Available Online: 9 February 2026 DOI: 10.54254/2977-5701/2026.31766

The impact of digital transformation of commercial banks on consumer finance

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Abstract. In the context of the digital economy and the rapid restructuring of financial business models driven by new productive forces, implementing digital transformation strategies has become a critical measure for commercial banks to enhance service efficiency and adjust credit systems. This study uses longitudinal data of Chinese commercial banks from 2011 to 2023 and employs text analysis methods for empirical research. By constructing an evaluation system for the degree of bank digitalization based on text mining techniques, the study explores the mechanisms through which digital transformation influences the development of consumer credit. Furthermore, a comprehensive consumer finance evaluation index is developed using the information entropy method, providing a quantitative tool to assess both the progress of bank digitalization and the development of consumer credit. The findings indicate that the digitalization of banks significantly promotes the growth of consumer credit, primarily by improving bank profitability, expanding credit issuance, and strengthening risk management effectiveness. The study also finds that these effects vary across regions with different levels of economic development and among different types of banking institutions. Robustness tests and instrumental variable methods confirm the reliability of these conclusions. This research not only clarifies the internal mechanisms through which bank digital transformation affects consumer credit from a micro-level perspective but also provides empirical support for commercial banks in formulating transformation strategies and enhancing consumer finance services.

Keywords: bank digital transformation, consumer credit, transmission mechanism, heterogeneity analysis

1. Research background

Currently, the rapid development of the digital economy, combined with increasing policy support, has significantly accelerated the digital transformation of commercial banks. National-level policy documents, such as the Overall Layout Plan for the Construction of Digital China and the 14th Five-Year Plan for Financial Industry Development, explicitly emphasize the need to leverage digital technologies to drive innovation in financial service models, optimize resource allocation, and expand business boundaries. At the same time, as household consumption continues to upgrade, the demand for high-quality consumer finance services is growing. Data show that in 2024, the final consumption of Chinese households exceeded 50 trillion yuan, accounting for over 50% of GDP, making consumption a core driver of economic growth. Against this

backdrop, achieving an effective alignment between capital supply and consumption scenarios has become a pressing challenge.

The digital transformation of commercial banks is widely regarded as an important driver of healthy consumer credit development. From a practical perspective, the application of digital technologies has not only transformed banks' customer acquisition methods, risk management approaches, and product development processes, but also significantly expanded the service coverage of consumer credit. Meanwhile, digital upgrading enhances banks' operational efficiency and information-processing capabilities, effectively increasing financial institutions' risk-bearing capacity in providing consumer credit. Existing research has partially examined how bank digitalization improves operational performance and innovation capacity; however, studies exploring the specific pathways and internal mechanisms through which it affects consumer credit remain insufficient. In particular, systematic analyses of mediating variables such as profitability, credit issuance capacity, and risk management effectiveness are lacking. Furthermore, whether banks of different types exhibit heterogeneous impacts warrants further investigation.

This study focuses on financial institutions within China's banking sector, aiming to analyze the transmission pathways and mechanisms through which digital technological innovation influences consumer credit. It also examines how these effects vary across different regional contexts and institutional characteristics. By doing so, this research seeks to fill gaps in existing theory and provide decision-making guidance for implementing digital strategies in the banking sector, thereby fully leveraging technological innovation to optimize consumer finance services and promote economic transformation and upgrading.

2. Literature review

2.1. Research progress on digital transformation in banking

Commercial banks, as pioneers of digital transformation in the financial system, are profoundly reshaping traditional operational models. Their technological innovations play a strategic role in promoting financial supply-side reform and enhancing the effectiveness of financial services for the real economy. Numerous empirical studies have confirmed that digital transformation can significantly improve banks' operational performance through process reengineering, service upgrades, and strengthened customer relationships [1]. Current academic discussions mainly focus on the effects of digitalization on organizational structure, operational efficiency, and risk management.

From the perspective of organizational structure, Wang Jie and Wang Jun [2] found that the application of digital technologies reduces banks' reliance on physical branches and enables remote service capabilities, thereby promoting branch downsizing and accelerating organizational transformation. Similarly, the research team led by Song Xiaoyang [3] demonstrated that this transformation positively optimizes human resource allocation. However, it is worth noting that Song Xiaoyang's team also observed that digitalization may suppress labor demand in banks, with this employment-substitution effect being particularly pronounced in small- and medium-sized banks and in financially advanced regions [3].

