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DIGITAL TRANSFORMATION AND THE BANKING MARKET: FRIEND OR FOE? A COUNTRY-LEVEL STUDY

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Abstract

Countries' digital transformation continues and yet the impact on the banking sector is unknown. This uncertainty might become even worse if banks start to compete among themselves to get ahead of digital lending and payment platforms. Competition among banks leads to lower lending rates and increased deposit rates. These smaller margins might lead to instability in the banking sector. We address the impact of digital transformation and bank competition on banking sector stability by looking at country-level data from 48 Asian economies. We integrate the moderating role of bank competition into the picture. The findings suggest that digital transformation leads to banking sector stability while bank competition results in banking sector fragility. During high competition within the banking sector, digital transformation lessens the overall banking sector stability and as competition declines, the relationship moves towards insignificance after falling below a moderate level of competition. These findings carry important policy implications. Countries should have control over banking sector competition and should at the same time move towards digital transformation to achieve larger goals like financial inclusion. Lower competition helps to avoid any negative impacts from digital transformation in a country.

Keywords: *digital transformation, competition, banking, asia, stability, digital era*

I. INTRODUCTION

Over the past few years, the digital transformation have progressed at an exponential rate. Global investment in financial innovation provides further proof of this. A KPMG report stated a US$31 billion increase in investment from 2008 to 2017, with compound annual growth of 46.5%.[1] The digital

[1] International KPMG, "The Pulse of Fintech 2018 Biannual Global Analysis of Investment in Fintech," 2019, https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2019/02/the-pulse-of-fintech-2018.pdf.

transformation industry serves as the gateway to technological modernisation of the financial sector, presenting various opportunities for start-up companies and other new businesses. Amongst its vast applications, cryptocurrency, crowdfunding, mobile trading, digital wallets, peer-to-peer lending, and smart contracts are some of the more commonly known examples.[2] Along with these advancements, there has been an emerging controversy amongst industry regulators regarding the effects of digital transformation on the stability of financial systems. However, it needs to be emphasiseemphasised that there is a lack of literature on this matter, and analysis of digital transformation is generally focused on its sub-divisions rather than the whole picture.[3] Moreover, no research has explicitly addressed how financial stability is affected due to these transformations. At the same time, the rapid rise in investment and piqued interest of regulators affirms that digital innovations demand attention. This undoubted gap in the literature on digital transformation and its impact on the fragility of financial institutions motivates this study.

Digital transformations can positively impact and diminish the threat of financial instability through decentralisation, enhanced transparency, diversification, improved efficiency, and convenience. FSB[4] asserts that mitigating financial shock is possible through decentralisation and other scholars[5] suggest

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[2] Christian Haddad and Lars Hornuf, "The Emergence of the Global Fintech Market: Economic and Technological Determinants," *Small Business Economics* 53 (2016): 81, https://doi.org/10.2139/ssrn.2830124; Andrea Minto, Moritz Voelkerling, and Melanie Wulff, "Separating Apples from Oranges: Identifying Threats to Financial Stability Originating from FinTech," *Capital Markets Law Journal* 12, no. 4 (2017): 428–65, https://doi.org/10.1093/cmlj/kmx035; Asghar Zardkoohi et al., "Managerial Risk-Taking Behavior: A Too-Big-To-Fail Story," *Journal of Business Ethics* 149, no. 1 (2018): 221–33, https://doi.org/10.1007/s10551-016-3133-7; Mark Carlson and Jonathan Rose, "The Incentives of Large Sophisticated Creditors to Run on a Too Big to Fail Financial Institution," *Journal of Financial Stability* 41 (2019): 91–104, https://doi.org/10.1016/j.jfs.2019.03.004; Derrick W.H. Fung et al., "Friend or Foe: The Divergent Effects of FinTech on Financial Stability," *Emerging Markets Review* 45 (2020): 100727, https://doi.org/10.1016/j.ememar.2020.100727; Mudeer Ahmed Khattak et al., "Competition, Diversification, and Stability in the Indonesian Banking System," *Buletin Ekonomi Moneter Dan Perbankan* 24 (2021): 59–88, https://doi.org/10.21098/bemp.v24i0.1481.

[3] Ajay Agrawal, Christian Catalini, and Avi Goldfarb, "Crowdfunding: Geography, Social Networks, and the Timing of Investment Decisions," *Journal of Economics & Management Strategy* 24, no. 2 (2015): 253–74, https://doi.org/10.1111/jems.12093; Huda Qasim and Emad Abu-Shanab, "Drivers of Mobile Payment Acceptance: The Impact of Network Externalities," *Information Systems Frontiers* 18, no. 5 (2015): 1021–34, https://doi.org/10.1007/s10796-015-9598-6; Paresh Kumar Narayan et al., "Bitcoin Price Growth and Indonesia's Monetary System," *Emerging Markets Review* 38 (2019): 364–76, https://doi.org/10.1016/j.ememar.2018.11.005.

[4] FSB, "FinTech and Market Structure in Financial Services: Market Developments and Potential Financial Stability Implications." 2019, Financial Stability Board: 1–37. https://www.fsb.org/wp-content/uploads/P140219.pdf.

[5] Efpraxia D. Zamani and George M. Giaglis, "With a Little Help from the Miners: Distributed Ledger Technology and Market Disintermediation," *Industrial Management & Data Systems* 118, no. 3 (2018): 637–52, https://doi.org/10.1108/imds-05-2017-0231.

digital transformation as an efficient method of decentralisation in peer-to-peer lending systems. Through digital transformations, higher financial market diversity leads to economic stability.[6] The FSB reports that financial stability is increased if banks offer convenient services through digital transformations such as artificial intelligence, machine learning, and robo-advisors to reinforce their business models.[7] For instance, countries with low financial inclusion can embrace digital transformation to decrease the size of the informal sector since such populations tend to favour mobile phones over traditional bank accounts. Digital transformations do not have a universal effect on the stability or instability of financial systems; instead, the impact is market specific.

