). Conversely, outcomes for *RFIEI_mean* were divergent: while LLC and IPS indicated stationarity ($p < 0.001$), the Fisher-ADF test failed to reject the unit root ($\chi^2(44) = 47.12$, $p = 0.346$), reflecting localized cross-country heterogeneity in financial deepening trends. Furthermore, *DGI_factor* and *BSII_factor* exhibited non-stationarity in levels ($I(1)$) across IPS and Fisher-ADF tests ($p > 0.99$), confirming persistent longitudinal trends and macroeconomic structural shifts over the 22 years.

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Table 4. Results of panel stationarity tests (LLC, IPS, Fisher-ADF)

Variable	TestLevin-Lin-Chu (LLC)	Test Im-Pesaran-Shin (IPS)	Test Fisher (ADF)
DGI_mean	Adjusted t= –2.6806, p = 0.0037	tbar = –3.4648, p < 0.001	$\chi^2(44)$ = 134.97, p < 0.001
BSII_mean	Adjusted t = –5.5735, p < 0.001	tbar = –2.6470, p < 0.001	$\chi^2(44)$ = 95.76, p < 0.001
RFIEI_mean	Adjusted t = –6.3584, p < 0.001	tbar = –4.7398, p < 0.001	$\chi^2(44)$ = 47.12, p = 0.346
DGI_factor	Adjusted t = –2.3012, p = 0.0107	tbar = -0.4295 p = 1.0000	$\chi^2(44)$ = 18.3382, p=0.999
BSII_factor	Adjusted t = 0.2868, p = 0.6129	tbar = –0.7133, p = 1.0000	$\chi^2(44)$ = 19.73, p = 0.9994
RFIEI_factor	Adjusted t = –21.5581, p < 0.001	tbar = –7.5109, p < 0.001	$\chi^2(44)$ = 460.25, p < 0.001

To eliminate autocorrelation and spurious regression risks when estimating short-run dynamic impacts, variables were transformed using the first-difference operator (Δ) for the robustness specifications. Post-transformation unit root tests confirmed that all differenced series achieved strict level-stationarity ($I(0)$), enabling a unified evaluation of dynamic year-over-year shock responses.

To empirically substantiate the temporal direction of transmission before estimating the SEM, Dumitrescu–Hurlin panel causality tests (Lag = 1) were conducted. The test for DGI → BSII rejected the null hypothesis of non-causality at the 5% level ($\bar{W}$ = 1.658; $\bar{Z}$ = 2.183; p = 0.029), confirming that digital governance improvements possess predictive power over future banking stability. Conversely, the direct short-run causality *DGI → RFIEI* was statistically insignificant ($\bar{W}$ = 0.788; $\bar{Z}$ = –0.704; p = 0.482), demonstrating that revealed financial inclusion and engagement do not respond instantaneously to digital governance impulses.

This short-run insignificance highlights an institutional lag: deepening citizen financial engagement through digital transparency requires time for users to accumulate experience, adopt digital channels, and overcome regional financial divides. Consequently, four SEM specifications were estimated across different lag horizons: the baseline contemporaneous model (L_0) alongside lagged models (L_1, L_2, L_3). In this baseline specification (*DGI → BSII → RFIEI*), *BSII_mean* and *RFIEI_mean* serve as endogenous variables, while *DGI_mean* and the crisis dummy (*D_Crisis*) act as exogenous drivers, allowing the modeling framework to capture both direct and indirect transmission channels under macroeconomic stress (Tables 5-6).

Table 5. Baseline static SEM model (latent factor specifications in levels)

Way		Coefficient	pvalue
BSII_lat ← DGI_lat		β = 4.102	p = 0.079
RFIEI_lat ← BSII_lat		β = 2.087	p = 0.041
RFIEI_lat ← DGI_lat		β = –19.010	p = 0.606
Latent variable			
DGI	d_E_PI	1 (fixed)	–
	d_OSI	0.680	p = 0.004
	d_gov_Effect	0.498	p < 0.001
BSII	d_roa	1 (fixed)	–
	d_Tier	–0.317	p = 0.220
	d_npl	–3.684	p = 0.018
	d_Cntrl_Corrup	0.034	p = 0.006
RFIEI	d_depositors	1 (fixed)	–
	d_dep_accounts	2.077	p < 0.001
	d_debit_cards	1.437	p < 0.001
	d_bank_dep	0.057	p < 0.001

Note: All SEM path coefficients (β) are estimated with Huber-White cluster-robust standard errors clustered at the country level (N = 22). Models incorporate year fixed effects and crisis dummies to control for common shocks. Evaluates long-run structural linkages using factor-derived latent variables in levels with country-level cluster-robust standard errors.

Structural equation modeling (SEM) reveals crucial short-term (L_0) transmission dynamics among digital governance, banking stability, and revealed financial inclusion and engagement (Table 5). The impact of digital governance on banking stability ($BSII_{lat} \leftarrow DGI_{lat}$) is positive but only marginally significant (β = 4.102; p = 0.079), demonstrating that short-term expansion of digital public services exerts a weakly pronounced immediate influence on structural institutional resilience at the conventional 5% significance level. In turn, banking stability exerts a strong and statistically significant positive influence on revealed financial inclusion and engagement ($RFIEI_{lat} \leftarrow BSII_{lat}$) (β = 2.087; p = 0.041), proving that tangible improvements in bank financial health convert directly into heightened citizen participation and account

usage. Crucially, the direct path from digital governance to financial inclusion ($RFIEI_{lat} \leftarrow DGI_{lat}$) is statistically insignificant (β = –19.010; p = 0.606). Rather than functioning through an immediate or direct structural link, these contemporaneous parameters indicate a weak indirect transmission channel. This implies that digital governance does not drive citizen banking engagement directly or instantly, but instead requires time to operate through the gradual stabilization of the banking sector (BSII).

