“GovTech maturity and digital payment adoption in transition economies: Delayed associations and divergent deployment models”

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GovTech MATURITY AND DIGITAL PAYMENT ADOPTION IN TRANSITION ECONOMIES: DELAYED ASSOCIATIONS AND DIVERGENT DEPLOYMENT MODELS

Abstract

Digital government platforms are expected to accelerate the shift to cashless payments, and banks stand between the two: they hold the accounts that digital credentials open and process the government-to-person and person-to-government flows that digital services generate. Cross-country evidence for transition economies remains scarce and largely contemporaneous. The study aims to determine whether digital government maturity is associated with the uptake of cashless payment instruments contemporaneously or with a delay, and whether the deployment model shapes that association beyond aggregate index scores. Wave panels combining the Global Findex database (2011–2024) with the UN E-Government Development Index for eleven transition economies were estimated using pooled, fixed-effects, between-country, lagged, and first-difference specifications, supplemented by an exploratory annual panel of ATM density and a structured comparison of three deployment models. A strong cross-country association between GovTech maturity and both digital payment adoption (0.551, $p < 0.001$) and account ownership (0.730, $p < 0.001$) did not survive within-country identification: fixed-effects coefficients turned negative and insignificant, so H1-H3 are not supported. With a four-to-five-year lag, the Online Service Index entered positively and significantly in the baseline specification (0.290, $p < 0.05$); as significance is not retained with controls, the evidence is consistent with a delayed association rather than establishing it. Adoption expanded under all three deployment models, from 47% to 85% in Kazakhstan, 48% to 83% in Ukraine, and 12% to 61% in Armenia; what distinguished the cases was the interface between the state and private bank ecosystems, which aggregate indices do not capture.

Keywords financial inclusion, e-government, cashless economy, account ownership, banking infrastructure, panel data, post-socialist countries

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INTRODUCTION

Digital payments have become the most widely used formal financial service: 79% of adults worldwide hold an account at a bank or other regulated provider, up from 51% in 2011, and 61% of adults in low- and middle-income economies made or received a digital payment in 2024, 27 percentage points more than in 2014 (Klapper et al., 2025). Governments contribute directly, since digitized government-to-person transfers, tax payments, and service fees create entry points into formal finance – and those entry points run through banks: a state-issued digital identity serves payments only once a bank accepts it for onboarding, and a digitized transfer reaches a household only through an account a regulated provider operates, so

digital public infrastructure and banking infrastructure are complements. The World Bank benchmarks the former through the GovTech Maturity Index, and the IMF documents the latter through the Financial Access Survey.

The transition economies of Europe and Central Asia share a legacy of cash-dominated retail finance and state-centered administration, yet their digitalization paths have diverged sharply, so different routes to digital government can be compared from a shared starting point. Kazakhstan launched a centralized e-government portal in 2006 and later embedded public services into dominant private banking super-applications (Suominen, 2024); Ukraine consolidated digital government late, creating a dedicated ministry in 2019 and launching in 2020 the Diia platform, which links digital identity to government-to-person and person-to-government payment rails; Armenia introduced individual e-services through the 2010s and adopted a consolidated digitalization strategy only in 2021. For banks, these differences are consequential: digital government platforms shape customer onboarding, the digitization of social transfers, and the demand for cashless instruments.

Whether government digitalization translates into payment system development nevertheless remains unclear. Micro-level program studies yield credible estimates, whereas cross-country evidence rests largely on contemporaneous correlations between aggregate maturity indices and inclusion outcomes, which cannot separate stable differences between countries from changes within them and assume that effects materialize without delay; comparative evidence for the region is scarce and rarely distinguishes the architecture of digital government – centralized, platform-based, or fragmented – from the maturity score a country records. The study asks whether GovTech maturity is associated with the uptake of cashless payment instruments contemporaneously or with a delay, and whether the deployment model shapes that association beyond aggregate scores. Pooled, within-country, between-country, and lagged specifications are estimated on a panel of eleven transition economies; Kazakhstan, Ukraine, and Armenia enter not as the estimation sample but as comparative cases for the three deployment models.

1. LITERATURE REVIEW

The maturity of digital government became a measurable object of comparative research when the World Bank introduced the GovTech Maturity Index as a whole-of-government benchmark covering nearly 200 economies (Dener et al., 2021; Vasconcelos et al., 2025). Studies of the parallel UN E-Government Development Index link e-government maturity to innovation capacity and prosperity (Zambrano-Yépez et al., 2023), show that citizens' digital interaction with public authorities depends on education, age, and income (Suhanyi et al., 2024), identify human development rather than income as the strongest enabler of digital public services at city level (Kuzior et al., 2023a), and treat artificial intelligence as a component of digital governance (Keser & Mudrić, 2026; Lajka et al., 2025). Whether maturity translates into service outcomes is conditional: digital government improves health system performance but affects expenditure efficiency non-linearly (Hrytsenko et al., 2026), and public financial management reforms catalyze good governance (Ntuli et al., 2025). Trust is the recurrent mediator: relationship marketing builds it in the public sector (Litovtseva et al., 2022), institutional trust and governance effectiveness mediate the effect of digital maturity on post-war recovery (Topazly et al., 2026), and ambiguous accountability in automated decision-making undermines it (Hayes & Burrell, 2026). These findings matter for banks because government-to-person and person-to-government payments – the services through which citizens experience digital government – run on bank accounts and payment rails.

The demand-side literature builds on the Global Findex program, which found digital merchant and government payments to be the main drivers of account ownership growth in 2014–2021 (Demirgüç-Kunt et al., 2022): the account at a bank or regulated provider is where digital public infrastructure becomes financial inclusion. Inclusion is linked to social outcomes in the EU (Laskienė et al., 2026), mediates the ef-

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fect of financial literacy on financial well-being (Mangudhla et al., 2025), stimulates growth while institutional-quality effects prove heterogeneous (Marozva et al., 2026), and is measured by multidimensional indices (Sethy, 2024). On the supply side, banks and payment providers decide which rails carry government-generated flows: central bank digital currencies follow country-specific trajectories (Koparan, 2025), fintech market leadership depends on identifiable digital-economy factors (Anguelov & Stoyanova, 2025), LendTech stabilizes consumer finance when bank lending contracts in crises (Waliszewski et al., 2024), and fintech and technological infrastructure jointly support growth (Mustafa, 2025). In transition economies, a structural divide between foreign-invested and state-funded banks persists (Tarasenko et al., 2022), digital personalization of banking products has become a competitive necessity (Rysin et al., 2023), and cash displacement is incomplete – users of electronic payments retain a precautionary demand for cash linked to risk attitudes (Pietrucha & Maciejewski, 2025) – so the network of branches and automated teller machines coexists with banks' digital channels rather than being replaced at once.