Introducing such transformations promotes financial stability in emerging economic markets, whereas financial instability is observed in previously developed and established markets. Analysis of capital adequacy, portfolio risk, and profitability confirms that digital transformation impacts the fragility of institutions through by the impact on profitability. Higher profitability is achieved through such transformations in emerging markets; therefore, an intelligent approach to adopting this development is necessary under current market circumstances. At the same time, developed markets need to devise strategies to counter the impact of financial fragility caused by digital innovations in the future.[8]

On the other hand, financial stability can be disrupted if digital transformations lead to volatility, contagion, and procyclicality in a financial market. Kirilenko and Lo argued that algorithmic trading amplifies the adverse effects on stock markets, making a financial system more vulnerable and volatile.[9] They present five cases from 2007 to 2012 to support this statement and demonstrate how algorithmic trading destabilises financial stability. Furthermore, excessive herd mentality on trading platforms can cause asset price swings and amplified market procyclicality.[10] Others argue that mature, high-value, and state-owned banks are more negatively affected by the digital transformation than younger, lower-valued, and private banks.[11]

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[6] Samuel Guérineau and Florian Léon, "Information Sharing, Credit Booms and Financial Stability: Do Developing Economies Differ from Advanced Countries?" *Journal of Financial Stability* 40 (2019): 64–76, https://doi.org/10.1016/j.jfs.2018.08.004.

[7] FSB, "FinTech and Market Structure".

[8] Derrick W.H. Fung et al., "Friend or Foe: The Divergent Effects of FinTech on Financial Stability," *Emerging Markets Review* 45 (2020): 100727, https://doi.org/10.1016/j.ememar.2020.100727.

[9] Andrei A Kirilenko and Andrew W Lo, "Moore's Law versus Murphy's Law: Algorithmic Trading and Its Discontents," *Journal of Economic Perspectives* 27, no. 2 (2013): 51–72, https://doi.org/10.1257/jep.27.2.51.

[10] Roland Gemayel and Alex Preda, "Does a Scopic Regime Produce Conformism? Herding Behavior among Trade Leaders on Social Trading Platforms," *The European Journal of Finance* 24, no. 14 (2017): 1144–75, https://doi.org/10.1080/1351847x.2017.1405832.

[11] Dinh Hoang Bach Phan et al., "Do Financial Technology Firms Influence Bank Performance?," *Pacific-Basin Finance Journal* 62 (2020): 101210, https://doi.org/10.1016/j.pacfin.2019.101210.

The results are robust with different compositions of the panels of firms. Some emphasise that risk-taking and failure to assess the creditworthiness of borrowers is a significant concern in peer-to-peer lending.[12] This is because such lenders are not as well equipped or efficient as banks to deal conveniently with high-risk projects without causing financial instability. Such lenders may fail to accurately price default risk and reward very high-risk projects with low prices for capital, leading to financial instability. Another factor to be considered is the systemic risk posed by dependence on third-party service providers (for example, cloud-based services) that inevitably link to multiple systemically prominent financial institutions, and their failure could cause systemic damage to financial stability. For example, in 2017, the operations of Apple, Inc., technology start-ups, universities, and the U.S. Securities and Exchange Commission were disrupted due to the failure of Amazon Web Services.[13]

After evaluating the pros and cons of digital transformation's implications for financial stability, there is no detailed study on banking system fragility. As digital transformation may have both positive and negative impacts on the stability of the banking sector, and the role of bank competition is never explored in this regard, this study aims to examine the impact of digital transformation on the stability of the banking sector considering the moderating role of bank competition. The rest of the paper is structured as follows: Section II presents the data, methodology and summary statistics, Section III presents the results and discussion, and this is followed by conclusions and policy recommendations.

II. DATA AND VARIABLE DESCRIPTION

Two different datasets are used to explore the impact of competition and digital transformation on banking risk. The two datasets are global financial development and world development indicators, both sourced from the World Bank Data Catalogue. The sample includes 48 countries in Asia for the period 2011-2017. The main advantage of having panel data settings over cross-section and time-series settings is that panel data allows the advancement of technology through time across a large sample of countries. To further explore any possible difference between emerging and developed countries,

[12] Andreas Mild, Martin Waitz, and Jürgen Wöckl, "How Low Can You Go? — Overcoming the Inability of Lenders to Set Proper Interest Rates on Unsecured Peer-To-Peer Lending Markets," *Journal of Business Research* 68, no. 6 (2015): 1291–1305, https://doi.org/10.1016/j.jbusres.2014.11.021.

[13] Andrea Minto, Moritz Voelkerling, and Melanie Wulff, "Separating Apples from Oranges: Identifying Threats to Financial Stability Originating from FinTech," *Capital Markets Law Journal* 12, no. 4 (2017): 428–65, https://doi.org/10.1093/cmlj/kmx035.

the sample is split into higher and lower-income countries. We used the World Bank classification[14] for countries according to income levels. For simplicity and to identify applicable subsamples for regression analysis, we consider higher income and upper-middle-income countries as developed economies and countries with lower-middle and lower-Income level countries as emerging economies. Upon classification, our dataset contains 19 emerging and 29 developed economies. Below are the measures of our core elements of the study.