Factor loadings (λ) confirm the internal validity of these measurement constructs (Table 5). Digital governance is driven by significant contributions from online service delivery (λ = 0.680; p = 0.004) and government effectiveness (λ = 0.498; p < 0.001), with e-participation fixed as the baseline indicator. Within banking stability, non-performing loans present the largest negative loading (λ = –3.684; p = 0.018), identifying toxic assets as the primary threat to systemic integrity, while corruption control provides a positive stabilizing effect (λ = 0.034; p = 0.006) and capital adequacy growth remains short-term insignificant (λ = –0.317; p = 0.220), relative to return on assets. Revealed financial inclusion and engagement is anchored heavily by deposit accounts (λ = 2.077; p < 0.001), payment card adoption (λ = 1.437; p < 0.001), and bank deposits-to-GDP (λ = 0.057; p < 0.001), relative to the baseline depositor ratio. Overall model fit diagnostics confirm acceptable structural alignment (χ^2 = 312.44; p < 0.001), with a Tucker–Lewis Index (TLI) of 0.907, a Root Mean Square Error of Approximation (RMSEA) of 0.090, and a Coefficient of Determination (CD) of 0.676, indicating that the specification captures 67.6% of the joint dynamic variance.

Estimating SEM models across different lag horizons (L_0 to L_3) reveals the temporal transmission dynamics between digital governance growth, banking stability, and revealed financial inclusion and engagement.

Across all time intervals (L_0–L_3), the growth channel from digital governance to banking stability ($\Delta DGI \rightarrow \Delta BSII$) remains statistically insignificant (p > 0.05). Current or past accelerations in e-governance do not exert an immediate or delayed short-term impact on banking sector resilience, confirming that this institutional mechanism operates with a long-term time lag. Conversely, the banking stability to revealed financial inclusion and engagement channel ($\Delta BSII \rightarrow \Delta RFIEI$) exhibits a highly significant, persistent positive effect across all stages (p < 0.05). The impact peaks in the current period (β = 0.038, p = 0.010) and at the first lag (β = 0.039, p = 0.009) before gradually attenuating by the third lag (β = 0.031, p = 0.041), reflecting rapid public market responsiveness and engagement to improvements in bank financial health.

The direct channel from digital governance to financial inclusion ($\Delta DGI \rightarrow \Delta RFIEI$) reveals a statistically significant negative effect across all lags (ranging from β = –0.024 to p = 0.013 at L_0 to β = –0.030 to p = 0.002 at L_1). Negative coefficients (β = –0.024 to –0.030) indicate that rapid public service digitalization temporarily suppresses the growth rate of citizen banking engagement, peaking at lags 1 and 2 (p < 0.01). This friction stems from consumer adaptation lags, the "digital divide," and technological adoption hurdles outpacing financial literacy. The divergence between the static latent SEM specification-where ($DGI \rightarrow BSII$) is marginally positive (β = 4.102, p = 0.079)- and the dynamic differenced specification ($\Delta DGI \rightarrow \Delta BSII$), where it loses significance (β = 0.027, p = 0.516), is econometrically justified. Latent factor modeling filters measurement noise to capture long-term cumulative structural impacts, whereas annual differenced specifications measure instantaneous short-term adjustments, which are insufficient for digital governance mechanisms to fully materialize.

Table 6. Results of the lag* SEM model (DGI → BSII → RFIEI) on the average values

Lag	DGI → BSII	BSII → RFIEI	DGI → RFIEI
L0	β = 0.027, p = 0.516	β = 0.035, p < 0.001	β = –0.011 to p = 0.086
L1	β = –0.019 to p = 0.596	β = 0.034, p < 0.001	β = –0.017 to p = 0.001
L2	β = –0.042 to p = 0.240	β = 0.023 to p = 0.001	β = –0.017 to p < 0.001
L3	β = –0.040 to p = 0.284	β = 0.021, p < 0.001	β = –0.007 to p = 0.085

Note: The lag model estimates short-term changes in first differences.

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Table 7. Robustness analysis of short-run dynamic effects across alternative SEM specifications (L0–L3)

Lag / Variable	Model 1: *d_BSII_factor* ← *DGI/RFIEI*	Model 2: *RFIEI_factor/DGI_mean* ← *d_BSII_factor*	Model 3: *RFIEI_factor/DGI_mean* ← *DGI/RFIEI*
d_DGI_factor (0)	β = –0.239, *p* = 0.001	β = –0.419, *p* = 0.026	β = –0.582, *p* = 0.041
d_DGI_factor (Lag 1)	β = –0.033, *p* = 0.653	β = –0.457, *p* = 0.013	β = –0.453, *p* = 0.104
d_DGI_factor (Lag 2)	β = –0.052, *p* = 0.501	β = –0.439, *p* = 0.015	β = –0.366, *p* = 0.188
d_DGI_factor (Lag 3)	β = –0.357, *p* < 0.001	β = –0.523, *p* = 0.004	β = –0.356, *p* = 0.225
RFIEI_factor (0)	β = –0.022, *p* = 0.060	β = –0.110, *p* < 0.001	β = –0.015, *p* = 0.043
RFIEI_factor (Lag 1)	β = –0.022, *p* = 0.059	β = –0.110, *p* < 0.001	β = –0.015, *p* = 0.051
RFIEI_factor (Lag 2)	β = –0.031, *p* = 0.011	β = –0.117, *p* < 0.001	β = –0.018, *p* = 0.026
RFIEI_factor (Lag 3)	β = –0.035, *p* = 0.007	β = –0.122, *p* < 0.001	β = –0.024, *p* = 0.004
d_RFIEI_mean (0)	β = –1.437, *p* < 0.001	β = –0.058, *p* = 0.308	β = –0.621, *p* = 0.086
d_RFIEI_mean (Lag 1)	β = –0.592, *p* = 0.054	β = –0.060, *p* = 0.297	β = –0.292, *p* = 0.422
d_RFIEI_mean (Lag 2)	β = –0.409, *p* = 0.198	β = –0.052, *p* = 0.366	β = –0.855, *p* = 0.020
d_RFIEI_mean (Lag 3)	β = –0.993, *p* = 0.002	β = –0.005, *p* = 0.926	β = –1.862, *p* < 0.001

Note: All SEM path coefficients (β) are estimated using Huber-White cluster-robust standard errors clustered at the country level (N = 22) with year fixed effects and crisis controls (D_Crisis). The prefix 'd_' denotes variables transformed into first differences (I(1)) to assess short-run dynamic lag adjustments (L0–L3), comparing factor-derived latent variables and mean-based composite constructs.

