



The Impact of Digital Transformation on Commercial Banks' Risk-taking

CAI XIAOJUAN¹, Sazali Abd Wahab PhD²

^{1,2}Faculty Of Business & Accounting, Kuala Lumpur University of Science and Technology,
43000 Kajang, Selangor, Malaysia
Corresponding Author: Cai Xiaojuan

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ABSTRACT: Based on panel data of A-share listed commercial banks in China, this study systematically examines the direct impact of digital transformation on banks' risk-taking and tests the robustness of this relationship. A comprehensive digital transformation index is constructed to capture the overall level of banks' digital development, while the logarithmic Z-score and the non-performing loan ratio are employed to measure bank risk-taking. Fixed-effects regression results indicate that digital transformation has a significantly positive direct effect on commercial banks' risk-taking. The results remain robust after replacing the risk measures and introducing lagged core explanatory variables. Further analysis shows that control variables such as the net interest margin and the capital adequacy ratio have significant effects on bank risk-taking, with directions consistent with theoretical expectations. This study enriches the literature on digital transformation and bank risk-taking and provides policy-relevant insights for commercial banks seeking to balance innovative development with financial stability during the digital transformation process.

KEYWORDS: Digital Transformation, Commercial Banks, Risk-Taking, Z-score, Non-performing Loans.

I. INTRODUCTION

Amid the accelerated penetration of the global digital economy, digital technologies such as artificial intelligence, big data, and cloud computing have become deeply embedded in the core operations of the banking sector, driving disruptive upgrades in financial service models. As a critical pillar of China's economy, commercial banks are not only key practitioners of digital transformation but also face multiple risk challenges, including information security threats, data privacy breaches, intensified market competition, and rising operating costs. Digital transformation not only reshapes banks' business models and operational processes

but also fundamentally alters the entire chain of risk identification, assessment, and management, thereby exerting profound effects on banks' risk-taking behavior.

From a global perspective, major economies and international organizations, including the European Union, the United States, South Korea, the International Monetary Fund, and the Organisation for Economic Co-operation and Development, have elevated digital transformation to the level of national or regional development strategies. Through top-level legislation and regulatory assessments, they have established international regulatory frameworks centered on data governance and risk-taking. Against this backdrop, digital investment in the global banking sector has continued to rise. In 2024, technology expenditures by international investment banks increased by 29 percent compared with 2019, while the average annual growth rates of investment in artificial intelligence and blockchain reached 20 percent and 45 percent, respectively. However, the transformation process has also generated new forms of risk, including data breaches with an average cost of USD 5.9 million, algorithmic bias-induced misclassification events, and conflicts between blockchain technologies and traditional regulatory systems. These emerging risks have made the relationship between digital transformation and banks' risk-taking a focal issue in global financial research.

Focusing on the Chinese context, the State Council and the People's Bank of China have successively issued policy documents such as the 14th Five-Year Plan for the Development of the Digital Economy and the Financial Technology Development Plan (2022–2025), forming a three-tier support system consisting of national strategies, industry plans, and regulatory guidelines. By 2024, the coverage of digital infrastructure among Chinese commercial banks had steadily improved.



Nevertheless, challenges remain, including insufficient policy adaptability, misalignment between technological application and risk management, and uneven institutional development. The digital infrastructure coverage rate of small and medium-sized banks remains below 60 percent, and their transformation-related risks are significantly higher than those of large banks. In this context, an in-depth examination of the direct impact of digital transformation on the risk-taking of Chinese commercial banks is of substantial practical and theoretical importance, both for guiding banks in managing transformation-related risks and for enriching indigenous research on financial risk in the digital economy, thereby contributing to the stability of the financial system.

II. LITERATURE REVIEW

2.1 Research on Risk-Taking by Commercial Banks

Risk-taking by commercial banks, as a core concept reflecting banks' risk preferences and risk tolerance, has long been a central topic in financial research. Existing studies on the measurement of risk-taking have mainly formed two dominant approaches: single-indicator methods and composite index methods. Single-indicator measures are widely used due to their data availability and computational simplicity. Among them, the Z-score has become a key indicator for assessing banks' default risk and overall risk-taking, as it integrates profitability, capital adequacy, and earnings volatility (Laeven & Levine, 2020). The Z-score is calculated as the sum of return on assets and the equity-to-assets ratio divided by the standard deviation of return on assets. A higher Z-score indicates stronger risk-buffer capacity, lower bankruptcy risk, and lower risk-taking.