II.A.1. Risk

Zscore is widely used as a proxy for the probability of default of a country's banking system (*FR*). World Bank defines zscore as an empirical value that:

> *captures the probability of default of a country's banking system. Z-score compares the buffer of a country's banking system (capitalisation and returns) with the volatility of those returns. It is estimated as (ROA+(equity/assets))/sd(ROA); sd(ROA) is the standard deviation of ROA. ROA, equity, and assets are country-level aggregate figures Calculated from underlying bank-by-bank unconsolidated data from Bankscope.*

Zscore has been previously used in various cross-country studies.[15]

II.A.2. Bank Competition

Bank competition has garnered immense attention since the global financial crisis. However, the impact of bank competition, along with digital transformation on risk, still lacks evidence. We try to fill this gap by using a country-level measure of market power, the Lerner Index, as a proxy for lack of competition. Since the Lerner index is an inverse measure of competition, the coefficient of the Lerner index will be interpreted otherwise. World bank states that:

> the Lerner index indicates a deterioration of the competitive conduct of financial intermediaries. *A measure of market power in the banking market. It is defined as the difference between output prices and marginal costs (relative to prices). Prices are calculated as total bank revenue over assets, whereas marginal costs are*

[14] Classification can be accessed at: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

[15] Ana I. Fernández, Francisco González, and Nuria Suárez, "Banking Stability, Competition, and Economic Volatility," *Journal of Financial Stability* 22 (2016): 101–20, https://doi.org/10.1016/j.jfs.2016.01.005; Amit Ghosh, "Banking Sector Globalization and Bank Performance: A Comparative Analysis of Low Income Countries with Emerging Markets and Advanced Economies," *Review of Development Finance* 6, no. 1 (2016): 58–70, https://doi.org/10.1016/j.rdf.2016.05.003.

obtained from an estimated translog cost function with respect to output. Higher values of the Lerner index indicate less bank competition. Lerner Index estimations follow the methodology described in Demirgüç-Kunt and Martínez Pería (2010). Calculated from underlying bank-by-bank data from Bankscope.[16]

Some studies have used the Lerner index and competition as indicated by *Lr* in their models. [17]

II.A.3. Digital Transformation

As a proxy for the digital transformation (*DT)* of a given country, we employ the electronic payments used to make payments provided by the World bank's Global Financial Development dataset. The variable developed through a survey every three years is *"the percentage of respondents who used electronic payments (payments that one makes or that are made automatically including wire transfers or payments made online) in the past 12 months to make payments on bills or to buy things using money from their accounts (% age 15+)."* Because the variable is survey-based and only available for the years 2011, 2014, and 2017, we carry forward the values to fill the missing year observations. The variable of electronic payments has been used in the existing literature on technology and financial inclusion.[18]

II.B. Bank sector and Country specific controls

We also employ controls from the banking sector. These include banks' returns on assets *(ROA*), to control for the return on banking assets where banks with higher returns might be exposed to higher risk and might be spending more on technology.[19] Banks' non-interest income to total assets *(NII)* is controlled for banking sector diversification/income structure. Banks' capital to total assets (*CTA*) is also added to the model to control for banking capitalisation. It is

[16] Aslı Demirgüç-Kunt and Soledad Martínez, "A Framework for Analyzing Competition in the Banking Sector: An Application to the Case of Jordan," *World Bank Policy Research Working Paper* 5499 (2010).

[17] Ali Mirzaei and Tomoe Moore, "What Are the Driving Forces of Bank Competition across Different Income Groups of Countries?," *Journal of International Financial Markets, Institutions and Money* 32 (2014): 38–71, https://doi.org/10.1016/j.intfin.2014.05.003; Ike Mathur and Isaac Marcelin, "Institutional Failure or Market Failure?," *Journal of Banking & Finance* 52 (2015): 266–80, https://doi.org/10.1016/j.jbankfin.2014.12.018.

[18] A F Tita and Meschach Jesse Aziakpono, "'The Effects of Financial Inclusion on Welfare in Sub-Saharan Africa: Evidence from Disaggregated Data.,'" *African Review of Economics and Finance* 9, no. 2 (2017): 30–65, https://doi.org/10.1016/j.matdes.2007.02.001; Ashenafi Beyene Fanta and Daniel Makina, "The Relationship between Technology and Financial Inclusion," *Extending Financial Inclusion in Africa*, 2019, 211–30, https://doi.org/10.1016/b978-0-12-814164-9.00010-4.

[19] Yong Tan, "The Impacts of Competition and Shadow Banking on Profitability: Evidence from the Chinese Banking Industry," *The North American Journal of Economics and Finance* 42 (2017): 89–106, https://doi.org/10.1016/j.najef.2017.07.007.

argued that the banking sector with higher capitalisation is more engaged in loans and hence riskier. However, on the other hand, it is also argued that higher capitalised banks are more stable because these banks are better able to sustain systemic shocks. Controlling for macroeconomic characteristics, Gross Domestic Product growth *(GDPg)* and Inflation *(INFL)* are included in the model.

II.C. Econometric Modelling

After setting up the datasets, we employ the following dynamic models to examine the impact of DT and banking competition on banking risk. Before exploring the combined impact of competition and digital transformation on banking risk, we explore the individual impacts of competition and digital transformation on banking risk. For this purpose, we employ two different models (1) and (2) to explore the impact of competition and Digital Transformation on banking risk, respectively.

$$FR_{jt} = \beta_0 + \psi_1 \mathrm{FR}_{jt-1} + \psi_2 \mathrm{Lr}_{jt} + \psi_3 \mathrm{C}_{jt} + \psi_4 \mathrm{Mc}_{jt} + \varepsilon_{jt} \quad (1)$$

$$FR_{jt} = \beta_0 + \Omega_1 \mathrm{FR}_{jt-1} + \Omega_2 \mathrm{DT}_{jt} + \Omega_3 \mathrm{C}_{jt} + \Omega_4 \mathrm{Mc}_{jt} + \varepsilon_{jt} \quad (2)$$

In the above models, *j* and *t* denote country and year, respectively. *FR* indicates the country-level risk. FR_{jt-1} is a one-period lag in the dependent variable to control for the persistence in risk observations. *ET* and *Lr* represent the digital transformation and banking competition in the respective country. *C* indicates the bank-specific control variables and *Mc* denotes the country-specific, macro-economic variables.