Finally, a comparative analysis across alternative data aggregation methods and lag structures (Table 7) provides a formal robustness check, confirming parameter stability across specifications.

A comparative analysis of structural effects across differenced SEM specifications confirms complex dynamic linkages among digitalization (*ΔDGI*), banking stability (*ΔBSII*), and revealed financial inclusion and engagement (*ΔRFIEI*) across L_0–L_3 lag horizons. Digitalization exerts an immediate positive impact on banking stability (β = 0.027, *p* = 0.516), which re-emerges strongly at lag 3 (β = 0.045, *p* = 0.021). Conversely, its direct short-run impact on citizen financial engagement is negative (β = –0.024; *p* = 0.013), though this effect dissipates at subsequent lags.

For the factor-derived inclusion channel ($\Delta RFIEI_{Factor}$), the influence of citizen financial engagement on stability strengthens progressively over time, rising from β = 0.012 (*p* = 0.104) at L_0 to β = 0.028 (*p* = 0.003) at L_1 and β = 0.035 (*p* = 0.001) at L_2. Feedback from banking stability to inclusion remains persistently high and statistically significant across all horizons (β = 0.038 to 0.039; *p* < 0.01). In contrast, financial engagement exerts a weak negative direct effect on digitalization (β = –0.008 to –0.012), reflecting a conservative drag from traditional banking structures on e-governance adoption rates.

Under the mean-derived inclusion metric ($\Delta RFIEI_{Mean}$), financial inclusion shows a strong immediate positive effect on stability (β = 0.041, *p* = 0.002), which weakens at L_1 (β = 0.018, *p* = 0.089), fades at L_2, and resurges at L_3 (β = 0.029, *p* = 0.011). Meanwhile, short-term stability fluctuations show no significant feedback on average inclusion rates (β = 0.005, *p* = 0.612). Notably, the direct impact of financial engagement on digitalization turns strongly negative in the medium term (β = –0.031, *p* = 0.004 at L_1; β = –0.027, *p* = 0.008 at L_2), suggesting that rapid traditional banking engagement can entrench conventional financial models and slow state-led digital initiatives.

To ensure additional empirical robustness under macroeconomic stress, a crisis dummy variable (*D_Crisis*) capturing exogenous and localized shocks was introduced to test parameter stability across all specifications, with results reported in Table 8.

Integrating the crisis dummy variable (*D_Crisis*) into the differenced SEM system confirms that systemic shocks exert persistent negative pressure on both banking stability (*ΔBSII* ← *D_Crisis*: β = –0.130; *p* = 0.009 at L_0; β = –0.098; *p* = 0.035 at L_1) and revealed financial inclusion and engagement growth (*ΔRFIEI* ← *D_Crisis*: β = –0.027, *p* < 0.001 at L_0; β = –0.021, *p* = 0.004 at L_1). Crucially, even under severe stress, the structural link from banking stability to citizen financial engagement

Table 8. Effects of digital governance (DGI) and crisis periods (D_Crisis) on banking stability (BSII) and revealed financial inclusion and engagement (RFIEI)

Lag	BSII ← DGI	BSII ← D_Crisis	RFIEI ← DGI	RFIEI ← D_Crisis
L0	β = –0.002, p = 0.965	β = –0.130, p = 0.009	β = 0.027, p < 0.001	β = –0.027, p < 0.001
L1	β = –0.035, p = 0.321	β = –0.137, p = 0.005	β = 0.025, p < 0.001	β = –0.026, p < 0.001
L2	β = –0.050, p = 0.161	β = –0.118, p = 0.016	β = 0.016, p = 0.008	β = –0.022, p < 0.001
L3	β = –0.045, p = 0.232	β = –0.114, p = 0.025	β = 0.015, p = 0.003	β = –0.009, p = 0.015

(*ΔRFIEI* ← *ΔBSII*) maintains its positive significance across all lags (β = 0.038 to 0.039; $p < 0.05$), proving that institutional stability serves as a fundamental shield sustaining customer participation during macro-financial disruptions.

In contrast, the direct effect of digital governance on financial stability (*ΔBSII* ← *DGI*) remains statistically insignificant across all horizons (β = 0.027; $p = 0.516$ at L_0; β = 0.015, $p = 0.712$ at L_1), confirming that public e-governance does not directly mitigate core balance-sheet risks such as toxic loans or capital shortages. Meanwhile, the direct path to inclusion dynamics (*ΔRFIEI* ← *ΔDGI*) stays negative (β = –0.024; $p = 0.013$ at L_0; β = –0.030; $p = 0.002$ at L_1), illustrating institutional market saturation where advanced public digitalization coincides with mature financial sectors and decelerating customer acquisition.

For the final evaluation (Table 9), model trimming removed the statistically insignificant direct path (Δ*RFIEI* ← Δ*DGI*) to evaluate an indirect transmission structure (*DGI* → *BSII* → *RFIEI*), which yielded a strong overall statistical fit ($\chi^2 = 312.44$; $p < 0.001$; CD = 0.676). To capture historical and institutional divides across the sample ($N = 484$), countries were grouped into three distinct clusters: the highly integrated Baltics and Central Eastern Europe operating under strict EU regulatory regimes; the Western Balkans and Adriatic undergoing active structural reforms; and the Eastern Partnership and Central Asia, characterized by geopolitical shocks, elevated macroeconomic instability, and weaker transmission between state reforms and banking performance.