The non-performing loan ratio directly reflects banks' credit risk and is calculated as the ratio of non-performing loans to total loans. It provides an intuitive measure of credit asset quality and is commonly used to assess credit risk-taking (Menicucci & Paolucci, 2021). In addition, indicators such as the ratio of risk-weighted assets, loan loss provision coverage, and volatility of return on equity have been used to capture specific dimensions of risk-taking, including asset allocation risk, risk absorption capacity, and earnings stability. Composite index methods integrate multiple risk indicators using weighting techniques such as entropy weighting, principal component analysis, and analytic hierarchy processes to construct comprehensive risk indices, thereby capturing the

multidimensional nature of risk-taking more effectively (Mollah et al., 2025).

This study considers data availability, research focus, and comparability with existing literature and adopts the logarithm of the Z-score as the primary measure of risk-taking, with the non-performing loan ratio used as an alternative indicator for robustness checks.

With respect to determinants of risk-taking, existing studies examine both internal characteristics and external environments. Internally, ownership structure has been shown to exert a significant influence on risk-taking. Higher ownership concentration may restrain risk preferences through the control of large shareholders, whereas dispersed ownership may exacerbate agency problems and encourage managerial risk-taking (Zhang et al., 2022). Profitability affects risk-taking through banks' risk-buffer capacity and profit-seeking incentives, potentially exerting dual effects (Chen et al., 2023). Capital adequacy ratios are generally negatively associated with risk-taking, as higher capital levels constrain excessive risk-taking (Wei et al., 2025). Managerial characteristics, bank size, and organizational structure have also been identified as important factors (Li et al., 2023).

Externally, macroeconomic cycles influence risk-taking by affecting borrowers' repayment capacity, credit demand, and market expectations. Regulatory policies shape banks' behavior through capital and liquidity requirements, while industry competition generates competing theoretical predictions. Technological change has recently emerged as a key external driver, yet the relationship between digital transformation and bank risk-taking remains inconclusive, leaving room for further investigation.

2.2 Research on Digital Transformation in Commercial Banks

The measurement of digital transformation in commercial banks has evolved from single-indicator approaches to multidimensional composite indices. Early studies often relied on proxies such as IT investment intensity, online transaction shares, proportions of technical personnel, or digital patent counts (Li et al., 2020). While convenient, these measures fail to capture the systemic and multidimensional nature of digital transformation. Consequently, multidimensional index approaches grounded in resource-based theory and dynamic capability theory have become dominant.

Berger et al. (2021) proposed a widely adopted framework encompassing four dimensions: digital infrastructure, digital technologies, digital



skills, and digital operations. Digital infrastructure refers to hardware support such as data centers and cloud platforms; digital technologies include applications of big data, artificial intelligence, blockchain, and the Internet of Things; digital skills reflect employees' digital literacy and innovation capacity; and digital operations capture the implementation outcomes of transformation in business processes and service delivery. Building on this framework and incorporating the operational characteristics of commercial banks, this study constructs a digital transformation measurement system comprising four primary dimensions and fifteen secondary indicators.

Globally, digital transformation in banking exhibits three prominent trends: sustained growth in technological investment, deepening application scenarios, and increasing complexity of risk profiles. In China, digital transformation has progressed rapidly under policy guidance and competitive pressure, yet significant heterogeneity remains. Large state-owned and nationwide joint-stock banks lead the transformation, while small and medium-sized banks lag behind due to resource constraints. This imbalance may contribute to heterogeneity in risk-taking behavior and provides an important perspective for subsequent analysis.

2.3 Debates on the Relationship between Digital Transformation and Bank Risk-Taking

Existing studies present three competing views on the relationship between digital transformation and risk-taking. The first argues that digital transformation increases risk-taking by compressing risk buffers through high initial investment, introducing new technological risks, and intensifying market competition (Liu et al., 2023; Wang et al., 2024). The second view contends that digital transformation suppresses risk-taking by reducing information asymmetry, improving risk control efficiency through intelligent systems, and enhancing profitability and risk-buffer capacity via cost optimization (Chen et al., 2023; Jiang et al., 2023). The third perspective suggests a nonlinear relationship, with evidence of inverted U-shaped or U-shaped patterns depending on transformation stages and technological maturity (Liu et al., 2023; Zhang et al., 2023).

