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FinTech and Financial Stability: Risk Channels, Resilience, and Regulatory Trade-offs

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Abstract
This study examines the impact of FinTech on financial stability, with the aim of clarifying through which channels digital financial innovation strengthens or weakens resilience, and under which institutional conditions. Its objectives are to (i) synthesise four risk channels into a testable framework, (ii) measure digital-finance adoption consistently across the European Union and (iii) estimate its association with bank solvency, asset quality and systemic stress. Methodologically, a Digital Finance Adoption Index (DFAI) is constructed from Eurostat data on internet banking and online purchasing (the first principal component explains 93.3% of their joint variance) for the 27 member states over 2008–2025. The index is related to bank Z-scores, non-performing loan (NPL) ratios and the European Central Bank's country-level Composite Indicator of Systemic Stress (CISS) in two-way fixed-effects panels with Driscoll–Kraay standard errors, lagged regressors, an interaction with regulatory quality and eight robustness checks. The results show that adoption has converged strongly (the cross-country coefficient of variation of internet banking fell from 0.69 to 0.23), although Romania and Bulgaria remain the least digitalised. Higher adoption is associated with lower NPL ratios (a one within-country standard deviation increase corresponds to roughly 37% lower NPLs) and with lower systemic stress in the euro area. Its association with bank solvency is conditional: it is significantly negative where regulatory quality is weak (WGI estimate below about 0.7, including Romania, Bulgaria, Croatia, Greece and Italy) and turns positive above about 1.3. These relationships are absent in first differences and partly sensitive to country-specific trends, which indicates slow-moving structural rather than short-run effects. The paper concludes that FinTech's net effect on stability is conditional on governance, and that the European regulatory response, from DORA to MiCA and the AI Act, should be complemented by investment in supervisory capacity where institutional quality lags behind digital adoption.
Keywords: *FinTech; financial stability; systemic risk; regulatory quality; non-performing loans; European Union*

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1. Introduction

Financial technology has moved from the periphery to the core of the European financial system. In 2025, a median of 78% of individuals in the European Union used internet banking, compared with 25% in 2008, and the share of individuals purchasing online grew from 13% to 63% over the same period. Payments, credit scoring, compliance and an increasing part of risk management are now delivered through digital infrastructures, often provided by a small number of technology firms. This transformation raises a classic question in a new form: does financial innovation make the system safer by reducing frictions and broadening diversification, or does it introduce new sources of fragility that supervisors are not yet equipped to monitor?

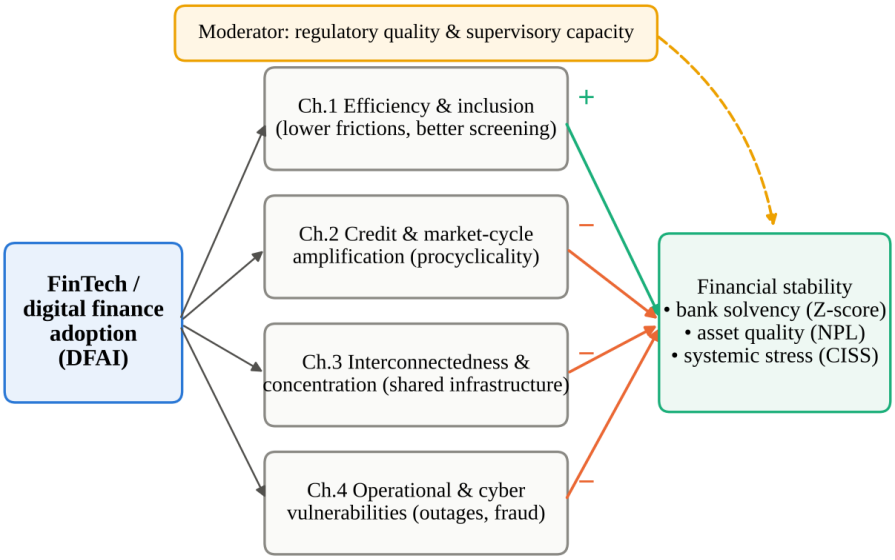
The literature has not converged on an answer. Cross-country evidence ranges from no net effect of FinTech on the fragility of financial institutions, with stabilising effects in emerging markets and destabilising effects in developed ones (Fung, Lee, Yeh & Yuen, 2020), to a stabilising association complemented by bank concentration in a panel of 63 countries (Daud, Ahmad, Khalid & Azman-Saini, 2022), and to an overall negative but statistically insignificant effect in 198 countries, driven by digital lending (Cevik, 2024). Bank-level evidence suggests that a greater FinTech presence is associated with more risk taking by financial intermediaries, but possibly with less risk taking where domestic institutions are stronger (Elekdag, Emrullahu & Ben Naceur, 2024). Policy bodies emphasise new vulnerabilities, including dependence on third-party providers, market correlations, cyber risk and model risk associated with artificial intelligence (Financial Stability Board [FSB], 2024).