Multi-group estimation results reveal an institutional pattern in how public digitalization transmits to revealed financial inclusion and engagement. In the Baltics and CEE countries (Group 1, N × T = 110), a strong two-step transmission channel holds: accelerated state digitalization drives banking sector resilience (β = 5.214, $p = 0.012$), which subsequently boosts revealed financial inclusion and engagement (β = 0.384, $p = 0.004$). In the Balkans and Adriatic region (Group 2, N × T = 176), this sequential path remains significant at the 5% level, showing moderate transmission from digitalization to stability (β = 3.102; $p = 0.038$) and from stability to inclusion (β = 0.241, $p = 0.026$). Conversely, in Eastern Partnership and Central Asian states (Group 3, $N_3 = 154$), the primary link is blocked due to an insignificant effect of digitalization on banking stability (β = 0.011, $p = 0.621$). However, the secondary link from stability to citizen financial engagement reaches its highest magnitude across all regions (β = 0.058, $p < 0.001$), emphasizing that core financial resilience is essential in higher-risk institutional environments.

To eliminate potential empirical distortions introduced by linear interpolation of two-year UN survey metrics (*E_PI* and *OSI*), a supplementary sensitivity analysis was conducted strictly on non-interpolated observation years (2008, 2010, 2012, 2014, 2016, 2018, 2020, 2022, and 2024; N × T = 198). Biennial first differences (Δ_2) estimated via cluster-robust panel regressions confirm parameter stability across specifications: the immediate dynamic path from digital governance to banking resilience remains statistically non-significant (β = 0.0324, $p = 0.630$), whereas systemic crisis shocks exert a severe destructive effect on banking sta-

Table 9. Structural effects of the SEM model by regional groups

Group	N	BSII ← DGI	RFIEI ← BSII	Const(BSII)	Const (RFIEI)
1	140	β = 0.409, p = 0.003	β = 0.055, p = 0.001	0.011 (0,062)	0.074(0,000)
2	180	β = 0.167, p = 0.042	β = 0.072, p = 0.036	0.030, p = 0.043	0.098(0,000)
3	120	β = 0.225, p = 0.155	β = 0.079, p = 0.001	–0.009 (0,800)	0.108 (0,000)

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bility (β = –0.3123, p = 0.001). Direct digital governance impulses toward revealed inclusion maintain a moderate positive response (β = 0.0209, p = 0.013). These non-interpolated estimates confirm that the absence of immediate shock-absorbing effects of digital governance on bank balance sheets is a structural feature of transition economies rather than an artifact of the interpolation rule.

Furthermore, evaluating parameter sensitivity against an alternative, strictly objective macroeconomic crisis definition ($D\_Crisis\_Macro_{it}$ = 1 if real GDP growth < 0) confirms structural invariance: the dynamic path from digital governance to banking resilience remains statistically non-significant (β = 0.0927, p = 0.166), while direct digital impulses toward financial inclusion maintain a positive response (β = 0.0149, p = 0.082).

Thus, the transmission efficiency from public e-governance to revealed financial inclusion and engagement depends on institutional maturity and European integration depth. Where regulatory frameworks and supervisory standards are strict (Baltics/CEE), digitalization effectively strengthens financial stability. In reforming economies (Balkans/Adriatic), the effect is moderate, whereas in weaker institutional settings with high corruption risks (Eastern Partnership/Central Asia), digital expansion fails to automatically stabilize banking systems, leaving fundamental balance-sheet strength as the sole foundation for sustaining citizen financial engagement.

4. FORMAL CROSS-GROUP EQUALITY ANALYSIS

To methodologically evaluate regional institutional heterogeneity, formal parameter equality constraints (Wald tests, H_0: $\beta_{GroupA} = \beta_{GroupB}$) were executed following the multi-group SEM estimation. Contrary to the initial narrative based solely on within-subsample p-values, formal cross-group tests demonstrate structural slope homogeneity across regional blocks. Specifically, the parameter governing the stability-to-inclusion link ($\Delta_2 BSII \rightarrow \Delta_2 RFIEI$) shows no statistically significant divergence between EU-integrated Baltics/CEE (Group 1) and Eastern Partnership/Central Asia (Group 3) ($\chi^2(1) = 0.03$, p = 0.855). Similarly, the dynamic governance-to-stability pathway ($\Delta_2 DGI \rightarrow \Delta_2 BSII$) is statistically uniform across Group 1 and Group 3 ($\chi^2(1) = 0.48$; p = 0.487). Furthermore, tests on the direct digitalization channel ($\Delta_2 DGI \rightarrow \Delta_2 RFIEI$) confirm no statistically significant slope divergence between CEE (Group 1) and the Balkan block (Group 2) at the standard 5% level ($\chi^2(1) = 2.65$; p < 0.104). Consequently, the observed variations in within-group significance levels reflect sample-size-induced estimation variance rather than empirical cross-regional structural slope heterogeneity.

5. DISCUSSION

The empirical findings indicate that public digital governance is associated with long-term structural banking resilience rather than functioning as an instantaneous countercyclical shock absorber. Dynamic panel SEM estimates show a positive, marginally significant association between digital governance and banking stability (β = 4.102, p = 0.079) in the static factor model, aligning with literature linking e-government to long-term institutional development (Juhászová et al., 2026; Masyk et al., 2023). Methodologically, the measurement model clarifies that this covariance is not merely an artifact of overlapping WGI indicators. The DGI construct is anchored by UN e-government deployment metrics, whereas BSII is empirically dominated by non-performing loan indicators (λ = –3.684; p = 0.018), with control of corruption providing a minor factor weight (λ = 0.034; p = 0.006). While previous studies propose that digitalization stabilizes core financial architectures by automating supervisory tools or reducing information asymmetry (Lyeonov et al., 2026; Ravšelj et al., 2026), these transmission channels represent plausible theoretical interpretations rather than measured variables in our model. In short-term dynamic specifications (β = 0.027, p = 0.516), we observe no statistically significant immediate association with bank capitalization or profitability, consistent with the view that e-governance operates as a long-term institutional feature rather than a short-run crisis-management instrument.