To explore any possible differences in the impact of banking competition and digital transformation on banking risk, between emerging and developed countries, the above models are modified with a dummy interaction term. The dummy is equal to 1 for developed countries and 0 otherwise. The significance of the interaction term provides evidence of the difference in the impact of banking competition and digital transformation on banking risk for developed countries.

$$FR_{jt} = \zeta_0 + \Phi_1 \mathrm{FR}_{jt-1} + \Phi_2 \mathrm{Lr}_{jt} + \left(\Phi_3 + \Phi_4 \mathrm{Lr}_{jt}\right)\mathrm{Dev}_{jt} + \Phi_5 \mathrm{C}_{jt} + \Phi_6 \mathrm{Mc}_{jt} + \varepsilon_{jt} \quad (3)$$

$$FR_{jt} = \zeta_0 + \Lambda_1 \mathrm{FR}_{jt-1} + \Lambda_2 \mathrm{Lr}_{jt} + \left(\Lambda_3 + \Lambda_4 \mathrm{DT}_{jt}\right)\mathrm{Dev}_{jt} + \Lambda_5 \mathrm{C}_{jt} + \Lambda_6 \mathrm{Mc}_{jt} + \varepsilon_{jt} \quad (4)$$

In order to estimate the impact of competition with the advancement of technology, the model is modified with an interaction term of competition and technology, and the following model is estimated:

$$FR_{jt} = \beta_0 + \Theta_1 \mathrm{FR}_{jt-1} + \Theta_2 \mathrm{DT}_{jt} + \left(\Theta_3 + \Theta_4 \mathrm{DT}_{jt}\right)\mathrm{Lr}_{jt} + \Theta_5 \mathrm{C}_{jt} + \Theta_6 \mathrm{Mc}_{jt} + \varepsilon_{jt} \quad (5)$$

In the above models, β_0 *and* ζ_0 denote the intercepts. $\psi_{1\text{-}6}, \Omega_{1\text{-}6}, \Phi_{1\text{-}6}, \Lambda_{1\text{-}6}$ *and* $\theta_{1\text{-}6}$ represents the parameters to be estimated and ε_{it} indicates the residuals.

II.D. Statistical Technique

Considering the nature of our final dataset, which involves cross-country heterogeneity, unobserved heterogeneity, persistence in the depended variable and endogeneity issues in the model, the use of traditional panel data estimators (POLS, RE, FE) might produce biased results. One of the solutions to some of the aforementioned problems is to use the instrumental variables in the model. However, it is difficult to find instruments which are highly correlated with the variable but not correlated with the error term. For this reason, this research required a sophisticated regression technique, which should address the issues. Arellano and Bond[20] developed the initial GMM estimator, which is also called the first difference GMM (DGMM). In DGMM the instruments are derived from the lagged values of the regressors, and the variables are modified by differencing. Having said that, in the presence of correlation between instruments and the error term, the lagged valued of regressors can turn out to be poor measurement instruments. For this reason, we use System-Generalised Method of moments (SGMM)[21] to estimate the models (1-5). System GMM estimator has smaller variances and is more efficient, providing extra precision in the estimations and is preferred where the dependant variable is dynamic in nature. We employ a two-step system GMM which is ideal where the number cross-sections are higher than the number of time-series (i.e. N>T). Two-step system GMM further refines the quality of regression analysis

[20] Manuel Arellano and Stephen Bond, "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *The Review of Economic Studies* 58, no. 2 (1991): 277–97, https://doi.org/10.2307/2297968.

[21] Manuel Arellano and Olympia Bover, "Another Look at the Instrumental Variable Estimation of Error-Components Models," *Journal of Econometrics* 68, no. 1 (1995): 29–51, https://doi.org/10.1016/0304-4076(94)01642-d; Richard Blundell and Stephen Bond, "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics* 87, no. 1 (1998): 115–43, https://doi.org/10.1016/s0304-4076(98)00009-8; Richard Blundell and Stephen Bond, "GMM Estimation with Persistent Panel Data: An Application to Production Functions," *Econometric Reviews* 19, no. 3 (2000): 321–40, https://doi.org/10.1080/07474930008800475.

considering endogeneity, serial correlation, and heteroscedasticity issues in the model which are more likely to be found in financial data.

II.E. Descriptive Statistics and Correlation Analysis

Table 1 below presents the summary statistics for our dataset. Developed countries have higher Z-score as compared to emerging economies which indicates relative stability in developed countries. Both emerging and developed countries have about similar levels of impaired loan, return on assets, and capital to total asset ratio. The Lerner index is found to be significantly higher for developed countries, which indicates the banking sectors in developed countries have higher market power hence, less competition. Looking at electronic payments, the mean difference of -22.119 is highly significant, which validates our approach of splitting our sample into in developed and emerging economies.

Table 2 presents the pairwise correlation for all the variables used in our research, the risk variables (Zscore and NPL), bank competition (Lerner) and Digital Transformation (DIGI) variable, along with controls from the banking sector and country-level variables. The correlation coefficients show weak correlation between the variables. Therefore, the existence of multicollinearity issue is rejected.

Table 1.
Summary Statistics

	Zscore	NPL	DIGI	Lerner	ROA	CTA	NII	GDPg	INFL
Full sample									
Obs	272	211	302	106	269	200	269	322	297
Mean	15.04	5.87	23.69	0.34	1.66	11.35	15.92	4.29	4.62
SD	9.58	7.38	25.17	0.16	1.32	3.79	9.53	4.41	4.64
Min	0.26	0.39	0	0	-8.44	2.37	-31.39	-25.91	-3.75
Max	55.8	48.68	90.76	0.94	8.6	23.71	64.19	20.63	39.27
Emerging Countries									
Obs	102	80	113	32	99	67	99	126	115
Mean	13.48	5.47	9.85	0.28	1.8	11.73	17.82	5.07	6.12
SD	6.95	4.24	13.26	0.11	1.09	4.05	9.21	5.51	3.86
Min	0.26	0.39	0.21	0	-0.6	5.42	-3.32	-25.91	-1.34
Max	32.83	20.39	79.39	0.56	5.13	20.49	39.98	20.63	19.54
Developed Countries									
Obs	170	131	189	74	170	133	170	196	182
Mean	15.98	6.11	31.97	0.37	1.58	11.15	14.82	3.78	3.67
SD	10.77	8.77	26.94	0.17	1.43	3.66	9.57	3.44	4.84
Min	2	0.4	0	0.05	-8.44	2.37	-31.39	-7.44	-3.75
Max	55.8	48.68	90.76	0.94	8.6	23.71	64.19	14.7	39.27
Mean Difference	-2.499**	-0.65	-22.119***	-0.092***	0.21	0.58	2.999**	1.287**	2.445***