This paper contributes to the debate in three ways. First, it organises the mechanisms discussed in the literature into four risk channels, which yield testable predictions for different dimensions of stability. Second, it constructs a transparent and comparable Digital Finance Adoption Index (DFAI) for all 27 member states of the European Union over 2008–2025, a sample that is under-represented in a literature dominated by Chinese and global panels. Third, it tests whether the relationship between adoption and stability is conditional on regulatory quality, and it reports a systematic set of robustness checks, including specifications that challenge the main results. The analysis is particularly relevant for the post-communist member states, where digital adoption is catching up rapidly while institutional quality remains heterogeneous.

2. Risk channels and hypotheses

The framework distinguishes four channels (Figure 1).

Figure 1. Risk channels linking FinTech adoption to financial stability



Source: Author's conceptualisation.

The first is an *efficiency and inclusion channel*. Digital distribution lowers intermediation costs, while alternative data and automated underwriting improve screening and monitoring (Fuster, Plosser, Schnabl & Vickery, 2019; Philippon, 2016). Broader participation diversifies funding and lending bases. This channel predicts better asset quality and, other things equal, stronger bank solvency.

The second is a *credit and market-cycle amplification channel*. Platform lending can grow rapidly outside the prudential perimeter, as illustrated by the shift of mortgage origination towards non-bank FinTech lenders after the global financial crisis (Buchak, Matvos, Piskorski & Seru, 2018). Competitive pressure on incumbents can compress margins and encourage risk taking (Vives, 2019; Thakor, 2020), while FinTech credit may respond differently from bank credit to monetary policy, with lower sensitivity to policy-rate shocks (Cornelli, De Fiore, Gambacorta & Manea, 2024).

The third is an *interconnectedness and concentration channel*. Banks and non-banks increasingly rely on the same cloud providers, application programming interfaces and payment gateways. Such shared infrastructure creates common exposures and single points of failure, and stock-market evidence shows significant risk spillovers between FinTech firms and incumbent institutions (Li, Li, Zhu, Yao & Casu, 2020).

The fourth is an *operational and cyber channel*. Outages, data breaches, fraud and model failures become more material as activity migrates online, and the widespread use of similar artificial intelligence models may increase herding and procyclicality (Daníelsson, Macrae & Uthemann, 2022; FSB, 2024).

The net effect of these channels is theoretically ambiguous, and it is likely to depend on the quality of governance. Strong regulatory and supervisory institutions can capture the efficiency gains of the first channel while containing the externalities of the other three. Three hypotheses follow. *H1*: higher digital-finance adoption is associated with better asset quality (lower NPL ratios). *H2*: the association between adoption and bank solvency is conditional on regulatory quality, being more favourable where

regulatory quality is higher. *H3*: higher adoption is associated with lower systemic stress, through better diversification and faster price discovery, unless the concentration and cyber channels dominate.