Regarding operational efficiency, studies by Litimi H., BenSaïda A., and Raheem M. M. [4], based on a sample of Gulf region banks, indicate that investment in financial technology significantly enhances overall bank performance. The resulting economies of scale and digital synergy effects contribute to cost reduction and operational efficiency improvements for commercial banks.

In the area of risk management, Hu Jun, Li Qiang, and Zeng Yong [5] found that, in the context of consumer credit, digital footprints and technology-enabled tools substantially improve default identification capabilities, thereby strengthening banks' risk screening and post-lending management performance.

Furthermore, Huang Yiping and Qiu Han [6] noted that large-scale technology-driven lending, by reconstructing information acquisition and credit evaluation frameworks, effectively mitigates information asymmetry problems inherent in traditional risk control. However, it is also important to recognize that the expansion of fintech may, by intensifying inter-institutional business linkages and risk exposure correlations, pose potential challenges to systemic stability [4].

Within China's bank-centered financial system, commercial banks play a critical role in connecting the real economy with household sectors. As fintech continues to penetrate, the structure of bank credit allocation has undergone systematic adjustment. Bruhn M. and Love I. [7] found that improved financial accessibility significantly enhances the efficiency of resource allocation toward high-productivity entities. Moreover, Sumei Luo, Yongkun Sun, and Rui Zhou [8] demonstrated that fintech innovation, by alleviating financing constraints and improving credit matching, substantially promotes household consumption expansion. Domestic evidence further shows that digital finance can enhance banks' allocation efficiency, optimize loan approval processes and product structures, and strengthen financial support for small- and medium-sized enterprises and households [9].

2.2. Research progress on consumer finance

Consumer finance, as a key driver for stimulating domestic consumption and promoting economic transformation, has become a prominent topic in recent academic research.

From a conceptual perspective, Tufano P. [10] defines consumer finance as an indispensable foundational component of the modern economic system, systematically outlining its core functions in payment settlement, risk management, capital allocation, and wealth distribution. Kempson E. and Whyley C. [11], from the perspective of financial accessibility, emphasize the critical role of consumer finance in alleviating financial exclusion and expanding household participation in financial markets. Domestic research further extends the concept in the context of the digital economy. Li Jia [12] notes that under the "New Retail" framework, consumer finance is increasingly integrated with scenario-based economic activities, exhibiting platform-based and ecosystem-oriented characteristics. Cheng Xuejun [13] similarly highlights that fintech is reshaping the business boundaries and service models of consumer finance.

From a functional perspective, consumer finance serves as an essential financial tool supporting household consumption, with significant effects at the individual, industrial, and macroeconomic levels. At the individual level, Bruhn M. and Love I. [7], using a quasi-natural experiment, found that improved financial accessibility significantly promotes household consumption and entrepreneurial activities. Furthermore, Sumei Luo, Yongkun Sun, and Rui Zhou [8] demonstrate that fintech innovations, by alleviating financing constraints and improving credit matching, effectively stimulate household consumption. Domestic evidence also shows that digital inclusive finance, by narrowing the digital divide and enhancing financial service accessibility, substantially increases household consumption and subjective well-being [9, 14-17].

At the industrial level, consumer finance promotes industrial upgrading through credit expansion and demand guidance mechanisms. Li Jia [12] finds that, compared with traditional investment-oriented financial services, the expansion of consumer credit more effectively drives industrial structure optimization through end-consumer demand. Additionally, Peng Zhixiong [18], from the perspective of financial functionality, points out that fintech-enabled consumer finance enhances resource allocation efficiency and facilitates technology diffusion.

At the national economic level, consumer finance has become a critical nexus connecting households and the real economy. He Yong and Qi Jiasi [19] show that the development of internet finance and consumer finance, by expanding domestic demand and improving capital circulation, provides substantial support for

macroeconomic growth. Zhang Junying, Luo Qiong, and Tang Hongtao [20] further indicate that the co-evolution of digital business ecosystems and consumer finance is reshaping production layouts and regional development patterns. Policy-level fintech practices also demonstrate that deep integration of technology and finance promotes market penetration into lower-tier regions and strengthens new drivers of economic growth [21].