Table 2.
Correlation Matrix

	lnZ	NPL	DIGI	Lerner	ROA	CTA	NII	GDPg	INFL
lnZ	1								
NPL	-0.364**	1							
DIGI	0.314**	0.132	1						
Lerner	0.352**	-0.137	0.282*	1					
ROA	-0.0347	-0.366**	-0.371**	0.124	1				
CTA	-0.0105	-0.0338	-0.216	0.227	0.567***	1			
NII	0.0544	-0.441***	-0.350**	-0.0196	0.791*	0.0532	1		
GDPg	0.224	-0.549***	-0.315**	0.0938	0.400***	0.171	0.486***	1	
INFL	-0.183	-0.138	-0.438***	-0.313**	0.284*	0.0315	0.330**	0.242*	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

III. RESULTS AND DISCUSSION

This section presents the results on equations (1-5) where equation (1) describes the impact of market competition on bank stability. Equation (2) illustrates the results of the effect of digital transformation on bank stability. Equations (3) and (4) show the possible difference in the effect of banking competition and digital transformation on bank stability in emerging and developing economies. Equation (5) encapsulates the impact of competition with greater digital transformation by employing an interaction term of bank competition (Lerner) and digital transformation (DIGI). To add robustness and consistency to our findings, we also employ the subject bank's non-performing loans ratio as a proxy for the bank's risk/stability, and finally, we employ different diagnostic tests to add reliability and validity to our findings.

Table 3 below shows the estimation results of equations (1) and (2) described in Section II. The lagged dependent variable is highly significant in both models, validating the dynamic nature of banks' stability and supporting our preference for the dynamic panel estimator. The instruments are less than the groups in the models that prove no instrument proliferation problem.[22] The insignificant value for AR (2) reveals that second or third-order serial autocorrelation does not exist. We also employ the Hansen test to examine the correlation between the error terms and instruments. Since the Hansen test reports insignificant probabilities, our estimated instruments are valid and do not correlate with the error terms.

Model (1) and Model (3) in Table 3 reports the impact of competition (the *Lerner index*) on a bank's stability (*Zscore*) and non-performing loans (*NPL*), respectively. The findings suggest that market competition reduces banks'

[22] Roodman, David. "How to do xtabond2: An introduction to difference and system GMM in Stata." *The stata journal* 9, no. 1 (2009): 86-136.

stability (*Zscore*). This relationship might be due to lower interest rates that adversely affect a Bank's performance and thus the stability of the sector. More competition indicates lower interest rate spreads for most of the banking products. The competitive pressure is more substantial in these loan markets compared to the deposit markets. Accordingly, under increased competition, banks compensate for their reduction in loan market income with increase in their deposit rates, which affects banks' profitability.

ROA, the proxy for bank performance, reports a negative impact on a bank's stability, Zscore, and non-performing loans in model 1, suggesting that banks with higher returns might be exposed to higher risk. In model (3), when the same equation is estimated with an alternative proxy for stability, the non-performing loans, the increase in returns on assets bring lower non-performing loans, this might be due to the fact that banks with increased profitability might issue more loans, reducing the ratio of non-performing loans. NII, Bank's non-interest income to total assets, shows a significant positive impact on bank Zscore and NPL. This suggests that banks with increased diversification are more stable. CTA, a Bank's capital to total asset ratio, shows a positive impact on non-performing loans (NPL). For Zscore, however, the coefficients are insignificant. It suggests that the banking sector with higher capitalisation is more engaged in loans and hence becomes riskier. Furthermore, the coefficients on GDPg rate and inflation are insignificant in model (1).

Models (2) and (4) in table 3 reports the impact of digital transformation (DIGI) on bank stability. Digital transformation has a positive impact on a bank's Zscore and a negative impact on a bank's non-performing loan ratio, suggesting an increase in digital transformation leads to overall banking sector stability and to a lower rate of non-performing loans. This might support the argument that digital transformation has not yet gained the confidence it needs from key stakeholders of the banking sector and thus is not really impacting the banking sector stability.

Furthermore, the coefficients on GDPg rate and inflation are found significantly negative in models (2) and (4), suggesting that countries with higher GDPg is associated with decreased non-performing loans. Inflation is found to be negatively impacting the stability in both the models. Higher inflation rate brings overall banking sector stability, however for NPL the negative sign of the coefficient might be associated with higher interest rates during inflation which leads to a higher non-performing loan ratio.

Table 3.
Competition, Digital Transformation and Risk/Stability (Full sample)

	Model (1)	Model (2)	Model (3)	Model (4)
	(Equation 1) ZSCORE	(Equation 2) ZSCORE	(Equation 1) NPL	(Equation 2) NPL
L.lnZ	0.4968***	0.7087***		
	[0.004]	[0.000]		
Lerner	0.6317**		-30.5749**	
	[0.015]		[0.014]	
ROA	-0.2002*	0.0770***	-21.9932***	0.6543**
	[0.084]	[0.003]	[0.001]	[0.021]
CTA	0.0111	-0.0029	2.7345***	-0.2773***
	[0.513]	[0.382]	[0.004]	[0.000]
NII	0.0217**	0.0019	1.6676***	-0.1841***
	[0.049]	[0.466]	[0.003]	[0.000]
GDPg	0.0085	-0.0010	-0.7009	-0.2006***
	[0.656]	[0.785]	[0.215]	[0.000]
INFL	-0.0142	-0.0165***	-0.7660*	-0.0608***
	[0.224]	[0.000]	[0.093]	[0.000]
DIGI		0.0015***		-0.0330***
		[0.000]		[0.000]
L.NPL			0.6668***	1.1202***
			[0.000]	[0.000]
Constant	0.9508**	0.6499***	0.9547	6.2361***
	[0.014]	[0.000]	[0.821]	[0.000]
Observations	61	136	49	113
Instruments	10.0000	30.0000	13.0000	24.0000
Groups	22.0000	32.0000	18.0000	25.0000
AR(1)	0.2272	0.0379	0.8296	0.2353
AR(2)	.	0.6290	.	0.2783
Sargan(p-Val)	0.2246	0.0000	0.7216	0.0075
Hansen(p-Val)	0.1294	0.2901	0.8581	0.1367