A further difficulty in the literature concerns measurement. Supply-side measures, such as FinTech start-up funding (Haddad & Hornuf, 2019) or the volume of FinTech and big tech credit (Cornelli, Frost, Gambacorta, Rau, Wardrop & Ziegler, 2023), capture the size of new providers but are concentrated in a few financial centres and are sensitive to where platforms are domiciled. Studies that use alternative-finance volumes find that the effect on stability depends on the instrument, with digital lending and digital capital raising pointing in different directions (Cevik, 2024). Demand-side measures, based on the share of the population using digital financial services, are less granular but more comparable across countries and closer to the diffusion process through which FinTech reshapes incumbent banks. Because most FinTech activity in the European Union is channelled through, or in partnership with, licensed banks, a demand-side measure is particularly appropriate for a European panel.

3. Data and methodology

3.1. Sample and variables

The panel covers the 27 member states of the European Union from 2008 to 2025. Table 1 defines the variables and reports descriptive statistics. All series were retrieved from the original providers' application programming interfaces on 31 October 2026 and were verified by checksums after processing.

Table 1. Variables, sources and descriptive statistics (EU-27, 2008–2025)

Variable	Source (code)	Obs.	Mean	S.D.	Min – Max
Bank Z-score	World Bank GFDD (GFDD.SI.01)	376	14.30	9.78	−0.33 – 57.44
NPL ratio (%)	World Bank (FB.AST.NPER.ZS)	447	6.12	7.31	0.15 – 47.75
CISS (annual mean, 10 EA countries)	ECB, CISS (SS_CIN)	180	0.14	0.14	0.01 – 0.60
Internet banking (% individuals)	Eurostat (isoc_ci_ac_i, I_IUBK)	485	51.99	24.81	1.52 – 97.76
Online purchases, last 3 months (%)	Eurostat (isoc_ec_ibuy; isoc_ec_ib20)	485	40.70	21.26	1.67 – 87.47
DFAI (standardised units)	Authors, from Eurostat	485	0.00	0.97	−1.94 – 1.97
Regulatory quality	World Bank WGI	486	1.10	0.49	0.11 – 2.07
Real GDP growth (%)	World Bank WDI	486	1.70	3.95	−16.04 – 24.62
Inflation (%)	World Bank WDI	486	2.67	3.16	−4.45 – 19.70
GDP per capita, PPP (const. 2021 $)	World Bank WDI	486	49,745	22,000	21,251 – 136,772
Private credit (% GDP)	World Bank WDI	451	83.11	42.56	22.07 – 254.67
Bank capital/assets (%)	World Bank (FB.BNK.CAPA.ZS)	448	7.55	2.32	−1.26 – 15.05
Bank concentration (%)	World Bank GFDD (GFDD.OI.01)	378	70.75	15.95	28.56 – 98.73

Note: The Z-score and bank concentration are available until 2021. Sources: Eurostat (2026); World Bank (2026a, 2026b); European Central Bank (2026); author's calculations.

Digital-finance adoption is measured with two Eurostat indicators that are available for all member states on a harmonised basis: the share of individuals using internet banking and the share of individuals who made online purchases in the previous three months. Internet banking captures the migration of retail banking relationships to digital channels; online purchasing captures the diffusion of digital payments. The two indicators are highly correlated (r = 0.87). A principal component analysis on their standardised values shows that the first component explains 93.3% of the joint variance, with identical loadings (0.71), so the DFAI is defined as the average of the two standardised indicators. Compared with indices based on FinTech start-up funding or alternative-finance volumes, this measure reflects the demand side of adoption, is available annually for all countries and is not distorted by the domicile of large platforms.