Micro-level research identifies perceived usefulness as the main driver of digital banking intentions (Hedau, 2025), security, trust, and perceived benefit as dominant in e-banking adoption elsewhere (Kadri, 2025), usefulness, privacy, trust, and ease of use as raising satisfaction with digital payment services (Thapaliya & Dongol, 2026), and mobile data quality as shaping trust in mobile banking (Malaquias & Hwang, 2025). Inclusion gaps persist within digital finance: older adults remain underserved in AI-driven insurance (Poorna Chandran & Ittimani Tholath, 2025), and regulation, ethics, and price transparency form the research core of digitalized insurance markets (Kuzior et al., 2023b). On capability and risk, lifelong learning preserves human capital in crises (Yeremenko, 2026), mobile smart technologies reshape service delivery (Kostiushko et al., 2025), cybercrime depends on regulation and user competence rather than infrastructure (Yarovenko et al., 2025), cyber resilience in smaller firms requires its own metrics (Deruma, 2025), and user awareness of algorithmic data processing remains low (Wieczorek & Postrzednik-Lotko, 2025).

For the region the evidence is fragmented and mostly single-country: finance digitalization compresses the shadow economy in Ukraine (Bozhenko et al., 2024), digital economy development is directly related to growth in Azerbaijan (Huseynov et al., 2025), digital formats of financial information support analysis and audit (Shygun et al., 2023), and digital remittances sustained the financial resilience of Ukrainian households during the war (Polishchuk et al., 2025), whose macroeconomic costs appear in foreign-trade dynamics (Tsymbal & Demediuk, 2025). Institutional constraints remain binding: corruption and limited economic freedom restrict the institutional convergence of Ukrainian business-service ecosystems with European clusters (Kyzenko et al., 2026), demographic losses and migration create structural labor-market imbalances (Zahorodnia et al., 2026), and accountability erosion with rent-seeking marks declining governance quality (Ugulava, 2026).

A broader literature on technology-enabled services outside finance is drawn on for one purpose: it shows that the effects of digital public services depend on their setting – the conditionality examined here for payments. Anticorruption technology (Yefimenko et al., 2025) and anti-corruption audit (Bezverkhyi et al., 2024), artificial intelligence for energy equity (Kirichok et al., 2025), behavioral incentives for sustainable practices (Burrell et al., 2025), and smart-specialization strategies in regional innovation policy (Vakhovych et al., 2021) all show effects that depend on trust, connectivity, and skills rather than on the technology itself; at firm level the same holds for governance-oriented sustainability practices and financial performance (Shafitranata et al., 2026), sustainability reporting as a corporate social responsibility instrument (Shygun & Bezverkhyi, 2026), uneven inclusive growth across EU members (Saher et al., 2025), and financial constraints stratifying small firms' digital transformation (Sartamorn et al., 2025).

A mechanism links these literatures. Digital government platforms issue the credentials on which payment accounts depend: a verified digital identity supports remote onboarding, electronic documents satisfy know-your-customer requirements without branch visits, government-to-person transfers deliver the first inflow into a new account,

and person-to-government payments give households a recurring reason to transact digitally. Each step requires legal recognition, bank integration, and habituation, and banks are the intermediaries throughout: they decide whether a state credential is accepted for onboarding, hold the account into which the transfer is paid, and operate or connect to the rails over which payments run. The behavioral evidence above suggests why adoption lags – recipients of digitized transfers first verify that their money is safe and only later change how they transact – so a GovTech platform acts on payment behavior through intermediate steps, and its association with adoption should appear with a delay rather than contemporaneously.

Three gaps follow. Most cross-country studies of digital government and financial outcomes rest on contemporaneous correlations, with lag structures rarely modelled; aggregate maturity indices do not distinguish deployment models – centralized portals, platform-based mobile-first ecosystems, or fragmented e-services – so evidence on whether architecture matters is scarce; and the region is represented mainly by single-country case studies rather than comparative panels. Against these gaps, the study tests four hypotheses and examines one comparative question:

H1: GovTech maturity is positively associated with the share of adults making or receiving digital payments.

H2: GovTech maturity is positively associated with account ownership.

H3 (exploratory): The association between GovTech maturity and the physical payment access infrastructure of the banking system is conditional on digital connectivity. Its sign is theoretically ambiguous: digital government may expand the network of physical access points by drawing new users into the formal financial system, or contract it by substituting digital channels for cash withdrawal.

H4: The association between GovTech maturity and digital payment adoption operates with a lag of several years rather than contemporaneously.

CQ (comparative question): Do the trajectories of national payment system development differ across GovTech deployment models, and along which dimensions? The question is descriptive by design and is examined through structured comparison rather than tested by regression.

2. METHOD

2.1. Sample and research design

The study covers eleven transition economies of Europe and Central Asia: Ukraine, Armenia, Kazakhstan, Azerbaijan, Georgia, Moldova, Belarus, Uzbekistan, the Kyrgyz Republic, Tajikistan, and Mongolia (Appendix A). The sample follows the classification of transition economies used by the European Bank for Reconstruction and Development (EBRD, 2024), with three documented exclusions: Russia (breaks in data comparability after 2022), the Baltic states (euro-area members operating within the Single Euro Payments Area, a qualitatively different payment ecosystem), and Turkmenistan (failure to meet the data-coverage criterion, being absent from the IMF Financial Access Survey). Within this panel, Kazakhstan, Ukraine, and Armenia serve as comparative cases rather than as the estimation sample: they are selected following a most-similar-systems logic, sharing a post-socialist institutional legacy and a bank-centered, cash-dominated structure of retail finance while differing in their GovTech deployment models (an early centralized portal, a late platform-based mobile-first model, and fragmented digitalization, respectively), and they represent three sub-regions of the sample. The logic holds the institutional starting point broadly constant but not everything else: the three economies differ in size, in the concentration and ownership structure of their banking sectors, in internet penetration, and in exposure to geopolitical shocks, including the full-scale war in Ukraine from 2022. The comparison therefore treats deployment model as one dimension of variation among several and is used to describe how trajectories differ, not to attribute the differences to the deployment model.