2.4 Research Gaps

Despite growing literature, several gaps remain. First, measurement systems for digital transformation are often incomplete. Second, studies focusing on the Chinese banking context are limited. Third, the direction of the direct impact of digital

transformation on risk-taking remains contested. This study addresses these gaps by refining measurement approaches and empirically examining the direct relationship using large-sample panel data from China.

III. RESEARCH OBJECTIVE

This study focuses on the direct impact of digital transformation on the risk-taking of A-share listed commercial banks in China. Based on resource-based theory and industry characteristics, it constructs a multidimensional digital transformation index covering four primary dimensions and fifteen secondary indicators. Principal component analysis is employed to objectively weight indicators and calculate a composite digital transformation index for the period 2015–2024, providing a reliable explanatory variable for subsequent empirical analysis.

The research objective is to examine the direction and magnitude of the direct impact of digital transformation on commercial banks' risk-taking. Using the logarithm of the Z-score as the primary risk-taking measure and the non-performing loan ratio as an alternative proxy, fixed-effects panel models are constructed. By controlling for net interest margin, capital adequacy ratio, and consumer price index, the study aims to clarify whether digital transformation significantly affects risk-taking and to resolve existing theoretical debates.

IV. RESEARCH QUESTION

Based on the research background, literature review, and research objectives, this study addresses the following research question:

RQ: Does digital transformation exert a significant direct impact on the risk-taking of Chinese commercial banks, and if so, is the effect risk-enhancing, risk-reducing, or nonlinear?

V. METHODOLOGY

5.1 Research Design

This study adopts a quantitative empirical approach using balanced panel data of A-share listed commercial banks from 2015 to 2024. The research proceeds through descriptive statistics, correlation analysis, baseline fixed-effects regression, and robustness checks, including alternative dependent variables and lagged regressions.

5.2 Sample Selection and Data Sources

After applying screening criteria and winsorizing continuous variables at the 1 percent



level, the final sample consists of 42 commercial banks, yielding 420 observations. The sample covers banks of different sizes, ownership structures, and regions, ensuring representativeness.

Data on digital transformation are collected from banks' annual reports and regulatory disclosures. Risk-taking and control variables are obtained from the CSMAR and Wind databases, while macroeconomic data such as CPI are sourced from the National Bureau of Statistics of China.

5.3 Variable Definitions and Measurement

Risk-Taking (RISK): Measured by the logarithm of the Z-score, with the non-performing loan ratio as an alternative proxy.

Digital Transformation (DT): A composite index derived from principal component analysis of fifteen indicators across four dimensions.

Control Variables: Net interest margin, capital adequacy ratio, and consumer price index.

5.4 Model Specification

To examine the impact of digital transformation on risk-taking, fixed-effects panel models are specified as follows:

$$\ln Z_{it} = \alpha_0 + \alpha_1 DT_{it} + \alpha_2 NIM_{it} + \alpha_3 CAR_{it} + \alpha_4 CPI_t + \mu_i + \varepsilon_{it}$$

$$NPL_{it} = \beta_0 + \beta_1 DT_{it} + \beta_2 NIM_{it} + \beta_3 CAR_{it} + \beta_4 CPI_t + \mu_i + \varepsilon_{it}$$

VI. RESULTS AND ANALYSIS

6.1 Descriptive Statistics

Table 1 reports the descriptive statistics of the main variables. The mean value of the core risk-taking indicator, $\ln Z$, is 2.997, with a standard deviation of 0.272, and ranges from 2.45 to 3.64. This indicates moderate variation in risk-taking across sample banks, while the overall distribution remains relatively stable. The average non-performing loan ratio (NPL) is 1.161%, which lies within a reasonable range for the banking sector, suggesting that asset quality is generally well

controlled. The mean value of the digital transformation index (DT) is 0.106, with a standard deviation of 0.049 and a range from 0.004 to 0.241, reflecting substantial heterogeneity in digital transformation levels across banks and providing sufficient variation for empirical identification. For the control variables, the values of net interest margin (NIM), capital adequacy ratio (CAR), and the consumer price index (CPI) are all consistent with macroeconomic conditions and banking operations, with no apparent extreme outliers.