Regarding future development trends, existing research generally suggests that scenario-based applications and digital upgrades will be the core directions for consumer finance evolution. Fintech innovation has been shown to play a key role in expanding credit accessibility and the coverage of inclusive finance [7, 22]. With ongoing advancements in big data, cloud computing, and intelligent algorithms, consumer finance is rapidly transitioning toward scenario-embedded and personalized services [13]. Meanwhile, digital footprints and intelligent risk-control technologies have substantially improved default detection and automated approval processes [5]; the introduction of generative AI is also beginning to reshape product design and customer management in consumer finance [23].

2.3. Research on the interaction between bank digitalization and consumer finance

The digital transformation of financial institutions is reshaping the consumer finance landscape. In practice, commercial banks have significantly enhanced the coverage of consumer finance services and the ability to identify risks by introducing big data analytics, intelligent risk-control systems, and automated approval mechanisms. At the bank level, Litimi H., BenSaïda A., and Raheem M. M. [4] found that fintech investments systematically improve bank performance, with the underlying mechanism being cost reduction and operational efficiency gains resulting from process digitalization and scale synergies. At the same time, consumer finance has gradually become a key entry point for banks' digital transformation, driving continuous optimization in product systems, channel integration, and internal collaboration [12].

From a strategic synergy perspective, digitalization is not merely a technological upgrade; it constitutes a comprehensive system encompassing business restructuring and organizational reconfiguration. Huang Yiping and Qiu Han [6] note that large-scale technology-driven lending reshapes information acquisition and credit evaluation frameworks, achieving deep coupling between technological capabilities and business strategies. Correspondingly, consumer finance scenarios provide a practical context for banks to test the synergistic effects of "technology empowerment—business innovation". Relevant research indicates that banks with higher fintech capabilities demonstrate faster product updates and stronger market adaptability in the consumer finance sector [18].

Furthermore, academic attention has increasingly focused on banks' specific innovation pathways in consumer finance. On one hand, the integration of digital footprints and algorithmic models has significantly improved default prediction accuracy and post-lending management efficiency, enabling banks to serve small-scale and long-tail consumer segments more precisely [5]. On the other hand, by collaborating with internet platforms and embedding services across diverse consumption scenarios, banks are accelerating the ecological layout of consumer credit products [24]. With the expanded application of generative artificial intelligence, consumer finance is increasingly exhibiting intelligent features in areas such as customer profiling, product design, and collection management [23].

A systematic review of existing literature reveals that while previous studies have examined the relationship between bank digital transformation and consumer finance development from various perspectives, three key shortcomings remain:

Mechanism and interaction gaps: Existing studies largely focus on the impact of digitalization on consumer credit scale or service efficiency, with limited systematic analysis of the underlying transmission mechanisms

and bidirectional interactions. Digital technology is often simplified as a tool for enhancing financial service efficiency, neglecting its structural guidance role in consumer finance resource allocation. Considering China's strategic emphasis on strengthening consumption's role in economic circulation and building a robust domestic market, it is necessary to further elucidate how banks' digital transformation guides credit flows, stimulates household consumption, and serves the real economy.

Empirical limitations: Current empirical research mainly relies on case studies or limited samples, lacking large-scale bank data analyses. As a result, it remains challenging to comprehensively assess the real impact of digital transformation on bank profitability, asset-liability management efficiency, and risk-control performance.

Heterogeneity considerations: Given the significant differences in scale and ownership within China's banking system, as well as uneven regional financial development, future research needs to examine the heterogeneous effects of digital transformation on consumer finance across different types of banks and explore the mechanisms behind these differences. Such evidence is crucial for supporting differentiated regulatory approaches and precise policy design.

3. Theoretical framework construction

The deep application of digital technologies is systematically reshaping commercial banks' business philosophy, resource allocation patterns, and customer service systems. By leveraging fintech tools such as big data analytics, intelligent algorithms, and cloud computing, banks have not only substantially improved operational performance and risk management capabilities, but also strengthened their intermediary functions, thereby driving the continuous expansion of consumer finance. Existing studies indicate that fintech investment can significantly enhance overall bank performance through process digitalization and scale synergy effects, while also improving cost structures and operational efficiency [4]. At the same time, the deep integration of large-scale technology with the banking system is restructuring information acquisition and credit evaluation frameworks, transforming traditional credit allocation models [6]. Based on this, this study conceptualizes the internal transmission mechanisms through which commercial banks' digital transformation affects consumer finance development along three dimensions: profitability, liquidity, and credit scale.