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2.2. Data and variables

Digital payment adoption is measured by the share of adults who made or received a digital payment, and account ownership by the share of adults holding an account, both taken from the Global Findex Database (waves 2011, 2014, 2017, 2021, and 2024; the digital payment indicator is available from 2014 onwards). The Azerbaijani wave fielded in 2022 is treated as the 2021 wave; Belarus lacks the 2021 and 2024 waves, which makes the panel unbalanced. GovTech maturity is proxied by the UN E-Government Development Index and its Online Service Index component, published in eleven editions between 2004 and 2024 and biennially since 2010. Physical payment access infrastructure is measured by the number of automated teller machines per 100,000 adults from the IMF Financial Access Survey (2004–2024); it is the only access-point indicator harmonized across the sample for the full period. It is a measure of the physical access network of the banking system rather than of digital payment adoption, and the annual panel built on it is used as an exploratory complement to the wave panels rather than as a test of the main research question. Control variables – GDP per capita (constant prices, in logarithms), the share of internet users, and urbanization – are taken from the World Development Indicators.

The Online Service Index is used as the primary measure of GovTech maturity, because the composite E-Government Development Index incorporates a telecommunication infrastructure component that overlaps with the internet penetration variable used as a control and as a moderator (Appendix B); specifications based on the composite index are therefore reported as supplementary evidence. Because index editions do not coincide with all Findex waves, index values are linearly interpolated for the 2011, 2017, and 2021 waves and throughout the annual panel; the 2014 and 2024 waves and all lagged specifications use original edition values. Interpolation is a limitation of the annual panel in particular, where the explanatory series is mechanically smoothed between biennial editions; the level estimates on that panel are accordingly read as auxiliary evidence, and the first-difference estimates on index-edition years, which contain no interpolated values, as the more informative of the two.

2.3. Empirical strategy

Hypotheses H1 and H2 are tested on wave panels (eleven countries and four to five waves; 42 and 53 observations, respectively). The baseline two-way fixed-effects specification is

$$y_{it} = \beta \cdot OSI_{it} + \gamma^{'X_{it}} + \alpha_i + \lambda_t + \varepsilon_{it}, \qquad (1)$$

where y_{it} denotes digital payment adoption (*H1*) or account ownership (*H2*) in country i and wave t; X_{it} is a vector of controls; α_i and λ_t are country and wave fixed effects; and standard errors are clustered by country. Three nested variants are estimated: pooled ordinary least squares, in which the fixed effects are replaced by a constant; two-way fixed effects; and fixed effects with controls. A fourth variant replaces the contemporaneous index with the latest edition released before each wave, a lag of one to two years. Between-country specifications on country means (N = 11) isolate the cross-sectional component of the association. Hypothesis *H3* is examined in an exploratory capacity on the annual panel (212 observations; 210 in the interaction specification) by augmenting equation (1) with an interaction between the mean-centered Online Service Index and mean-centered internet penetration, with automated teller machines per 100,000 adults as the dependent variable; because that variable measures the physical access network rather than digital payments, the interaction tests whether digital government is associated with changes in physical banking infrastructure, a question adjacent to, not identical with, the main research question.

The robustness package includes: replacing the Online Service Index with the composite index; measuring GovTech maturity with a four-to-five-year lag, which provides the test of *H4*; leave-one-country-out estimation; the exclusion of the Ukrainian observations from the 2021 and 2024 waves, which may be affected by the war; and first-difference specifications for changes between consecutive waves. The four-to-five-year lag is defined by a structural rule: the lagged regressor is the latest index edition released at least four years before each wave, so that it predates not only the wave being explained but also the preceding Findex wave, and the horizon is bracketed by prior evidence on the time digitized transfers need to change payment behavior, from about two years for savings habits (Bachas et al., 2021) to about six

years for the poverty effects of mobile money (Suri & Jack, 2016). The complete set of alternative lags of one to two, eight, and ten years and a lead of the index is reported in Appendix D, so that the lag structure can be assessed as a whole rather than at the reported horizon alone. The comparative question is examined through a structured comparison of the payment adoption and GovTech trajectories of the focal countries against verified reform milestones, without regression analysis. Given the small number of clusters and the observational nature of the data, all estimates are interpreted as associations rather than causal effects.

Three threats to identification are acknowledged. First, causality may run in the opposite direction: a developed payment system may itself raise the demand for digital public services and the fiscal capacity to build them. Second, unobserved and slow-moving factors – institutional trust, banking competition, the pace of regulatory reform – may drive both series. Third, GovTech maturity is itself highly persistent, which leaves limited within-country variation to exploit. With eleven countries, dynamic panel and instrumental-variable estimators are not feasible, and no credible external instrument is available. Three partial remedies are therefore used: lagged specifications, which break strict simultaneity; placebo tests on longer lags and on a lead of the index, reported in Appendix D; and first differences on index-edition years only, which remove interpolated values. Multicollinearity is not a concern in the estimated specifications (maximum variance inflation factor 2.39). Cross-sectional dependence is rejected in the annual panel (Pesaran CD test, $p = 0.43$), so standard errors clustered by country are the appropriate choice, but with eleven clusters their asymptotic justification is weak. Inference therefore does not rely on the normal approximation: p-values and significance levels are assessed against the t distribution with $G - 1 = 10$ degrees of freedom, a standard small-cluster correction, which raises the 5% critical value from 1.96 to 2.23 and treats as insignificant several coefficients that the asymptotic approximation would accept. Two further conservative rules apply: substantive conclusions rest only on coefficients that are significant at the 5% level in the baseline specification and retain their sign and magnitude across the robustness package, and marginal results (p between 0.05 and 0.10) are reported but not counted as support for any hypothesis. The estimates on which the conclusions rest clear the small-cluster threshold by a margin, with t-ratios of 5.8 and 7.2 for the pooled estimates and 3.1 for the lagged estimate, whereas coefficients with t-ratios between 1.96 and 2.23 are reported as insignificant. Panel unit-root tests indicate that the level of ATM density is non-stationary even with country-specific trends (Im–Pesaran–Shin, $p = 1.00$), while the Online Service Index is borderline ($p = 0.11$); the annual panel is therefore also estimated in first differences.

3. RESULTS

3.1. Descriptive overview

Table 1 reports descriptive statistics for both panels. Digital payment adoption ranges from 9% to

Table 1. Descriptive statistics

Source: Authors' calculations based on the Global Findex Database (World Bank, 2025), the IMF Financial Access Survey (IMF, 2026a), the UN E-Government Development Index (UN, 2024), and the World Development Indicators (World Bank, 2026).