Financial stability is measured along three dimensions. Bank solvency is captured by the bank Z-score, which compares the buffer of capital and returns with the volatility of returns, so that a higher value indicates a lower probability of insolvency (Laeven & Levine, 2009; Lepetit & Strobel, 2013); it is available from the World Bank's Global Financial Development Database until 2021. Asset quality is measured by the ratio of non-performing loans to gross loans (World Bank, available until 2025), used in logarithms. Systemic stress is measured by the country-level CISS of the European Central Bank (Holló, Kremer & Lo Duca, 2012), averaged over each year from daily data for the ten euro-area countries for which it is published. Regulatory quality is taken from the Worldwide Governance Indicators (Kaufmann, Kraay & Mastruzzi, 2011). Control variables include real GDP growth, inflation, the logarithm of GDP per capita, domestic credit to the private sector, bank concentration (in the Z-score models) and the bank capital-to-assets ratio (in the NPL models).

3.2. Empirical strategy

The baseline specification is a two-way fixed-effects panel model:

$$S_{it} = \beta \cdot DFAI_{i,t-1} + \theta \cdot (DFAI \times RQ^{c})_{i,t-1} + \gamma \cdot RQ_{i,t-1} + \delta' X_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it} \qquad (1)$$

where S is one of the stability measures for country i in year t, X is the vector of controls, μ are country fixed effects and λ are year fixed effects. Country effects absorb time-invariant differences in financial structure, while year effects absorb common shocks, such as the sovereign debt crisis, the pandemic and the monetary tightening of 2022–2023. All regressors are lagged by one year to reduce simultaneity. In the interaction term, the superscript c denotes regulatory quality centred on its sample mean (1.10), so that β measures the association at average regulatory quality and θ measures how it changes with regulatory quality. The marginal effect of adoption, $\beta + \theta(RQ - 1.10)$, is evaluated across the observed range of regulatory quality (Brambor, Clark & Golder, 2006). Standard errors follow Driscoll and Kraay (1998), which are robust to heteroskedasticity, serial correlation and cross-sectional dependence, an important property in a monetary union exposed to common shocks.

Two further design choices deserve mention. First, the lag structure does not remove all endogeneity concerns, since unobserved country-specific trends could drive both digital adoption and bank stability. For this reason, the robustness analysis adds country-specific linear trends and estimates the model in first differences and in non-overlapping three-year averages, which separate short-run from structural associations.

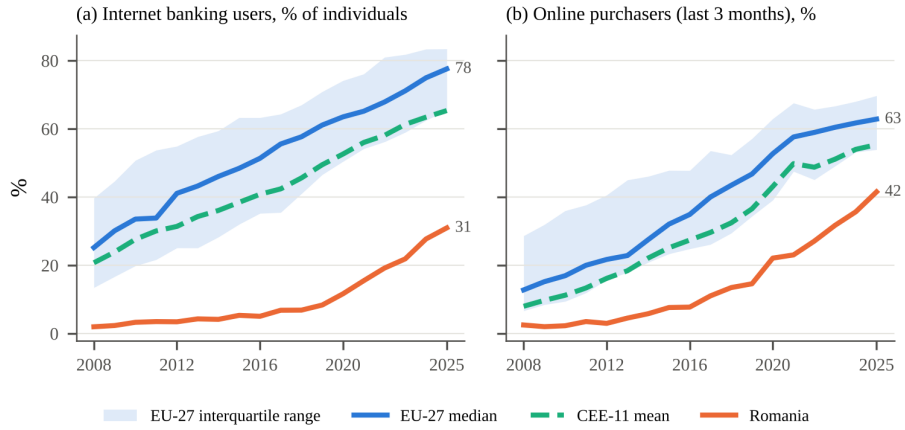
Second, because the post-communist member states share a common history of rapid financial deepening through foreign bank ownership, an interaction between the DFAI and an indicator for the eleven Central and Eastern European members is used to test whether the adoption–stability relationship differs in this group beyond what regulatory quality explains.