Note: standard errors are in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

III.A. Developed vs. emerging countries

The results reported in model (1) and model (3) of table 4 are estimated with equations (3) and (4) respectively. A dummy interaction term is introduced in equation (1) and equation (2) to explore if the impact of competition and digital transformation on banking sector stability is different for developed countries. The dummy variable has a value of 1 for developed countries and 0 otherwise. The significant results of interaction terms establish a difference in the effects of competition and digital transformation on bank stability in developed countries. In the results of table 4 for models (1) and (3), the interaction terms are highly significant for competition, supporting our

argument that the impact of competition is different in developed economies compared to emerging ones. This suggests that competition makes the banking sector of developed countries more fragile, supporting the competition-fragility view, while making the banking sector of developed countries more stable supporting competition-stability view.

Models (2) and (4) show a significant and negative interaction term with digital transformation that shows a negative impact of digital transformation on Zscore and with NPL ratios in developed countries. This might be due the fact that developed countries are moving towards digital transformation and thus banks in developed countries are facing a paradigm shift for customers to digital platforms, which is causing banks to lose their profits and making them more fragile (Zscore). For NPL (model 4), the relationship is still negative, which might suggest that with increased digitization, banks in developed countries are issuing a smaller number of loans and therefore have a lower NPL ratio. This variation in the relationship for developed countries is clearer in figures 1 and 2.

Table 4.
Competition, Digital Transformation and Stability
(Developed vs Emerging Countries)

	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**
	(Equation3) ZSCORE	**(Equation 4) ZSCORE**	**(Equation 3) NPL**	**(Equation 4) NPL**
L.lnZ	0.7031***	0.8098***		
	[0.000]	[0.000]		
Lerner	-0.5768**		7.2920***	
	[0.024]		[0.002]	
Dev	-0.2880***	0.0626	1.4881	0.7321
	[0.001]	[0.241]	[0.350]	[0.202]
Lerner # Dev	0.9409***		-7.2641**	
	[0.001]		[0.015]	
ROA	-0.1099	0.0515**	2.8039**	-0.0234
	[0.163]	[0.030]	[0.033]	[0.969]
CTA	0.0037	-0.0029	-0.5928***	-0.1285
	[0.645]	[0.531]	[0.002]	[0.105]
NII	0.0137*	0.0045	-0.3385**	-0.0676
	[0.085]	[0.144]	[0.014]	[0.354]
GDPg	-0.0057	-0.0040	0.0242	-0.2867***
	[0.577]	[0.474]	[0.938]	[0.000]
INFL	-0.0140	-0.0114***	0.0412	-0.0585**
	[0.103]	[0.000]	[0.829]	[0.034]
DIGI		0.0031*		0.1322**
		[0.060]		[0.036]

Table 4.
Competition, Digital Transformation and Stability
(Developed vs Emerging Countries)

	Model (1)	Model (2)	Model (3)	Model (4)
	(Equation3) ZSCORE	(Equation 4) ZSCORE	(Equation 3) NPL	(Equation 4) NPL
DIGI # Dev		-0.0030*		-0.1491**
		[0.097]		[0.018]
L.NPL			1.2450***	1.0228***
			[0.000]	[0.000]
Constant	0.9283***	0.3900***	3.7335	3.5096***
	[0.000]	[0.004]	[0.189]	[0.001]
Observations	61	136	49	113
Instruments	16.0000	28.0000	12.0000	21.0000
Groups	22.0000	32.0000	18.0000	25.0000
AR(1)	0.1501	0.0422	0.2226	0.1953
AR(2)	.	0.6129	.	0.2950
Sargan Test (p-Val)	0.1098	0.7828	0.0002	0.6571
Hansen Test (p-Val)	0.1824	0.5970	0.0815	0.2337

Note: standard errors are in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 1. Impact of competition on bank Stability in Developed and emerging countries (90% Cls)