Variable	N	Mean	SD	Min	Median	Max
Panel A. Wave panel (11 countries, 2011–2024)						
Digital payments (% adults)	42	0.52	0.23	0.09	0.50	0.97
Account ownership (% adults)	53	0.51	0.25	0.03	0.53	0.98
EGDI	53	0.62	0.14	0.34	0.61	0.90
OSI	53	0.57	0.20	0.06	0.60	0.99
GDP per capita (log)	53	8.11	0.67	6.70	8.25	9.38
Internet users (%)	53	57.81	24.87	12.50	59.71	93.39
Urban population (%)	53	54.19	14.66	26.18	57.02	77.02
Panel B. Annual panel (11 countries, 2004–2024)						
ATMs per 100,000 adults	212	45.37	28.16	0.61	42.19	119.39
OSI (interpolated)	212	0.50	0.21	0.04	0.53	0.99
GDP per capita (log)	212	8.03	0.69	6.43	8.14	9.31
Internet users (%)	210	46.71	29.01	0.30	48.13	94.26

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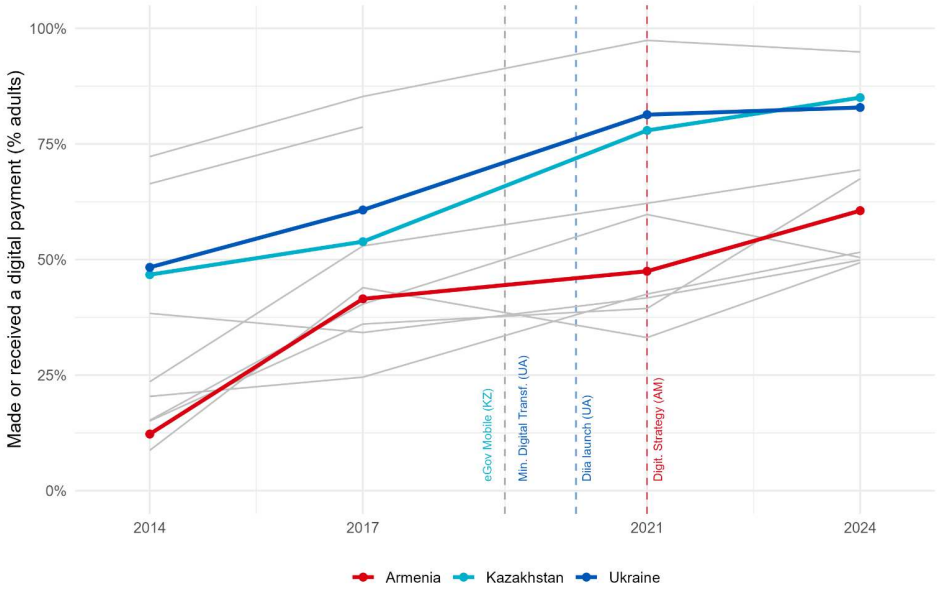
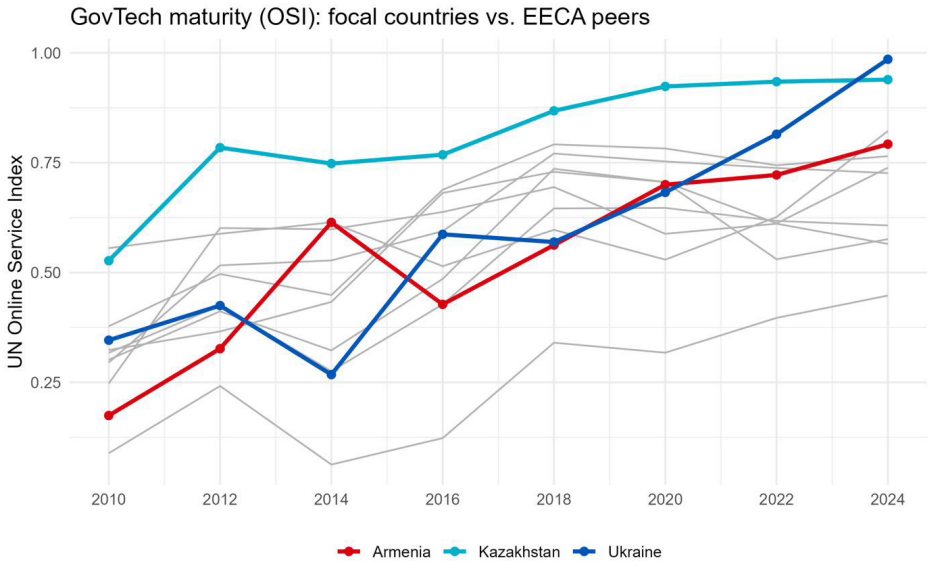
Source: Authors' calculations based on the Global Findex Database (World Bank, 2025); milestones from the Ministry of Digital Transformation of Ukraine (2020), the Government of Armenia (2021), and the Electronic Government of the Republic of Kazakhstan (2026).



Note: Solid lines show the three focal countries; grey lines show the eight remaining transition economies of the sample (Appendix A). Vertical dashed lines mark the GovTech milestones that fall within the observation window: the launch of the eGov Mobile application of Kazakhstan and the creation of the Ministry of Digital Transformation of Ukraine (both 2019, marked by a single grey line), the launch of the Diia portal and mobile application (February 2020), and the adoption of the consolidated Digitalization Strategy of Armenia (February 2021). The centralized eGov.kz portal of Kazakhstan was launched in 2006, before the observation window, and is therefore not marked. The digital payment indicator is available from the 2014 wave onwards; the Azerbaijani wave fielded in 2022 is treated as the 2021 wave, and Belarus lacks the 2021 and 2024 waves.

Figure 1. Digital payment adoption in the focal countries against the regional background, 2014–2024

Source: Authors' calculations based on the Online Service Index component of the UN E-Government Development Index (editions 2010–2024).



Note: Solid lines show the three focal countries; grey lines show the eight remaining transition economies of the sample (Appendix A). Index values are shown for the survey editions published between 2010 and 2024, when the survey became biennial; the interpolated values used in the annual panel are not displayed.

Figure 2. GovTech maturity (Online Service Index) in the focal countries against the regional background, 2010–2024

97% of adults, reflecting the 2014–2024 span and cross-country heterogeneity. Figure 1 traces the focal countries against the sample: Ukraine and Kazakhstan start from the upper half of the distribution (48% and 47% of adults in 2014) and reach 83% and 85% by 2024, with Kazakhstan closing and reversing the initial gap to Ukraine, while Armenia starts from 12% and shows the steepest growth in the trio, reaching 61% by 2024.