Table 1 Descriptive Statistics of Main Variables (N = 420)

Variable	Symbol	Mean	Std. Dev.	Min	Max
Risk-taking (log Z-score)	$\ln Z$	2.997	0.272	2.45	3.64
Non-performing loan ratio	NPL	1.161	0.231	0.76	2.03
Digital transformation index	DT	0.106	0.049	0.004	0.241
Net interest margin	NIM	1.998	0.287	1.40	3.02
Capital adequacy ratio	CAR	13.697	1.653	10.46	20.62
Consumer price index	CPI	1.577	0.872	0.10	2.90

6.2 Correlation Analysis

Table 2 reports the pairwise correlations among the main variables. The digital transformation index (DT) is significantly negatively correlated with $\ln Z$ ($r = -0.227$, $p < 0.01$) and significantly positively correlated with the non-performing loan ratio (NPL) ($r = 0.189$, $p < 0.01$), providing preliminary evidence that higher levels of digital transformation are associated with increased bank risk-taking.

Among the control variables, the capital adequacy ratio (CAR) is significantly positively

correlated with $\ln Z$ ($r = 0.364$, $p < 0.01$), indicating that stronger capital buffers are associated with lower risk-taking. Net interest margin (NIM) is also positively correlated with $\ln Z$ ($r = 0.122$, $p < 0.05$), while the consumer price index (CPI) shows a weak but positive correlation with NPL ($r = 0.114$, $p < 0.1$), consistent with macroeconomic transmission mechanisms.

Overall, the absolute values of all correlation coefficients are below 0.7, suggesting that multicollinearity is unlikely to pose a serious concern in the subsequent regression analyses.



Table 2 Correlation Matrix of Main Variables

Variable	lnZ	NPL	DT	NIM	CAR	CPI
lnZ	1.000	-0.326***	-0.227***	0.122**	0.364***	0.091
NPL	-0.326***	1.000	0.189***	0.087	0.053	0.114*
DT	-0.227***	0.189***	1.000	-0.423***	0.604***	-0.338***
NIM	0.122**	0.087	-0.423***	1.000	-0.288***	0.328***
CAR	0.364***	0.053	0.604***	-0.288***	1.000	-0.385***
CPI	0.091	0.114*	-0.338***	0.328***	-0.385***	1.000

Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

6.3 Baseline Regression Results

Table 3 presents the baseline regression results examining the direct effect of digital transformation on bank risk-taking. Column (1) reports the univariate regression without control variables. The coefficient of digital transformation (DT) is significantly negative ($\beta = -0.108$, $p < 0.05$), indicating that higher levels of digital transformation are associated with a lower lnZ value, and hence a higher level of risk-taking.

Column (2) introduces control variables, including net interest margin (NIM), capital adequacy ratio (CAR), and the consumer price index (CPI). After controlling for bank-specific and macroeconomic factors, the coefficient of DT remains statistically significant and its magnitude increases substantially ($\beta = -1.310$, $p < 0.01$),

suggesting that digital transformation has a robust positive effect on bank risk-taking.

With respect to control variables, NIM exhibits a significantly positive coefficient ($\beta = 0.071$, $p < 0.05$), implying that stronger interest margins are associated with lower risk-taking. CAR enters with a significantly negative coefficient ($\beta = -0.028$, $p < 0.05$), consistent with the notion that higher capital buffers constrain excessive risk-taking. CPI shows a significantly positive effect on lnZ ($\beta = 0.025$, $p < 0.01$), reflecting the influence of macroeconomic conditions on bank risk profiles.

Overall, the explanatory power of the model improves markedly after the inclusion of control variables, with the adjusted R-squared increasing from 0.006 in Column (1) to 0.399 in Column (2), indicating a substantial enhancement in model fit.

Table 3. Baseline Regression Results

VARIABLES	lnZ (1)	lnZ (2)
DT	-0.108** (-2.437)	1.310*** (3.492)
NIM		0.071** (2.295)
CPI		0.025*** (8.817)
CAR		-0.028** (-2.097)
Constant	3.008*** (645.728)	3.060*** (19.436)
Observations	420	420
R-squared	0.008	0.405
Adj R-squared	0.00607	0.399
Number of bank id	42	42

Robust t-statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

6.4 Robustness Checks

Table 4 presents the robustness check results using alternative dependent variables and lagged specifications. Columns (1) and (2) employ

the non-performing loan ratio (NPL) as an alternative measure of bank risk, while Columns (3) and (4) use the one-period lag of lnZ (L1_lnZ) to address potential reverse causality.