A key empirical outcome concerns the indirect path: digital governance relates to revealed financial inclusion primarily through its co-move-

ment with banking stability (β = 0.042, p = 0.008). Although micro-level studies suggest that digital interfaces directly enhance user confidence (Hedau, 2025; Malaquias & Hwang, 2025), our macro-level results show no statistically significant direct association between state-level digitalization and citizen engagement (β = 0.0149, p = 0.082). Because the direct governance-to-stability link is only marginally significant in levels (β = 0.0324, p = 0.079) and non-significant in short-run dynamic differences (β = 0.0324, p = 0.630), the observed empirical pattern is consistent with a sequential transmission structure rather than an immediate structural impact. Revealed inclusion co-moves fundamentally with indicators of bank solvency and risk profiles (Mursalov et al., 2025). Furthermore, short-term dynamic specifications display an inverse relationship between changes in digital governance and changes in revealed inclusion (β = −0.024, p = 0.013 at L_0; β = −0.030, p = 0.002 at L_1). We explicitly distinguish this observed negative statistical parameter from its underlying mechanisms. Because metrics for digital literacy, adoption difficulty, or market saturation were not included in the dataset, we hypothesize that this negative short-run parameter may reflect transitional adaptation friction or regional digital divides rather than a direct negative structural effect (Kiiko, 2026; Imanbayeva et al., 2026).

Stress-testing specifications incorporating crisis dummies (*D_Crisis*) and macro-regional subsamples outline the empirical boundaries of these relationships. Systemic shock variables display strong negative associations with both banking stability (β = −0.130, p = 0.009) and citizen financial engagement (β = −0.027, p < 0.001). Digital governance parameters do not exhibit a dampening effect on acute financial shocks ex-post, yet the statistical path from banking stability to inclusion retains its magnitude and significance during crisis periods (β = 0.038, p = 0.010). This statistical robustness suggests that balance-sheet health remains a primary correlate of citizen financial participation even during disruptions (Vakhovych et al., 2023). Post-estimation Wald tests confirm parameter homogeneity across regional blocks: dynamic transmission slopes for governance-to-stability ($\chi^2(1)$ = 0.48; p = 0.487) and stability-to-inclusion ($\chi^2(1)$ = 0.03; p = 0.855) do not statistically differ between EU-integrated CEE economies and the EaP/Central Asia block. Variations in within-subsample p-values reflect sample-size variance rather than true parameter divergence, indicating that observed macro-level associations are statistically uniform across transition contexts. Theoretical frameworks emphasizing foundational regulatory alignment and anti-corruption controls remain useful conceptual lenses for interpreting these broad structural patterns (Hakobyan et al., 2025; Szeberényi, 2026).

Finally, these empirical relationships were evaluated against indicator aggregation and data interpolation choices. While linear interpolation of biennial UN survey metrics (*E_PI* and *OSI*) creates smooth annual panels, a supplementary check on a non-interpolated biennial panel restricted strictly to UN publication years (2008–2024; $N \times T$ = 198) demonstrates that core findings are not artifacts of interpolation. In non-interpolated specifications, the immediate dynamic parameter between digital governance and banking resilience remains statistically non-significant (β = 0.0324, p = 0.630), whereas systemic crisis dummies retain strong negative parameters (β = −0.3123; p = 0.001). This confirms that the lack of immediate dynamic responsiveness is a robust statistical feature of the data rather than a modeling artifact. Future research could investigate these hypothesized mechanisms by incorporating granular administrative micro-data and metrics tracking non-traditional fintech intermediaries.

CONCLUSION

This research empirically uncovered the dynamic direct and indirect transmission pathways linking public digital governance, structural banking stability, and revealed financial inclusion across 22 transition economies over 2003–2024. The econometric framework combined normalized arithmetic indices and latent factor structures within a dynamic Structural Equation Modeling (SEM) architecture, incorporating Dumitrescu-Hurlin causality tests, multi-horizon lags (L_0–L_3), crisis-shock dummies (*D_Crisis*), and regional multi-group specifications.

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First, baseline static factor estimates demonstrate that digital governance exerts a positive, marginally significant influence on banking stability (β = 4.102, $p = 0.079$), which subsequently drives revealed financial inclusion (β = 0.042, $p = 0.008$). The direct link from digital governance to inclusion remains statistically insignificant (β = 0.0149, $p = 0.082$), establishing an indirect transmission mechanism operating over time. Second, structural path loadings show digital transformation strengthens balance-sheet stability primarily by suppressing non-performing loans ($\lambda = -3.684$; $p = 0.018$) and enhancing corruption controls ($\lambda = 0.034$; $p = 0.006$). Third, dynamic first-difference lag models (L_0–L_3) reveal that short-run e-governance accelerations do not instantly alter banking resilience ($\beta = 0.027$; $p = 0.516$) and exert a minor negative short-run drag on inclusion ($\beta = -0.024$; $p = 0.013$ at L_0), representing plausible adaptation friction or regional digital divides. Fourth, stress-testing confirms that while systemic shocks depress stability ($\beta = -0.130$; $p = 0.009$) and engagement ($\beta = -0.027$; $p < 0.001$), the mediating path from solvency to inclusion remains resilient ($\beta = 0.038$; $p = 0.010$). Fifth, multi-group SEM combined with post-estimation Wald tests confirms structural slope homogeneity across regional blocks ($\chi^2(1) = 0.48$, $p = 0.487$ for governance-to-stability; $\chi^2(1) = 0.03$, $p = 0.855$ for stability-to-inclusion), demonstrating that within-group significance variations stem from subsample variance rather than cross-regional structural slope divergence.

Regulatory authorities in transition economies must refrain from viewing e-governance initiatives as rapid, countercyclical substitutes for macroprudential oversight or crisis-management tools. Instead, public digitalization should be implemented as a long-term structural strategy designed ex-ante to reduce information asymmetry, curb non-performing loans, and reinforce institutional balance sheets. Furthermore, digitalization rollouts must be paired with targeted digital financial literacy programs to minimize consumer adaptation friction and foster long-term citizen engagement.

A key limitation involves sensitivity across indicator aggregation techniques, as direct digitalization effects lose statistical support under simple arithmetic averaging while remaining marginally significant within latent factor constructs (β = 0.0324, $p = 0.079$). Although annual panels required interpolation, sensitivity checks on non-interpolated UN survey years (2008–2024; $N \times T = 198$) confirmed parameter stability (β = 0.0324, $p = 0.630$), verifying that the lack of immediate dynamic shock absorption is a structural economic reality rather than an interpolation artifact. Future research should integrate high-frequency administrative records and examine how emerging fintech platforms mediate banking stability during macroeconomic stress.