3.1. Profitability optimization path: value reshaping of banks enabled by fintech

The sustainable development of commercial banks depends heavily on their profitability, in which fintech plays a crucial enabling role. Compared with traditional business models dominated by the interest rate spread between deposits and loans, digital transformation reshapes business processes and pricing mechanisms, allowing banks to expand the consumer finance market at lower unit costs. Relevant research shows that fintech investment significantly improves bank profitability and overall performance, with the mechanism primarily reflected in enhanced operational efficiency and cost reduction [4].

In the consumer finance context, banks use big data analytics and algorithmic models to finely characterize customer risk, enabling differentiated pricing and optimization of credit product structures. This "technology empowerment–business synergy" process not only improves product update efficiency and market adaptability, but also enhances banks' profit flexibility in the retail financial sector [18]. Moreover, the deep integration of consumer finance with scenario-based economic activities further amplifies the scale effects of fintech, making it a critical breakthrough point in banks' digital transformation [12, 13].

3.2. Liquidity optimization path: strengthening risk-resilience and consolidating the consumer credit base

As typical financial intermediaries, commercial banks' capacity for business expansion largely depends on their liquidity management. Fintech enhances the precision of fund allocation and risk monitoring, enabling banks to respond more effectively to fluctuations in loan demand and potential liquidity shocks. Huang Yiping and Qiu Han [12] note that the large-scale technology-driven credit framework, by reconstructing information processing and risk identification systems, effectively alleviates information asymmetry in traditional finance, thereby enhancing the stability of the banking system.

In practice, the integration of digital footprints and intelligent risk-control models allows banks to monitor client fund flows and changes in repayment capacity in real time, dynamically adjusting asset-liability structures accordingly. Empirical evidence based on consumer credit data indicates that digital tools substantially improve default prediction accuracy and post-lending management efficiency [5]. Stronger fund management capabilities equip banks with greater resilience to risk and sustainable lending capacity, providing the necessary liquidity support for the expansion of consumer finance.

3.3. Credit scale expansion mechanism: process reengineering and information restructuring driving consumer finance development

The impact of fintech on credit scale primarily stems from its systematic reshaping of loan approval processes and information structures. By implementing intelligent approval systems, credit scoring algorithms, and large-scale data processing technologies, banks significantly enhance the speed and matching efficiency of credit operations, activating segments of the personal credit market previously constrained by high transaction costs and complex procedures. Research shows that improved financial accessibility substantially enhances resource allocation efficiency and stimulates household consumption expansion [7].

Further evidence from Chinese households indicates that fintech innovations, by alleviating financing constraints and improving credit matching, significantly promote household consumption growth [8]. As credit scale expands, banks accumulate richer data on customer behavior and credit histories, which in turn enhances risk assessment accuracy, forming a positive feedback loop of "data accumulation → risk-control optimization → credit expansion". Therefore, the digital transformation of banks represents not merely a technological upgrade but a systemic reform in the allocation of credit resources, providing endogenous momentum for the sustainable development of the consumer finance market.

4. Research design

4.1. Research hypotheses

Based on the theoretical analysis above, this study proposes the following research hypotheses:

Hypothesis 1: The digital transformation of banks significantly enhances the development of their consumer finance business.

Hypothesis 2: The digital transformation of banks promotes the development of consumer finance by strengthening their profitability.

Hypothesis 3: The digital transformation of banks fosters the development of consumer finance by improving their deposit-to-loan ratios.

Hypothesis 4: The digital transformation of banks advances consumer finance development by enhancing their liquidity capacity.

Hypothesis 5: The digital transformation of banks stimulates the development of consumer finance by expanding their business scale.

Hypothesis 6: The size of commercial banks moderates the positive effect of digital transformation on the development of consumer finance.

Hypothesis 7: Upgrades in consumption structure moderate the positive effect of banks' digital transformation on consumer finance development.

Hypothesis 8: The positive impact of banks' digital transformation on consumer finance development varies according to regional location and institutional characteristics.

4.2. Data sources and variable definitions

Data Sources: This study selects the sample period from 2011 to 2023, based on the availability of relevant data. The data are drawn from authoritative databases, including the Guotai An Database and the National Bureau of Statistics of China. The study sample covers all commercial banks in China. The data processing procedure is as follows: (1) banks with severe missing data are excluded; (2) continuous variables are winsorized at the 1% upper and lower tails. After these procedures, the final sample consists of 3,347 observations.