Figure 2 shows the corresponding GovTech trajectories: Kazakhstan records the highest Online Service Index in every edition from 2012 to 2022 (0.75-0.93) before Ukraine overtakes it in 2024 (0.99 against 0.94); Ukraine follows a J-shaped path, falling to 0.27 in 2014 and rising to 0.99 by 2024; Armenia is volatile, sharing the second-highest score in 2014 (0.61), falling to 0.43 in 2016, and rising to 0.79 by 2024. Digital payment adoption and account ownership move almost in lockstep (r = 0.99; Appendix B), so the two indicators carry similar information.

3.2. Panel estimates

Table 2 reports the estimates for digital payment adoption. In the pooled specification (column 1), the Online Service Index coefficient is 0.551 ($p < 0.001$): an index 0.1 points higher corresponds on average to a 5.5 percentage-point higher share of adults using digital payments. With country and wave fixed effects (columns 2–3), the coefficient turns negative and indistinguishable from zero (–0.187; column 2), as does the one-to-two-year lag (column 4); the between-country estimates (columns 5-6) are imprecise at $\underline{N}$ = 11, falling from 0.435 to 0.120 once income is controlled for.

Account ownership shows the same pattern (Table 3): a strong pooled association (0.730, $p < 0.001$) disappears under fixed effects (within $R^2 = 0.008$), and the between-country estimate falls from 0.496 to 0.128 with income controlled for, neither significant at N = 11. Table 4 reports the exploratory annual-panel estimates for physical payment access infrastructure: the Online Service Index is insignificant throughout, as is its interaction with internet penetration (column 3), and only GDP per capita among the controls is significant (5% level, interaction specification). *H1* and *H2* are therefore not supported at the contemporaneous within-country level, and the exploratory evidence on *H3* does not indicate that the association is conditional on connectivity; the GovTech coefficient is moreover negative in every within-country specification, consistent with substitution rather than expansion of banks' physical access-point network. The robustness analysis below tests *H4*.

Table 2. GovTech maturity and digital payment adoption (H1)

Source: Authors' calculations based on the Global Findex Database (World Bank, 2025), the UN E-Government Development Index, and the World Development Indicators (World Bank).

	Pooled	FE	FE+ctrl	FE, lag 1-2y	Between	Betw+GDP
OSI	0.551***	–0.187	–0.211		0.435	0.120
	(0.095)	(0.105)	(0.147)		(0.259)	(0.503)
OSI (lag 1-2y)				–0.209		
				(0.167)		
log GDP pc			–0.014			0.095
			(0.192)			(0.105)
Internet users			–0.001			
			(0.001)			
Urban			–0.008			
			(0.013)			
Constant	0.179*				0.281	–0.319
	(0.073)				(0.154)	(0.584)
Observations	42	42	42	42	11	11
R^2	0.226	0.927	0.929	0.926	0.114	0.181
R^2 within		0.062	0.092	0.050		

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. DV: made or received a digital payment (% adults). SE clustered by country (1)–(4), heteroskedasticity-robust (5)–(6).

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Table 3. GovTech maturity and account ownership (H2)

Source: Authors' calculations based on the Global Findex Database 2025 (World Bank), the UN E-Government Development Index, and the World Development Indicators (World Bank).

Variable	Pooled	FE	FE+ctrl	Between	Betw+GDP
OSI	0.730***	–0.069	–0.086	(0.267)	0.128
	(0.101)	(0.129)	(0.156)		(0.468)
log GDP pc			0.019		0.112
			(0.119)		(0.096)
Internet users			–0.003		
			(0.001)		
Urban			–0.017		
			(0.011)		
Constant	0.101			0.243	–0.457
	(0.074)			(0.155)	(0.541)
Observations	53	53	53	11	11
R^2	0.345	0.934	0.942	0.133	0.216
R^2 within		0.008	0.136		

Note: * p < 0.05, ** p < 0.01, *** p < 0.001. DV: account ownership (% adults). SE clustered by country (1)–(3), heteroskedasticity-robust (4)–(5).

Table 4. GovTech maturity and payment infrastructure: levels and first differences (H3)

Source: Authors' calculations based on the IMF Financial Access Survey (IMF, 2026a), the UN E-Government Development Index, and the World Development Indicators (World Bank).

Variable	FE	FE+ctrl	Interaction	FD, editions	FD, ed.+ctrl
OSI	–11.639	–15.645			
	(17.359)	(18.191)			
OSI (centered)			–22.545		
			(15.350)		
Internet users (centered)			0.175		
			(0.429)		
OSI × Internet			0.754		
			(0.610)		
ΔOSI (editions)				–5.947	–9.651
				(7.934)	(6.912)
log GDP pc		38.442	57.289*		
		(18.311)	(20.063)		
Urban		–0.189	–0.932		
		(1.845)	(1.949)		
Δ log GDP pc					61.381**
					(15.023)
Δ Internet users					0.062
					(0.161)
Num.Obs.	212	212	210	99	97
R^2	0.806	0.824	0.836	0.004	0.182
R^2 within	0.007	0.102	0.166		

Note: * p < 0.05, ** p < 0.01, *** p < 0.001. DV: ATMs per 100,000 adults, in levels in columns (1)–(3) and in first differences in columns (4)–(5). Columns (1)–(3) are estimated on the annual panel 2004–2024 with country and year fixed effects. Columns (4)–(5) are estimated in first differences of all variables, taken between consecutive index editions only, so that no interpolated index values enter; differencing removes country fixed effects, with year fixed effects retained. Standard errors are clustered by country throughout.

3.3. Robustness checks

Table 5 reports the robustness analysis. The contemporaneous within-country null persists: the composite E-Government Development Index yields a fixed-effects coefficient that is, if anything, negative (column 1), and the first-difference estimate for simultaneous changes is negative and significant (–0.305, $p < 0.05$; column 5), so waves of faster GovTech improvement coincided with slower adoption. The pooled association is stable to the exclusion of any single country (0.505-0.613, all significant at the 1% level; Appendix C) and of the Ukrainian 2021 and 2024 observations. First differences on index-edition years, which remove both the non-stationarity of the levels and every interpolated observation, leave the coefficient of the change in the Online Service Index negative in both specifications and, with controls, marginally significant (–12.079 and –15.588, $p < 0.10$; columns 4-5 of Table 4; $N = 99$ and 97).