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REFERENCES

1. Abdullayev, K., Rakhimzhanova, K., Avetikyan, A., Zolkover, A., Danileviča, A., Povoroznyk, M., & Zhou, Y. (2026). AI ecosystem pillars and economic growth: Implications for knowledge economy architecture from AI vibrancy subindices. *Knowledge and Performance Management, 10*(1), 66-87. https://doi.org/10.21511/kpm.10(1).2026.06
2. Al Hayek, M. A. (2026). The impact of digital transformation in the Jordanian government on the efficiency of government accounting: The moderating role of government organizational culture. *Problems and Perspectives in Management, 24*(1), 99-112. https://doi.org/10.21511/ppm.24(1).2026.08
3. Alsammak, M., Majid, A. S. A., Allahham, M., & Alrwashdeh, M. (2026). The nexus between AI-driven capabilities and knowledge systems in digital business environments. *Knowledge and Performance Management, 10*(1), 122-136. https://doi.org/10.21511/kpm.10(1).2026.09
4. Altawalbeh, M. (2026). The impact of digital accounting practices on agency costs management: Evidence from an emerging market. *Accounting and Financial Control, 7*(1), 66-77. https://doi.org/10.21511/afc.07(1).2026.06
5. Alzubi, M. M. S. (2026). Digital maturity and corporate reputation in Jordanian insurance companies: The role of digital marketing, customer engagement, and brand trust. *Insurance Markets and Companies, 17*(2), 1-12. https://doi.org/10.21511/ins.17(2).2026.01
6. Antoni, A., Javed, H., Murtaza, M. R., Kiss, F., & Csiszárik-Kocsir, Á. (2026). Assessing the impact of tech-driven financial development and IT governance on environmental funds in emerging economies. *Environmental Economics, 17*(2), 128-142. https://doi.org/10.21511/ee.17(2).2026.10
7. Bashynska, I., Mukhamejanuly, S., Malynovska, Y., Bortnikova, M., Saiensus, M., & Malynovskyy, Y. (2023). Assessing the outcomes of digital transformation smartization projects in industrial enterprises: A model for enabling sustainability. *Sustainability, 15*(19), 14075. https://doi.org/10.3390/su151914075
8. 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
9. Bielialov, T., Kalina, I., Goi, V., Kravchenko, O., Shyshpanova, N., & Negoda, A. (2023). Global experience of digitalization of economic processes in the context of transformation. *Journal of Law and Sustainable Development, 11*(3), e814. https://doi.org/10.55908/sdgs.v11i3.814
10. Brychko, M., Yarovenko, H., Khouri, S., & Bilan, S. (2025). Behavioral impulses and the transmission channels of their impact on macroeconomic stability. *Economics and Sociology, 18*(3), 202-228. https://doi.org/10.14254/2071-789X.2024/18-3/12
11. Bui, H. D., & Dam, T. C. (2026). E-service quality, e-trust, brand image, customer e-satisfaction, and e-loyalty in the Vietnamese e-banking industry. *Banks and Bank Systems, 21*(1), 86-96. https://doi.org/10.21511/bbs.21(1).2026.07
12. Dao, M. H., & Nguyen, T. T. (2026). Digital transformation and internal control effectiveness: The moderating role of firm size in Vietnamese enterprises. *Accounting and Financial Control, 7*(2), 1-14. https://doi.org/10.21511/afc.07(2).2026.01
13. Dumitrescu, E.-I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic Modelling, 29*(4), 1450-1460. https://doi.org/10.1016/j.econmod.2012.02.014
14. European Bank for Reconstruction and Development (EBRD). (2023). *Transition report 2023-24: Transitions big and small*. Retrieved from https://www.ebrd.com/transition-report-2023-24
15. Goguadze, M. (2026). Digital transformation management in logistics security and supply chain sustainability. *Economics Ecology Socium, 10*(2), 56-67. https://doi.org/10.61954/2616-7107/2026.10.2-4
16. Hakobyan, N., Sotnyk, I., Chortok, Y., Khachatryan, A., Mkrtchyan, Z., & Firyan, A. (2025). Anomic trends in business ethics and leadership research in changing society. *Business Ethics and Leadership, 9*(4), 163-179. https://doi.org/10.61093/bel.9(4).163-179.2025
17. Haliah, Hasan, H., Syamsuddin, Fatmawati, Dewi, A. R. S., Oemar, M. A. F. I., & Razak, L. A. (2025). The effect of political will, information technology, and the quality of financial reporting information on fraud prevention. *Public*

http://dx.doi.org/10.21511/bbs.21(3).2026.17

and Municipal Finance, 14(1), 13-22. https://doi.org/10.21511/pmf.14(1).2025.02

18. Hedau, A. (2025). Socio-economic challenges of digital banking adoption: The impact of perceived usefulness, ease of use, and self-efficacy. *SocioEconomic Challenges, 9*(3), 133-146. https://doi.org/10.61093/sec.9(3).133-146.2025

19. Hrytsenko, L., Sheliemina, N., & Latysh, D. (2026). Digital government and health system performance: Does digitalization improve the effectiveness of health expenditure? *Health Economics and Management Review, 7*(1), 21-40. https://doi.org/10.61093/hem.2026.1-02

20. Imanbayeva, Z., Taskarina, B., Nikolov, G., & Stavrova, E. (2026). Digital financial inclusion, trust, and inequality in e-payment ecosystems: Comparative evidence from the EU, Bulgaria, and Kazakhstan. *Business Ethics and Leadership, 10*(2), 191-209. https://doi.org/10.61093/bel.10(2).191-209.2026

21. International Monetary Fund (IMF). (2024a). *Financial Access Survey (FAS)* [Data set]. Retrieved from https://data.imf.org/?sk=E89AF946-B690-4B1D-9B96-608B1FCD8EFA

22. International Monetary Fund (IMF). (2024b). *Global financial stability report, October 2024: Steadying the course: Uncertainty, artificial intelligence, and financial stability*. https://doi.org/10.5089/9798400277573.082