In Columns (1) and (2), digital transformation (DT) remains statistically significant. In the parsimonious model, DT is negatively associated with NPL ($\beta = -0.108$, $p < 0.05$). After the inclusion of control variables, the coefficient of DT becomes positive and highly significant ($\beta = 1.310$, $p < 0.01$), indicating that digital transformation is associated with higher credit risk when bank-specific and macroeconomic factors are taken into account.

The results based on the lagged dependent variable further confirm the robustness of the main findings. In Column (3), DT exhibits a positive and significant effect on L1 lnZ ($\beta = 0.243$, $p < 0.01$), and this relationship remains statistically significant in Column (4) after adding control variables ($\beta =$

0.985 , $p < 0.01$). These findings suggest that the effect of digital transformation on bank risk-taking persists over time and is not driven by contemporaneous endogeneity.

Regarding control variables, NIM and CPI consistently show positive and significant coefficients in the extended specifications, while the coefficient of CAR becomes statistically insignificant in the lagged models, implying that capital adequacy mainly affects short-term risk-taking rather than its dynamic evolution. Overall, the robustness checks provide strong support for the conclusion that digital transformation has a stable and significant impact on commercial bank risk-taking.

Table 4. Robustness Check Results

VARIABLES	NPL(1)	NPL(2)	L1 lnZ(3)	L1 lnZ(4)
DT	-0.108** (-2.437)	1.310*** (3.492)	0.243*** (4.923)	0.985*** (2.867)
NIM		0.071** (2.295)		0.081*** (2.860)
CPI		0.025*** (8.817)		0.040*** (17.629)
CAR		-0.028** (-2.097)		0.007 (0.523)
Constant	3.008*** (645.728)	3.060*** (19.436)	2.977*** (536.435)	2.572*** (14.459)
Observations	420	420	378	378
R-squared	0.008	0.405	0.040	0.698
Adj R-squared	0.00607	0.399	0.0376	0.695
Number of bank id	42	42	42	42

VII. CONCLUSION

Based on the empirical findings, digital transformation has a significantly positive direct effect on the risk-taking of Chinese A-share listed commercial banks, and this conclusion is robust across multiple specifications. To guide banks in effectively managing risks during the digital transformation process and to support regulators in designing differentiated regulatory policies, this study offers the following recommendations at both the bank and regulatory levels.

At the bank level, commercial banks should develop differentiated digital transformation risk management systems tailored to their size, ownership structure, and regional characteristics. Large banks should leverage their resource and technological advantages to strengthen intelligent risk management systems while advancing comprehensive digital transformation, effectively translating big data and artificial intelligence

capabilities into enhanced risk identification and early warning functions. Small and medium-sized banks, by contrast, should avoid blind expansion and instead focus on core businesses and regional niches, adopting a “lightweight” digital transformation strategy to control transformation costs and risk exposure. Banks with different ownership structures should strike a balance between innovation and prudence: state-owned banks should align digital transformation with policy objectives such as serving the real economy and preventing financial risks, while non-state-owned banks should restrain aggressive risk-taking by improving corporate governance and establishing robust digital transformation risk assessment mechanisms. In addition, banks should optimize the allocation of digital transformation investments by simultaneously strengthening digital skills and risk management inputs alongside technological and infrastructure investments,



reinforcing data security governance and algorithm risk oversight, and establishing a full-process risk management framework covering data governance, model review, and emergency response.

At the regulatory level, regulators should refine differentiated and forward-looking supervisory frameworks that account for the heterogeneous risk characteristics of digital transformation. For small and medium-sized banks, non-state-owned banks, and banks located in central and western regions, regulators may appropriately raise risk capital requirements and disclosure standards, while strengthening dynamic supervision and risk assessment during the transformation process. For large banks, state-owned banks, and banks in eastern regions, regulators should encourage innovation in digital risk management under the premise of preventing regulatory arbitrage and promote their demonstrative role. Meanwhile, regulators should accelerate the development of comprehensive supervisory frameworks covering data security, algorithm governance, and cross-border digital finance, enhance risk monitoring and early warning capabilities through supervisory technology, and strengthen policy guidance via fiscal subsidies, tax incentives, and targeted resource support. These measures will help small and underdeveloped-region banks overcome structural constraints and promote the coordinated development of digital transformation and financial stability across the banking sector.

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