Power is limited and treated as such: with 42 observations and eleven clusters, a formal power analysis would require simulation under assumptions about the within-country error structure that the data cannot pin down, so no claim is made that the within-country null is adequately powered against an association of the size observed across countries. Two observations nevertheless bear on its interpretation: the within-country coefficients are not merely imprecise but negative in every specification, arguing against a large positive contemporaneous association, and in the annual panel the change in income per capita is precisely estimated (46.818, $p < 0.05$) alongside the null GovTech coefficient, so the specification can detect associations it is designed to find. The contemporaneous null is therefore read as absence of evidence for a short-run within-country association, not as evidence of its absence.

Hypothesis *H4* is tested by longer-lag specifications. With GovTech maturity at a four-to-five-year lag, the fixed-effects coefficient of the Online Service Index is positive and significant (0.290, $p < 0.05$; column 2), a t-ratio of 3.1 against the small-cluster critical value of 2.23. The estimate

Table 5. Lagged and first-difference specifications (H4)

Source: Authors' calculations based on the Global Findex Database 2025 (World Bank), the UN E-Government Development Index, and the World Development Indicators.

Variable	EGDI, FE	OSI lag 4-5y, FE	lag 4-5y + ctrl	EGDI lag 4-5y, FE	FD	FD, lagged
EGDI	–0.749					
	(0.343)					
OSI (lag 4-5y)		0.290*	0.281			
		(0.094)	(0.191)			
EGDI (lag 4-5y)				0.933***		
				(0.198)		
ΔOSI					–0.305*	
					(0.118)	
ΔOSI (previous)						0.092
						(0.083)
log GDP pc			0.091			
			(0.160)			
Internet users			< 0.001			
			(0.002)			
Observations	42	42	42	42	31	20
R^2	0.932	0.931	0.932	0.938	0.209	0.036
R^2 within	0.129	0.116	0.126	0.204	0.107	0.012

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. DV: digital payment adoption in columns (1)–(4) and its change between consecutive waves in columns (5)-(6). The lag denotes the latest index edition released at least four years before each wave, a lag of four to five years. Country and wave fixed effects in columns (1)-(4); columns (5)-(6) are estimated in first differences, which allows for the elimination of country fixed effects, with wave fixed effects retained. Standard errors are clustered by country.

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is stable under leave-one-country-out estimation (0.240-0.358; Appendix C), falling just short of conventional significance only without Georgia ($p = 0.058$) and remaining significant without any single focal country (0.277 without Ukraine, 0.283 without Armenia, 0.332 without Kazakhstan; $p \leq 0.041$), so the delayed association does not rest on one case. It is virtually unchanged with income and internet penetration controlled for (0.281; column 3), although the standard error doubles and conventional significance is lost, as expected in a 42-observation panel with collinear regressors. The composite-index estimate is much larger (0.933, $p < 0.001$, within $R^2 = 0.20$; column 4) but embeds a telecommunication component strongly correlated with internet penetration ($r = 0.88$; Appendix B); the lagged first-difference estimate is positive but insignificant on the reduced sample (column 6). The evidence is thus consistent with a delayed association at a four-to-five-year horizon, although not significant in the most demanding specifications.

Appendix D locates the association in time. At an eight-year lag, the coefficient collapses to 0.030, and the within R^2 falls from 0.116 to 0.002; at ten years it turns negative (–0.081); a common slow-moving trend would produce a stable coefficient at any lag, whereas the association is confined to a four-to-five-year window. A placebo lead, using the next edition to explain adoption already observed, yields 0.108 with a standard error of 0.202: future maturity does not predict past adoption, as reverse causality would imply. The evidence is therefore read as consistent with *H4* rather than establishing a four-to-five-year effect, since the baseline lagged coefficient is significant but significance is not retained with controls or in the lagged first-difference specification.

3.4. Comparative trajectories

The three focal countries entered the window with a shared post-socialist legacy and a similar bank-centered, cash-dominated retail finance structure (EBRD, 2024), yet followed distinct GovTech deployment models. Kazakhstan represents the early centralized model: the eGov.kz portal was launched in 2006 and extended with eLicense.kz from 2012, and the eGov Mobile application from 2019 (Electronic Government of the Republic of Kazakhstan, 2026), so a mature one-stop-shop infrastructure predates the window. Ukraine represents the late platform-based, mobile-first model: after the Ministry of Digital Transformation was created in 2019, the Diia portal and application were launched on 6 February 2020 (Ministry of Digital Transformation of Ukraine, 2020), digital documents gained legal equivalence to physical ones in August 2021 (President of Ukraine, 2021), and the platform reached 9.5 million active users within two years (ITU, 2021). Armenia followed a fragmented path, introducing individual e-services during the 2010s without a unifying platform (Prime Minister of the Republic of Armenia, 2020) and adopting a consolidated digitalization strategy only in February 2021 (Government of Armenia, 2021).

Figure 1 sets the adoption trajectories against these models. Kazakhstan's early GovTech leadership coincides with a persistently high position in the sample distribution and with the closing and reversal of the gap to Ukraine by 2024; its fastest expansion (6.0 percentage points a year) fell in 2017–2021, between phases of 2.4 points a year in 2014–2017 and 2021–2024, and by 2021 more than 7 million people, about half the adult population, reached public services through the Kaspi.kz super-app (Suominen, 2024), one of two proprietary bank ecosystems dominating retail payments (IMF, 2026b). Ukrainian adoption was already among the highest in the sample before Diia, and its pace changed only moderately across the launch – 4.1 points a year in 2014–2017 against 5.2 in 2017–2021 – before flattening to 0.5 in 2021–2024, consistent with a platform entering an environment shaped by prior financial-sector digitalization rather than creating it, although with waves in 2017 and 2021 the launch cannot be separated from the pandemic. Armenia, without a unified platform for most of the period, shows the steepest growth from a low base: 9.7 points a year in 2014–2017, well before the 2021 strategy, then 1.5 in 2017–2021 and 4.4 in 2021–2024, the fastest in the trio in that interval; as real GDP per capita rose by about a quarter over 2021–2024 (World Bank, 2026), the renewed acceleration cannot be attributed to the strategy. Index scores and adoption diverge most in the Armenia–Ukraine pair: almost identical Online Service Index values in 2018 (0.56 and 0.57) and 2020 (0.70 and 0.68), yet

47% against 81% adoption in the 2021 wave. The comparative question is thus answered at the descriptive level: payment system development proceeded under all three deployment models, and convergence was not proportional to aggregate maturity scores. The trajectories are descriptions rather than effects of the deployment model, since the countries also differ in economic size, banking-market structure, internet penetration, and exposure to shocks, which the comparison cannot separate from deployment architecture; the delayed association observed under H4 is consistent with the Kazakhstani sequence of early leadership followed by sustained adoption, and with the expectation that the payment effects of Ukraine's post-2019 surge would materialize at the end of, or beyond, the observation window.