4. Results

4.1. Stylised facts

Figure 2 documents the diffusion of digital finance. Adoption has increased in every member state, and dispersion has declined sharply: the coefficient of variation of internet banking fell from 0.69 in 2008 to 0.23 in 2025. The eleven Central and Eastern European member states have narrowed the gap with the EU median, with average internet-banking use rising from 21% to 65%. Romania, however, remains at the bottom of the distribution: only 31% of individuals used internet banking in 2025, the lowest value in the Union (Bulgaria 31.1%, Denmark 97.6%), although online purchasing has accelerated to 42%. Over the same period, asset quality improved markedly, with the median NPL ratio falling from 8.0% in 2013 to 2.1% in 2024. This co-movement in trends is precisely why the econometric strategy relies on year effects and on robustness checks with country-specific trends.

Figure 2. Diffusion of digital finance in the European Union, 2008–2025



Note: CEE-11 = Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. Source: Author's representation based on Eurostat (2026).

4.2. Baseline estimates

Table 2 reports the main estimates. For bank solvency, the unconditional association between lagged adoption and the Z-score is negative but statistically insignificant (columns 1–2). Once the interaction with regulatory quality is introduced (column 3), the interaction term is positive and highly significant ($\theta = 3.71$, $p < 0.01$): the association between adoption and solvency becomes more favourable as regulatory quality improves, in line with H2.

Table 2. Digital finance adoption and financial stability: baseline estimates

	(1) Z	(2) Z	(3) Z	(4) ln NPL	(5) ln NPL	(6) CISS	(7) CISS
DFAI (t−1)	−1.137	−0.656	−0.775	−0.746***	−0.614***	−0.051***	−0.031
	(2.280)	(1.659)	(1.340)	(0.118)	(0.106)	(0.019)	(0.027)
Regulatory quality (t−1)			4.685***		−0.584***		−0.092**
			(1.733)		(0.163)		(0.045)
DFAI × RQ (t−1, centred)			3.712***		0.340***		0.065**
			(0.970)		(0.087)		(0.028)
GDP growth (t−1)		0.202*	0.157**	−0.016	−0.008	−0.001	0.001
		(0.104)	(0.065)	(0.012)	(0.011)	(0.001)	(0.002)
Inflation (t−1)		0.241***	0.174*	0.012	0.014	0.000	−0.001
		(0.093)	(0.103)	(0.010)	(0.011)	(0.007)	(0.006)
ln GDP per capita (t−1)		−13.561***	−13.008***	−2.748***	−2.836***	0.185**	0.083
		(2.035)	(2.528)	(0.376)	(0.334)	(0.089)	(0.087)
Private credit/GDP (t−1)		−0.004	−0.010	0.003**	0.004***	0.001***	0.001***
		(0.010)	(0.010)	(0.001)	(0.001)	(0.000)	(0.000)
Bank concentration (t−1)		−0.023	−0.001				
		(0.023)	(0.018)				
Capital/assets (t−1)				0.100***	0.087***		
				(0.013)	(0.013)		
Observations	348	340	340	409	409	168	168
Countries	27	27	27	27	27	10	10
Period (dependent var.)	2009–2021	2009–2021	2009–2021	2009–2025	2009–2025	2009–2025	2009–2025
R^2 (within, two-way)	0.004	0.113	0.194	0.504	0.540	0.255	0.323
Country and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Two-way fixed-effects estimates; Driscoll–Kraay standard errors in parentheses; **, , denote significance at 1%, 5% and 10%. Regulatory quality is centred on its sample mean (1.10). Source: Author's estimations.

For asset quality, higher adoption is associated with significantly lower NPL ratios (column 4). The coefficient of −0.75 implies that a one within-country standard deviation increase in the DFAI (0.63) corresponds to an NPL ratio that is about 37% lower in the following year, which supports H1. The positive interaction in column 5 indicates that this association is strongest in countries with weaker regulatory quality, where the initial stock of bad loans and the potential gains from better screening were largest.