23. International Monetary Fund (IMF). (2025). *Financial Soundness Indicators (FSI)* [Data set]. Retrieved from https://data.imf.org/?sk=51B0E324-A6E5-41B5-8E1E-54A8AF5641A4

24. Juhászová, Z., Brychko, A., Mosin, O., Povoroznyk, M., & Zakharkina, L. (2026). The role of GovTech in building an ethical, transparent, equitable, digital, and secure state during wartime and post-war reconstruction: Trends and patterns analysis from international experience. *Business Ethics and Leadership, 10*(2), 1-31. https://doi.org/10.61093/bel.10(2).1-31.2026

25. Kadri, N. (2025). Factors influencing customers' adoption of electronic banking services in commercial banks. *Financial Markets, Institutions and Risks, 9*(1), 140-161. https://doi.org/10.61093/fmir.9(1).140-161.2025

26. Kafoe, A. S., Foh, B. M., & Kafoe, M. A. (2026). Beyond panacea: Digital governance, AI, and the political economy of public benefit in African development. *Public Governance, Regulation and Law, 2*(2), 1-20. https://doi.org/10.61093/pgrl.2(2).1-20.2026

27. Kiiko, Y. (2026). Psychological determinants of customer loyalty: The interplay of satisfaction, trust, and financial security in Ukrainian banks. *Innovative Marketing, 22*(1), 296-314. https://doi.org/10.21511/im.22(1).2026.22

28. Kildei, A., Tumpach, M., & Shafranova, K. (2025). Artificial intelligence for smart customer feedback management: Improving content analysis approaches. *Knowledge Economy and Lifelong Learning, 1*(1), 48-65. https://doi.org/10.61093/kell.1(1).48-65.2025

29. Kline, R. B. (2023). *Principles and practice of structural equation modeling* (5th ed.). Guilford Press.

30. Klochan, I., & Filipov, D. (2023). Design of assessment and forecasting of a country's financial security in a change management context. *Smart Economy, Entrepreneurship and Security, 1*(1), 31-42. https://doi.org/10.60022/sis.1.(01).3

31. Krap, A., Bataiev, S., Bobro, N., Kozub, V., & Hlevatska, N. (2024). Examination of digital advancements: Their influence on contemporary corporate management methods and approaches. *Multidisciplinary Reviews, 7*, 2024spe026. https://doi.org/10.31893/multirev.2024spe026

32. Laeven, L., & Valencia, F. (2020). Systemic banking crises database II. *IMF Economic Review, 68*(2), 307-361. https://doi.org/10.1057/s41308-020-00107-3

33. Lyeonov, S., Hrytsenko, L., Zamek, D., & Remsei, S. (2026). E-government development, armed conflict, and government revenue: A cross-country panel analysis. *Journal of International Studies, 19*(1), 160-184. https://doi.org/10.14254/2071-8330.2026/19-1/9

34. Lygina, O., Kesoyan, N. M., Uvakbayeva, G., Kovshun, N., Dmitrieva, E., Shchokin, R., & Zakharkina, L. (2026). Digital governance as a tool against money laundering: Cross-country evidence for financial crime reduction. *Public and Municipal Finance, 15*(1), 68-86. https://doi.org/10.21511/pmf.15(1).2026.06

35. Maisyarah, R. (2026). Digital budget transparency and perceived budget credibility: Technocratic and normative mechanisms in Indonesian local governments. *Public and Municipal Finance, 15*(1), 43-57. https://doi.org/10.21511/pmf.15(1).2026.04

36. Malaquias, R. F., & Hwang, Y. (2025). Mobile devices and mobile internet data services: Implications for mobile banking. *Human Technology, 21*(1), 161-175. https://doi.org/10.14254/1795-6889.2025.21-1.8

37. Masyk, M., Buryk, Z., Radchenko, O., Saienko, V., & Dziurakh, Y. (2023). Criteria for governance institutional effectiveness and quality in the context of sustainable development tasks. *International Journal for Quality Research, 17*(2), 501-514. https://doi.org/10.24874/IJQR17.02-13

38. 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

39. Morshed, A., & Khrais, L. T. (2026). Artificial intelligence-driven predictive analytics and institutional performance in Gulf financial systems: Evidence from GCC financial institutions. *Banks and Bank Systems, 21*(1), 31-46. https://doi.org/10.21511/bbs.21(1).2026.03

40. Mursalov, M., Niemi, O., Kolomiiets, S., & Trofimenko, D. (2025). Determinants of financial

stability in banks: The impact of key regulatory financial indicators. *Financial Markets, Institutions and Risks, 9*(2), 123-134. https://doi.org/10.61093/fmir.9(2).123-134.2025

41. February, S., Ismanto, H., Nahar, A., & Amalia, I. (2026). Banking innovation and digital transformation as catalysts of infrastructure financing: Evidence from Indonesian banking. *Banks and Bank Systems, 21*(1), 268-282. https://doi.org/10.21511/bbs.21(1).2026.21

42. Polishchuk, Y., Kornyliuk, A., Lavreniuk, V., Horbov, V., Ivashchenko, A., & Tepliuk, M. (2024). Running a business during wartime: Voice of Ukrainian displaced business. *Problems and Perspectives in Management, 22*(3), 287-302. https://doi.org/10.21511/ppm.22(3).2024.23

43. Prokopenko, O., Koldovskiy, A., Khalilova, M., Orazbayeva, A., & Machado, J. (2024). Development of blockchain technology in financial accounting. *Computation, 12*(12), 250. https://doi.org/10.3390/computation12120250

44. Prokopenko, O., Sitenko, D., Zhanybayeva, Z., Lomachynska, I., & Rakhmetova, A. (2025). Financial systems and their influence on entrepreneurial development: Insights for building sustainable and inclusive ecosystems. *Journal of Risk and Financial Management, 18*(3), 131. https://doi.org/10.3390/jrfm18030131

45. Putri, J. A., Susanti, E., & Azwar, K. (2026). Weak-form market efficiency and integration dynamics in ASEAN capital markets during digital disruption. *Investment Management and Financial Innovations, 23*(2), 206-218. https://doi.org/10.21511/imfi.23(2).2026.16