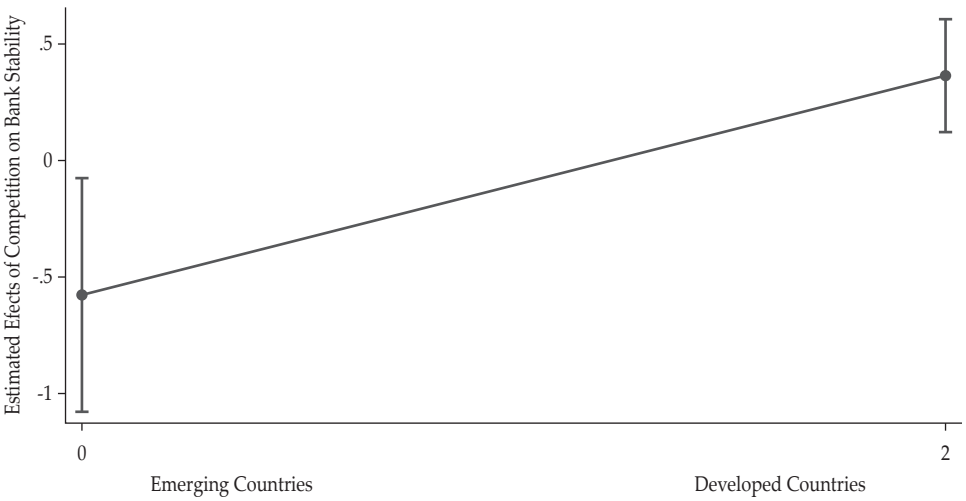
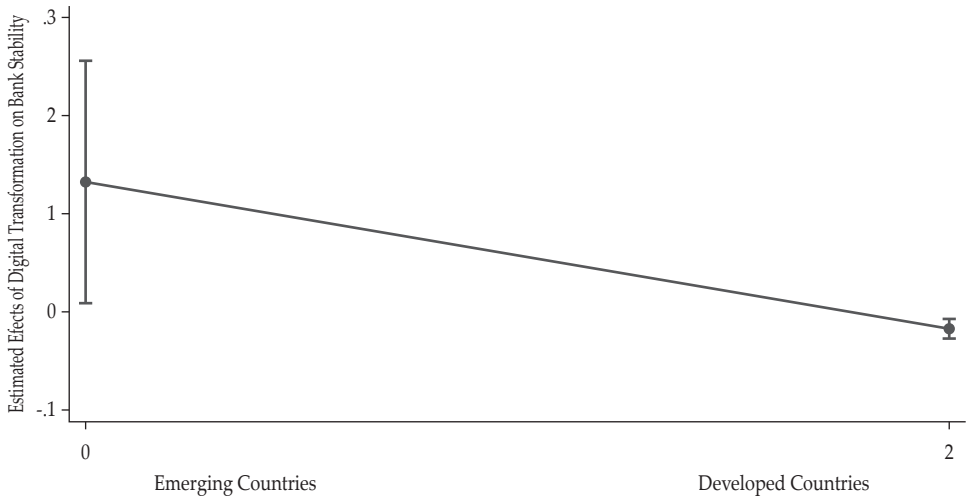


Figure 2. Impact of Digital Transformation on bnak Stability in Developed and Emerging countrie (90% Cls)



III.B. Impact of Digital Transformation on Bank Sector Stability as Competition in the Banking Sector Varies

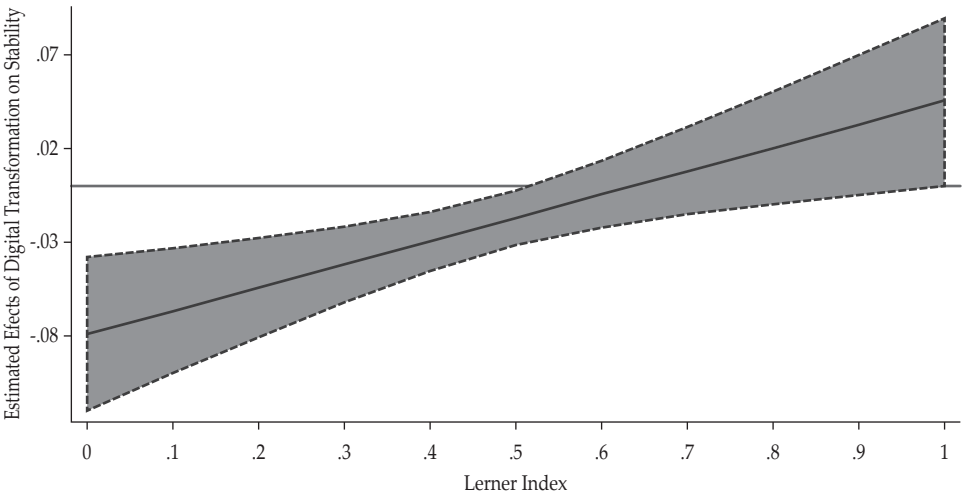
This section explores the moderating role of competition in explaining the relationship between digital transformation and banking sector stability by calculating equation (5). The interaction term (DIGI * Lerner) explains this moderating role. The term is found to be negatively significant for non-performing loans as a dependent variable. The coefficient suggests that during higher competition (lower Lerner index) the relationship is negative. However, as competition decreases, the impact of digital transformation starts to be positive and get insignificant below a moderate level of competition (See figure 3). This suggests that in a lower competition condition it is better to have increased capitalisation of overall digital transformation in the country.

Table 5.
Competition, Financial Technology and Risk/Stability (Full sample)

	(Equation 5)	(Equation 5)
	ZSCORE	**NPL**
L.lnZ	0.9692***	
	[0.000]	
Lerner	0.0220	-7.1361***
	[0.869]	[0.001]
ROA	-0.0203	-0.0556
	[0.552]	[0.954]
CTA	-0.0063**	-0.1198
	[0.016]	[0.449]
NII	0.0091	-0.1794
	[0.058]	[0.055]
GDPg	-0.0301***	-0.4115**
	[0.000]	[0.031]
INFL	-0.0083	-0.0955
	[0.123]	[0.571]
DIGI	-0.0039***	-0.0791***
	[0.002]	[0.001]
DIGI # Lerner	0.0064	0.1242**
	[0.094]	[0.011]
L.NPL		0.6915***
		[0.000]
Constant	0.2374	11.1919***
	[0.311]	[0.000]
Observations	61	49
Instruments	20.0000	16.0000
Groups	22.0000	18.0000
AR(1)	0.1628	0.3172
AR(2)	.	.
Sargan(p-Val)	0.5164	0.5680
Hansen(p-Val)	0.5071	0.6792

Note: standard errors are in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 3.
Marginal Effects of Digital Transformation on bank sector Stability as competition varies (90% Cls)



III.C. Robustness checks

Apart from using an alternate risk proxy we conduct further robustness checks of our findings in this study, we re-estimate the equations (1 - 4) with a differenced GMM estimator. All the results are found to be consistent and aligned with the findings in sections 3, 3.1, and 3.2. Tables A1, A2 and A3 in the appendix presents the robustness checks for results earlier reported in tables 3, 4, and 5.