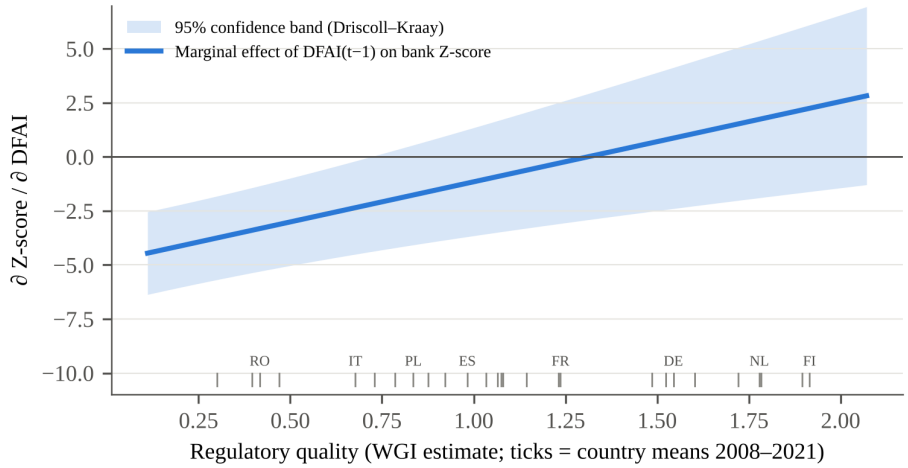
For systemic stress, adoption is associated with a lower CISS in the euro-area subsample (column 6). A one within-country standard deviation increase corresponds to a reduction of about 0.03 points, roughly a fifth of the sample mean, which supports H3. When the interaction is included (column 7), the main effect loses significance and the interaction becomes positive, suggesting that the stress-reducing association is concentrated in euro-area countries with lower regulatory quality, mainly in the southern periphery.

The control variables behave plausibly. Real GDP growth is positively associated with the Z-score (0.16, $p < 0.05$), and domestic credit to the private sector is positively associated with both NPL ratios and systemic stress, consistent with the view that rapid credit expansion is a leading indicator of vulnerability. The capital-to-assets ratio is positively associated with subsequent NPL ratios, which is likely to reflect the fact that banks with weaker loan books were required to hold, or chose to hold, larger buffers. The strong negative coefficient on GDP per capita in the Z-score and NPL models captures within-country convergence in income and should not be interpreted causally.

4.3. Conditional effects: the role of regulatory quality

Figure 3 plots the marginal effect of adoption on the Z-score across the range of regulatory quality. The effect is negative and statistically significant at the 5% level for regulatory-quality values below about 0.71, a range that includes Croatia, Greece, Romania, Bulgaria and Italy over 2008–2021. It crosses zero at about 1.31 and becomes positive, though imprecisely estimated, in the Nordic countries, the Netherlands, Germany and Ireland. For Romania (average regulatory quality 0.42), the estimated marginal effect is about −3.3 Z-score units per unit of the DFAI. Expressed in terms of a one within-country standard deviation of adoption, this corresponds to a decline of about 2.1 units, roughly 15% of the sample mean Z-score. An additional specification shows that the solvency association is also more negative in the Central and Eastern European member states beyond what regulatory quality explains (interaction with a CEE indicator: −2.87, $p = 0.02$), while no such difference exists for NPL ratios (−0.02, $p = 0.84$).