46. Ravšelj, D., Hodžić, S., & Aristovnik, A. (2026). E-government initiatives and economic growth in the EU member states. *Economics and Sociology, 19*(1), 11-27. https://doi.org/10.14254/2071-789X.2026/19-1/1

47. Ruthvika, J., & Hedau, A. (2025). Digital inclusion and economic equity: Evaluating the role of business analytics in overcoming socioeconomic challenges. *SocioEconomic Challenges, 9*(4), 150-164. https://doi.org/10.61093/sec.9(4).150-164.2025

48. Rysin, V., Prokopenko, O., Muravskyi, O., Pechenko, R., Holiachuk, N., & Zinchenko, A. (2023). Personalization of banking products (services) using digitalization technologies. *WSEAS Transactions on Business and Economics, 20,* 2528-2539. https://doi.org/10.37394/23207.2023.20.216

49. Saifi, H., & Saifi, F. (2025). Digital transformation as a socio-economic challenge: The impact on the commercial bank employees' job performance. *SocioEconomic Challenges, 9*(3), 48-63. https://doi.org/10.61093/sec.9(3).48-63.2025

50. 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

51. Sitnicki, M. W., Iwanowska, B., Kapranov, Y., Klapkiv, J., Dluhopolskyi, O., Panasyuk, V. M., & Halynskyi, D. (2026a). Digitalisation and entrepreneurial ecosystems as drivers of energy start-ups: Evidence from cross-country panel data. *Sustainability, 18*(11), 5475. https://doi.org/10.3390/su18115475

52. Sitnicki, M. W., Serhiienko, R., Halynskyi, D., & Zhytar, M. (2026b). Economic freedom and the dynamics of energy start-ups: Cross-country evidence on green and digital entrepreneurship and financing. *Journal of International Studies, 19*(1), 255-279. https://doi.org/10.14254/2071-8330.2026/19-1/14

53. Sobol, I., & Dopierała, Ł. (2025). Does corruption affect the profitability of Islamic banks? *Journal of International Studies, 18*(2), 94-107. https://doi.org/10.14254/2071-8330.2025/18-2/5

54. Spivakovskyy, S., Kesoyan, N. M., Astapova-Vyazmina, O., Melnychuk, A., Babaiev, D., Zakharkin, O., & Zhou, Y. (2026). E-government development: Artificial intelligence vibrancy and readiness as drivers of digital public administration. *Problems and Perspectives in Management, 24*(1), 649-672. https://doi.org/10.21511/ppm.24(1).2026.43

55. Szeberényi, A. (2026). From compliance to accountability in digital globalization: The ethical friction threshold model for artificial intelligence-enabled business leadership. *Business Ethics and Leadership, 10*(2), 228-243. https://doi.org/10.61093/bel.10(2).228-243.2026

56. Tarasenko, I., Saienko, V., Kirizleyeva, A., Vozniakovska, K., Harashchenko, L., & Bodnar, O. (2022). Comparative characteristics of the banking sector in Eastern Europe. *International Journal of Computer Science and Network Security, 22*(1), 639-649. https://doi.org/10.22937/IJCSNS.2022.22.1.84

57. Thapaliya, P. R., & Dongol, P. (2026). Factors influencing the use of digital payment services and customer satisfaction in banking sector: An implication for technological innovation. *Innovative Marketing, 22*(1), 55-64. https://doi.org/10.21511/im.22(1).2026.05

58. Tran, V. L., & Phan, T. H. (2026). AI adoption as a mediator in early trade defense behavior: Evidence from customs managers in an emerging economy. *Problems and Perspectives in Management, 24*(1), 1-15. https://doi.org/10.21511/ppm.24(1).2026.01

59. Tsaurai, K. (2026). Foreign direct investment, technology, and economic growth nexus in emerging markets. *Investment Management and Financial Innovations, 23*(2), 111-125. https://doi.org/10.21511/imfi.23(2).2026.09

60. United Nations (UN). (2024). *United Nations e-government survey 2024: Accelerating digital transformation for sustainable development*. United Nations Department of Economic and Social Affairs.

http://dx.doi.org/10.21511/bbs.21(3).2026.17

Retrieved from https://publicadministration.un.org/egovkb/

61. Vakhovych, I., Biloshapka, V., Ivashyna, O., Ivashyna, S., Korneev, V., & Khodzhaian, A. (2023). Modelling of the anti-crisis management system in the banking sector of the Ukrainian economy to ensure its financial stability. *Financial and Credit Activity: Problems of Theory and Practice, 5*(52), 52-66. https://doi.org/10.55643/fcaptp.5.52.2023.4185
62. Vasylieva, T., Krawczyk, D., Rącka, I., & Fenyves, V. (2026). Digital government and quality of life: Unpacking the human-centred mechanisms of e-government development. *Human Technology, 22*(1), 178-197. https://doi.org/10.14254/1795-6889.2026.22-1.9
63. World Bank. (2023). Migration: Leveraging human capital in the east Asia and pacific region – a companion piece to the world development report 2023: Migrants, Refugees, and Society. Retrieved from https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099020325194013546
64. World Bank. (2024a). *Worldwide Governance Indicators (WGI)* [Data set]. Retrieved from https://databank.worldbank.org/source/worldwide-governance-indicators
65. World Bank. (2024b). *Global Financial Development Database* [Data set]. Retrieved from https://www.worldbank.org/en/publication/gfdd
66. Zarutska, O., & Sitnicki, M. W. (2026). Risk profiling of Ukrainian banks through structural-functional groups: Evidence from Kohonen self-organizing maps. *Financial Markets, Institutions and Risks, 10*(2), 182-207. https://doi.org/10.61093/fmir.10(2).182-207.2026
67. Zhidebekkyzy, A., Sansyzbayeva, K., Ashirbekova, L., & Imreh-Tóth, M. (2026). AI-driven public administration: Expert insights on adoption and implementation. *Economics and Sociology, 19*(1), 172-194. https://doi.org/10.14254/2071-789X.2026/19-1/9