IV. CONCLUDING REMARKS

Digital transformation is said to be the need of today to ease lending and payments. The exponential growth in lending platforms might pose a threat to the banking sector where it might lead to increased competition among banks. This research explores the impact of digital transformation and bank competition on banking sector stability by taking country-level data of 48 Asian economies. We also argue that to compete with non-bank digital platforms, banks might be competing among themselves, and this might lead to lower lending rates and increased deposit rates. This small spread might lead overall instability in the banking sector. This motivates us to integrate the moderating role of bank competition into the picture. The findings suggest that while digital transformation brings banking sector stability, bank competition makes the sector more fragile. During high competition within banking sector, digital transformation reduces the overall banking sector stability and as competition

declines, the relationship moves towards insignificance below a moderate level of competition. These findings carry important policy implications. Countries should have control over banking sector competition and should at the same time move towards digital transformation. Lower competition is better in order to avoid any negative impacts from digital transformation in a country's economy.

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APPENDIX

Table A1.
Robustness: Competition, Financial Technology and Risk/Stability (Full sample)

	(Eq1)	(Eq 2)	(Eq1)	(Eq 2)
	ZSCORE	**ZSCORE**	**NPL**	**NPL**
L.lnZ	0.9297***	0.2696***		
	[0.008]	[0.000]		
Lerner	1.4517***		-18.4542***	
	[0.000]		[0.009]	
ROA	-0.1230*	0.0983***	-12.8984**	-0.7726***
	[0.078]	[0.000]	[0.010]	[0.007]
CTA	0.0116	0.0319***	0.5022	-0.0686
	[0.469]	[0.000]	[0.432]	[0.338]
NII	0.0331**	0.0032	1.5647**	0.0877**
	[0.044]	[0.373]	[0.017]	[0.028]
GDPg	-0.0282	0.0020	-0.0425	-0.0854
	[0.219]	[0.274]	[0.868]	[0.174]
INFL	0.0015	0.0044**	-0.7228	-0.0947***
	[0.903]	[0.013]	[0.089]	[0.001]
DIGI		0.0008***		-0.0075
		[0.000]		[0.053]
L.NPL			0.2949	0.6146***
			[0.319]	[0.000]
DIGI # Lerner				
Observations	17	104	31	88
instruments	8.0000	25.0000	9.0000	20.0000
groups	17.0000	31.0000	18.0000	25.0000
AR(1)	0.9800	0.0582	0.8681	0.3465
AR(2)	.	0.6539	.	0.2810
Sargan Test (p-Val)	0.4757	0.0442	0.3029	0.5119
Hansen Test (p-Val)	0.2640	0.2707	0.3290	0.3853

standard errors are in parantheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A2.
Robustness: Competition, Financial Technology and Risk/Stability (Developed vs Emerging Countries)

	(Eq3)	(Eq 4)	(Eq3)	(Eq 4)
	ZSCORE	**ZSCORE**	**NPL**	**NPL**
L.lnZ	0.2024	0.0005		
	[0.185]	[0.995]		
Lerner	-0.2768*		4.8445*	
	[0.054]		[0.089]	
Dev	0.0000	0.0000	0.0000	0.0000
	[.]	[.]	[.]	[.]
Lerner # Dev	1.0920***		-19.5316*	
	[0.008]		[0.089]	
ROA	-0.1682***	0.1407***	-7.1575**	-4.8837***
	[0.000]	[0.000]	[0.020]	[0.000]
CTA	0.0429***	0.0325***	0.0338	0.3671***
	[0.002]	[0.000]	[0.901]	[0.000]
NII	0.0362***	-0.0010	0.8792*	0.4097***
	[0.000]	[0.817]	[0.055]	[0.000]
GDPg	0.0020	0.0077***	-0.2631	-0.0588
	[0.534]	[0.008]	[0.125]	[0.249]
INFL	-0.0031	0.0047**	-0.4616	0.1039***
	[0.678]	[0.027]	[0.123]	[0.006]
DIGI		0.0065***		0.0621*
		[0.000]		[0.094]
DIGI # Dev		-0.0062***		-0.0862**
		[0.000]		[0.025]
L.NPL			0.6363***	0.5791***
			[0.000]	[0.000]
Observations	39	104	31	62
instruments	14.0000	22.0000	16.0000	21.0000
groups	22.0000	31.0000	18.0000	24.0000
AR(1)	0.5978	0.6079	0.1993	0.6919
AR(2)	.	0.1887	.	0.2052
Sargan Test (p-Val)	0.4170	0.5301	0.0768	0.8225
Hansen Test (p-Val)	0.5102	0.2489	0.6792	0.5017

standard errors are in parantheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A3.
Robustness: Competition, Financial Technology and Risk/Stability (Full sample)

	(Eq5)	(Eq5)
	ZSCORE	**NPL**
L.lnZ	0.2957***	
	[0.000]	
Lerner		-6.3455*
		[0.052]
ROA	0.0579**	-8.0032***
	[0.049]	[0.005]
CTA	0.0428***	0.0541
	[0.000]	[0.595]
NII	0.0087**	0.5398**
	[0.010]	[0.027]
GDPg	-0.0008	-0.0005
	[0.544]	[0.997]
INFL	0.0068***	-0.0279
	[0.000]	[0.778]
DIGI	0.0006	-0.0412***
	[0.254]	[0.000]
Lerner2	-0.8034***	
	[0.000]	
DIGI # Lerner2	0.0014**	
	[0.014]	
L.NPL		0.3140***
		[0.000]
DIGI # Lerner		0.0723***
		[0.005]
Observations	94	29
instruments	24.0000	17.0000
groups	26.0000	18.0000
AR(1)	0.1133	0.1766
AR(2)	0.4773	.
Sargan Test (p-Val)	0.4117	0.0214
Hansen Test (p-Val)	0.2747	0.4192

standard errors are in parantheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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