Figure 3. Marginal effect of digital finance adoption on bank solvency, conditional on regulatory quality



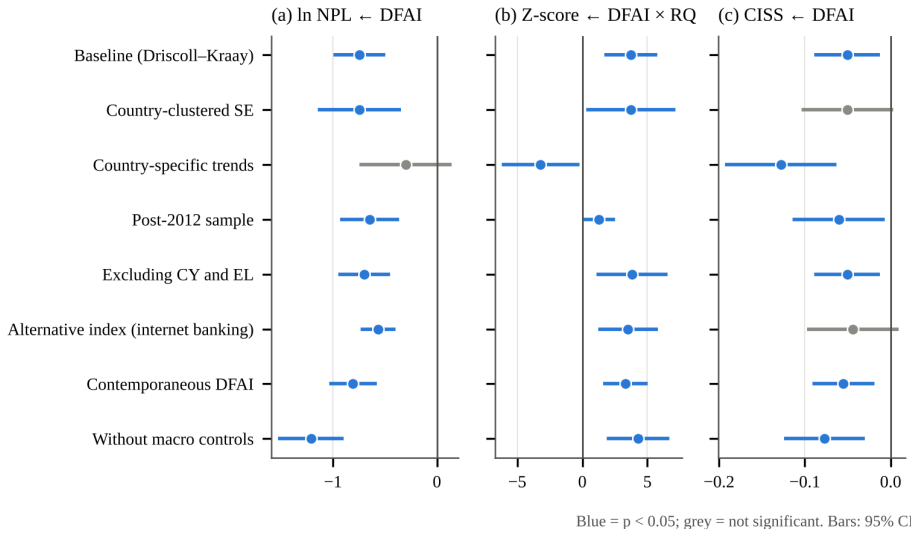
Note: Based on column (3) of Table 2. Source: Author's estimations.

4.4. Robustness

Figure 4 summarises eight robustness checks for the three key estimates: country-clustered instead of Driscoll–Kraay errors, country-specific linear trends, a post-2012 sample excluding the global financial and sovereign debt crises, the exclusion of Cyprus and Greece (the countries with the most extreme NPL ratios), an alternative index based

on internet banking only, contemporaneous instead of lagged adoption and the omission of macroeconomic controls.

Figure 4. Robustness of the key estimates



Note: Point estimates and 95% confidence intervals; panel (a) DFAI coefficient in the ln NPL model, panel (b) DFAI × RQ interaction in the Z-score model, panel (c) DFAI coefficient in the CISS model. Source: Author's estimations.

Three findings stand out. First, the NPL association is robust in sign and significance to every check except country-specific trends, under which it falls to −0.30 (p = 0.17); it also survives in non-overlapping three-year averages (−0.72, p = 0.05). Second, the stress-reducing association is robust, and it even strengthens with country-specific trends (−0.13, $p < 0.01$), although it becomes marginal with clustered errors (p = 0.06) or with the narrower index (p = 0.09). Third, the regulatory-quality interaction for bank solvency is robust to all checks except country-specific trends, under which it reverses sign (−3.21, p = 0.03). In first differences, none of the three associations is significant.

These results have a clear interpretation. The relationships identified are not short-run, year-to-year effects, but structural associations embedded in the medium-term trajectories of countries. Member states with strong institutions have combined rapid digitalisation with improving solvency, whereas member states with weaker institutions have digitalised without a comparable strengthening of bank buffers. Once each country's own linear trend is removed, the remaining deviations do not reproduce this pattern. The evidence is therefore consistent with a conditional, governance-dependent relationship between FinTech and stability, but it does not support a causal interpretation at short horizons.

5. Discussion: resilience and regulatory trade-offs

The results help to reconcile the mixed findings in the literature. The positive association with asset quality is consistent with the efficiency and inclusion channel, while the conditional association with solvency echoes the bank-level evidence that FinTech presence is associated with less risk taking where institutions are stronger (Elekdag, Emrullahu & Ben Naceur, 2024). The heterogeneity between emerging and developed

markets reported by Fung et al. (2020) may partly reflect differences in institutional quality rather than in the level of development as such.

For European policy, the findings point to three trade-offs. The first concerns *innovation versus prudential perimeter*. The Markets in Crypto-Assets Regulation (Regulation (EU) 2023/1114) and the planned revision of the payment services framework extend regulation to new activities, but supervisory resources determine whether the new rules are enforced proportionately. Where regulatory quality is low, the gains in asset quality from digital adoption appear to coexist with weaker solvency, which suggests that the efficiency channel is not matched by a corresponding strengthening of capital buffers.