4. DISCUSSION

Three strands of prior evidence frame the results. In ASEAN banking, digital governance matters for commercial banks' financial performance, yet only the telecommunication component of the composite index is significantly associated with returns on assets (Nguyen, 2025) – consistent with the pooled estimates here, and with the between-country specifications suggesting that much of the raw association reflects the joint dependence of GovTech maturity and payment adoption on economic development. Micro-level evidence contrasts: biometric digitalization of government-to-person payments produced faster, less corrupt transfers in a randomized rollout (Muralidharan et al., 2016), so causal effects identifiable at program level need not surface in contemporaneous national aggregates.

The within-country null and the negative first-difference estimate also have counterparts. For thirteen MENA economies, the contemporaneous effect of financial inclusion on growth is insignificant, with causality running from growth to inclusion (Chehayeb & Taher, 2024), a caution against reading short-run co-movements causally. The negative coefficients echo the substitutability effect in developing economies, where reliance on mobile technologies diminishes the relevance of traditional financial infrastructure (Azmeh & Al-Raeei, 2024): ATM density appears to track the legacy access network rather than payment digitalization, which is why H3 was left undirected. The delayed association is grounded in both sides: institutionally, e-government development shows strong path dependence (autoregressive coefficient 0.43; Samarkhanov et al., 2025), leaving little within-country variation for contemporaneous identification; behaviorally, recipients of digitized transfers first used the instrument to build trust in the bank, accumulating savings of 2% of annual income only after two years (Bachas et al., 2021), while the poverty effects of mobile money emerged across six years (Suri & Jack, 2016). A four-to-five-year horizon sits between these benchmarks, and the timing profile as a whole – associations null or negative at up to two years, positive at four to five, absent at eight and ten – marks four to five years as the shortest window at which an association becomes visible, not an optimal evaluation period.

The comparative trajectories show why an aggregate index cannot capture what distinguished the cases: the effects of digital finance depend on the configuration of providers, users, and regulation rather than on technology as such (Ozili, 2018), and the index scores the supply of online services, not the channel through which citizens reach them. Kazakhstan's decade-long index lead coexisted with a retail payment market built around proprietary bank ecosystems rather than a state channel (IMF, 2026b; Suominen, 2024); Ukrainian adoption plateaued at a high level during the full-scale war, in line with digital remittances sustaining household finances in wartime (Polishchuk et al., 2025); Armenian adoption advanced without a unified platform, consistent with citizens' digital interaction with public authorities depending on education, age, and income (Suhanyi et al., 2024), which the index does not measure. As the cases differ in more than deployment architecture, the comparison describes the divergence without attributing it to the deployment model alone.

Four implications follow for the banking system. For commercial banks, customers onboarded through a digital identity platform become active payment users only after habituation, so the return on accepting state credentials and disbursing government transfers lies in the deposit and transaction base built over several years – and a bank ecosystem can itself become the channel for public

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services, as the Kazakhstani case shows. For central banks, annual payment indicators are no verdict on digital public infrastructure, and expanding digital public services should coincide with a thinning, not a growth, of the physical access network. For banking regulators, the interface between state credentials and bank onboarding, and the interoperability of government payment rails with bank and wallet infrastructure, are the levers distinguishing trajectories with comparable index scores. For payment providers, a fragmented digital government, as in Armenia, does not preclude rapid adoption where private providers supply the missing channel, but leaves the onboarding gains of a unified credential unrealized.

Several limitations follow. Within-country tests on eleven countries and at most five waves have limited power, and inference with eleven clusters rests on a finite-cluster adjustment and on the consistency of estimates across specifications; index values are interpolated throughout the annual panel and for three of five waves, which is why that panel is exploratory, and its dependent variable measures physical access points rather than cashless use; the Belarusian panel is incomplete; the Ukrainian observations from 2021 onwards embody shocks no control fully captures; the lagged estimate loses conventional significance without Georgia and with controls; and the comparison cannot separate deployment architecture from differences in economic size, banking structure, and war exposure. The estimates are therefore associations, and the lagged specification is the most policy-relevant description of the data rather than a causal effect.

CONCLUSION

This study examined whether digital government maturity is related to national payment system development across eleven transition economies, with Kazakhstan, Ukraine, and Armenia as comparative cases for three deployment models.

A strong cross-country association between GovTech maturity and digital payment adoption (0.551, $p < 0.001$) and account ownership (0.730, $p < 0.001$) did not survive within-country identification: under fixed effects, the coefficients turned negative and insignificant (–0.187), as did the exploratory infrastructure interaction, so *H1-H3* are not supported. With a four-to-five-year lag, the Online Service Index entered positively and significantly in the baseline specification (0.290, $p < 0.05$), vanishing at longer lags and for a lead; as significance is not retained with controls, the evidence is consistent with *H4* rather than establishing it. Adoption expanded under all three deployment models – from 47% to 85% in Kazakhstan, 48% to 83% in Ukraine, and 12% to 61% in Armenia – so the comparative question is answered affirmatively at the descriptive level, without attributing differences to the deployment model.

For GovTech appraisal, within-country associations are null or negative at horizons of up to two years, positive at four to five, and absent at eight and ten, so a one-to-two-year evaluation cycle would record no payment effect where one may still be forming. Four to five years is therefore the shortest window at which such effects become visible – a lower bound for national strategies, donor programs, and disbursing banks, to be confirmed as Findex waves accumulate.

Aggregate maturity scores are weak guides to payment policy. What distinguished the focal cases was the interface between the state and private payment infrastructure: Kazakhstan embedded public services into bank super-applications, whereas Ukraine built government payment rails into a unified mobile platform. That interface – credential acceptance, transfer disbursement, and rail interoperability – is built inside the banking system and may be more actionable than index rankings.

A measurement gap also limits within-country identification: harmonized retail cashless statistics are unavailable for most of the region, and comparable annual series per adult from central banks and statistical agencies would enable credible evaluation.