The second trade-off concerns *efficiency versus concentration*. The Digital Operational Resilience Act (Regulation (EU) 2022/2554), applicable since January 2025, introduces an oversight framework for critical information and communication technology third-party providers. This addresses the interconnectedness and operational channels directly, but its effectiveness depends on the analytical capacity of national authorities, which our results suggest is most needed precisely where it is weakest. The Instant Payments Regulation (Regulation (EU) 2024/886) will further increase the speed of fund transfers, which supports efficiency but also accelerates potential deposit outflows in stress episodes.

The third trade-off concerns *automation versus model risk*. The Artificial Intelligence Act (Regulation (EU) 2024/1689) classifies creditworthiness assessment as a high-risk use and imposes governance obligations. The FSB (2024) highlights third-party concentration, market correlations, cyber risk and model risk as the main AI-related vulnerabilities. These risks are not yet visible in aggregate indicators such as Z-scores and NPL ratios, which reinforces the need for granular supervisory data.

The specific vulnerability of the Central and Eastern European member states also deserves attention. In these countries, digital banking has largely been introduced by subsidiaries of Western European banking groups, which often operate group-wide platforms and outsource technology services to the parent bank or to the same global providers. Digitalisation therefore tends to deepen operational dependencies on entities located outside the host jurisdiction, at the same time as it improves retail efficiency. This structure may explain why the solvency association is more negative in the region even after controlling for regulatory quality, and it gives host supervisors a strong interest in the cross-border cooperation mechanisms foreseen by DORA.

For Romania and other member states in the low-regulatory-quality range, the implication is not to slow digital adoption, which brings inclusion and asset-quality benefits, but to sequence it with investment in supervisory technology, cyber-resilience testing and data-sharing between financial and digital authorities. Proportionality should be understood as matching supervisory capacity to the speed of digital change, rather than as lighter rules for smaller markets.

Four practical recommendations follow from the analysis. First, national authorities should monitor digital adoption together with stability indicators, since the relationship between them depends on institutional conditions that differ across member states. Second, supervisory capacity, including data analytics and cyber-resilience expertise, should be treated as a macroprudential resource and expanded where digital adoption is growing fastest. Third, the European Supervisory Authorities could publish harmonised indicators of bank dependence on critical third-party providers, which would allow the concentration channel to be measured directly. Fourth, financial-inclusion strategies in the least digitalised member states, including Romania, should be

accompanied by consumer-protection and fraud-prevention measures, so that broader access does not translate into higher operational risk.

6. Conclusions

This paper examined the relationship between FinTech and financial stability in the European Union over 2008–2025. It proposed a framework of four risk channels and measured digital-finance adoption with a transparent index based on harmonised Eurostat data. Three conclusions emerge. First, digital-finance adoption has converged strongly across the Union, but Romania and Bulgaria remain clear laggards. Second, higher adoption is associated with lower NPL ratios and with lower systemic stress in the euro area, consistent with an efficiency and resilience channel. Third, the association with bank solvency is conditional on regulatory quality: it is negative where governance is weak and positive where it is strong. FinTech's net effect on stability is therefore neither positive nor negative in itself; it depends on whether institutions evolve as quickly as technology.

The analysis has limitations. The adoption index captures retail usage rather than FinTech firms' balance sheets, crypto-asset exposures or cloud concentration, for which harmonised data are not yet available. The Z-score series ends in 2021, the CISS is available only for ten euro-area countries and the associations are not robust to all specifications, notably country-specific trends and first differences. Future research should combine supervisory micro-data on bank–FinTech exposures with quasi-experimental designs around the implementation of DORA, MiCA and the Instant Payments Regulation, in order to move from conditional associations towards causal evidence.

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