AUTHOR CONTRIBUTIONS

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DATA AVAILABILITY STATEMENT

All data analyzed in this study were obtained from publicly available sources and can be accessed without restriction. Digital payment adoption and account ownership are from the Global Findex Database 2025 (World Bank, 2025), using country-level series for all adults across the survey waves of 2011, 2014, 2017, 2021 and 2024, with the digital payment indicator available from 2014 onwards. Digital government is measured by the E-Government Development Index and its Online Service Index component from the United Nations E-Government Survey (UN, 2024), drawing on the eleven editions published between 2004 and 2024; because these editions do not coincide with all Findex waves, index values are linearly interpolated between adjacent editions for the 2011, 2017 and 2021 waves and throughout the annual panel, while the 2014 and 2024 waves and all lagged specifications use original edition values. Payment infrastructure is measured by the number of automated teller machines per 100,000 adults from the Financial Access Survey (IMF, 2026a). Macroeconomic and structural controls – individuals using the Internet, GDP per capita in constant 2015 US dollars and urban population – are from the World Development Indicators (World Bank, 2026), retrieved through the World Bank application programming interface. The sample follows the classification of transition economies used by the European Bank for Reconstruction and Development (EBRD, 2024). All datasets were retrieved on 10 July 2026. The analysis was carried out in R 4.3.3 within a project-level renv environment, with estimation in fixest and tables produced with modelsummary; the assembled panels and Quarto notebooks reproducing all tables, figures, and appendices are available from the corresponding author upon reasonable request.

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APPENDIX A

Table A1. Sample composition

Source: IMF Financial Access Survey (IMF, 2026a).

Country	ISO3	Sub-region	Income group	Role	Findex waves	ATM years
Ukraine	UKR	Eastern Europe	Upper middle income	Focal (MSSD)	4	21
Armenia	ARM	South Caucasus	Upper middle income	Focal (MSSD)	4	21
Kazakhstan	KAZ	Central Asia	Upper middle income	Focal (MSSD)	4	19
Azerbaijan	AZE	South Caucasus	Upper middle income	Comparison	4	19
Belarus	BLR	Eastern Europe	Upper middle income	Comparison	2	21
Georgia	GEO	South Caucasus	Upper middle income	Comparison	4	21
Kyrgyz Republic	KGZ	Central Asia	Lower middle income	Comparison	4	21
Moldova	MDA	Eastern Europe	Upper middle income	Comparison	4	21
Mongolia	MNG	East Asia	Upper middle income	Comparison	4	17
Tajikistan	TJK	Central Asia	Lower middle income	Comparison	4	20
Uzbekistan	UZB	Central Asia	Lower middle income	Comparison	4	11

Note: Income groups follow the World Bank classification. Findex waves report the number of waves with a non-missing digital payment indicator; ATM years report the number of annual observations of ATMs per 100,000 adults.

APPENDIX B. Correlation matrices

Table B1. Correlation matrix: wave panel

Panel A. Wave panel (11 countries, 2011–2024)							
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Digital payments	1.00						
(2) Account ownership	0.99	1.00					
(3) EGDI	0.62	0.69	1.00				
(4) OSI	0.48	0.59	0.90	1.00			
(5) log GDP per capita	0.37	0.44	0.60	0.58	1.00		
(6) Internet users	0.38	0.48	0.88	0.74	0.52	1.00	
(7) Urban population	0.56	0.57	0.42	0.36	0.65	0.26	1.00

Note: Pairwise correlations. The near-unity correlation between digital payment adoption and account ownership (0.99) indicates that accounts in these economies are actively used. The correlation between the composite E-Government Development Index and internet penetration (0.88) reflects the telecommunication infrastructure component embedded in the composite index, which motivates the use of the Online Service Index as the primary measure of GovTech maturity.

Table B2. Correlation matrix: annual panel

Panel B. Annual panel (11 countries, 2004–2024)						
Variable	**ATMs per 100k**	**OSI**	**EGDI**	**log GDP pc**	**Internet users**	**Urban**
ATMs per 100k	1					
OSI	.64	1				
EGDI	.72	.92	1			
log GDP pc	.50	.55	.58	1		
Internet users	.61	.77	.89	.48	1	
Urban	.48	.35	.44	.67	.25	1

Note: Pairwise correlations, 212 country-year observations. The correlation between the composite E-Government Development Index and internet penetration (0.89) mirrors the overlap documented for the wave panel and reinforces the use of the Online Service Index as the primary measure of GovTech maturity.

APPENDIX C

Table C1. Leave-one-country-out estimation

Country excluded	OSI (pooled)	SE	p	OSI (FE, lag 4-5y)	p (lag)
Ukraine	0.539	0.120	0.001	0.277	0.014
Armenia	0.558	0.100	< 0.001	0.283	0.041
Kazakhstan	0.517	0.127	0.003	0.332	0.004
Azerbaijan	0.557	0.102	< 0.001	0.298	0.028
Belarus	0.613	0.074	< 0.001	0.287	0.013
Georgia	0.556	0.096	< 0.001	0.275	0.058
Kyrgyz Republic	0.505	0.097	0.001	0.262	0.018
Moldova	0.548	0.102	< 0.001	0.291	0.022
Mongolia	0.527	0.107	0.001	0.283	0.043
Tajikistan	0.534	0.162	0.009	0.240	0.030
Uzbekistan	0.599	0.083	< 0.001	0.358	0.002

Note: Each row reports the coefficient of the Online Service Index re-estimated with the indicated country excluded. Columns 2–4 correspond to the pooled specification (Table 2, column 1); columns 5-6 to the two-way fixed-effects specification with a four-to-five-year lag (Table 5, column 2). Standard errors are clustered by country. Dependent variable: share of adults who made or received a digital payment.

APPENDIX D

Table D1. Placebo tests on the timing of the association

Specification	OSI coefficient	Std. error	Within R2	N
Lag 4-5 years (baseline)	0.290*	0.094	0.116	42
Placebo: lag 8 years	0.030	0.116	0.002	42
Placebo: lag 10 years	-0.081	0.062	0.020	42
Placebo: lead (next edition)	0.108	0.202	0.015	32

Note: Fixed-effects estimates of digital payment adoption on the Online Service Index measured at different lags. The baseline uses the latest index edition released at least four years before each wave. Placebo lags use editions released at least eight and ten years before each wave; the placebo lead uses the first edition released at least two years after each wave. Country and wave fixed effects throughout; standard errors clustered by country. * $p < 0.05$.

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