Variable Definitions:

The dependent variable in this study is the development level of consumer finance (Consumer).

To measure consumer finance, we follow existing literature and construct a comprehensive consumer finance index using the entropy method based on three indicators: personal loans (y1), personal housing loans (y2), and credit card loans (y3). Specifically: Personal loans (y1): Reflects the overall scale of consumer finance and serves as a measure of general development. Personal housing loans (y2) and credit card loans (y3): Capture development from the perspective of term structure within consumer finance.

The core explanatory variable is the digitalization level of commercial banks. Existing indices present limitations: the Digital Transformation Index released by Peking University is only updated until 2021, lacking timeliness; the CSMAR database indicators cover only listed banks, limiting sample coverage. Therefore, neither is suitable for this study. Following Zhang Yongshen et al., this study adopts text analysis on banks' financial statements and annual reports. Specifically, the focus is on intangible asset line items. Items containing terms such as "software system", "internet", "mobile terminal", "information platform", and "intelligent terminal" are classified as "digital intangible assets". Multiple digital intangible assets for the same bank in the same year are summed, and the natural logarithm is taken to quantify the bank's level of digitalization.

Mediating Variables: For mechanism analysis, the following mediators are selected:

1. Profitability (Ebit):

Measured by the ratio of Earnings Before Interest and Taxes (EBIT) to average total assets. This indicator reflects the profit generated per unit of asset before interest and tax payments and serves as a key measure of asset profitability efficiency. The formula is: Earnings Before Interest and Taxes (EBIT) divided by average total assets. A higher value indicates stronger profitability.

2. Liquidity status:

(1) Loan-to-Deposit Ratio (LTD): Measures the proportion of loans relative to deposits. Generally, a lower LTD indicates better liquidity, whereas a higher LTD suggests potential liquidity risk. When the proportion of credit assets is too high, poor convertibility can negatively affect liquidity.

(2) Liquidity Ratio (Liq): Calculated as the ratio of liquid assets to liquid liabilities. Liquid assets refer to assets that can be converted into cash within 30 days, while liquid liabilities include demand deposits,

maturing time deposits, interbank borrowing, interest payable, and other short-term obligations. A higher ratio indicates stronger liquidity.

3. Credit scale and moderating variables:

Table 1. Variable definitions

Variable Type	Variable Name	Symbol	Calculation	Data Source
Dependent Variable	Consumer Finance	Cons	Personal loans y1, personal housing loans y2, personal credit card loans y3– Calculated using the entropy method	Guotai An Database, National Bureau of Statistics
Independent Variable	Digitalization Level of Commercial Banks	Dig	Natural logarithm of the sum of digital technology intangible assets	
Mediating Variables	Profitability (Earnings Before Interest and Taxes)	Ebit	Ebit = Earnings Before Interest and Taxes (EBIT)/average total assets	
	Loan-to-Deposit Ratio	LTD	LTD = loans/deposits	
	Liquidity Ratio	Liq	Liq = liquid assets/liquid liabilities	
	Bank Loan Scale	Loan	Loan = In (total bank loans)	
Moderating Variables	Regional Consumption Structure Upgrade	Ind	Ind = development and enjoyment consumption expenditure/total expenditure	
	Number of Commercial Bank Branches	Size	Natural logarithm of the number of branches	
	Regional Financial Regulation	Fin	regional financial regulatory expenditure/financial industry added value	
	Equity-to-Debt Ratio	Etd	Equity-to-debt ratio	
Control Variables	Net Interest Spread	NIS	Net interest spread	
	Shareholding Ratio of Largest Shareholder	Top1	Shareholding ratio of the largest shareholder	
	Capital Adequacy Ratio	Cap	Capital adequacy ratio	
Instrumental Variables	Instrumental Variable 1	IV1	Natural logarithm of the geographic distance from the sample enterprise to Hangzhou	
	Instrumental Variable 2	IV2	Cube of the difference between the bank's digital transformation level and the provincial banking industry digital average	

Regarding the moderating variables (see Table 1), this study examines two dimensions: first, the degree of regional consumption upgrading (Ind, measured by the proportion of development-oriented consumption

expenditures in total consumption expenditures); second, the number of bank branches (Size).

The control variables include (see Table 1): regional financial Regulatory intensity (Fin), Equity-to-debt ratio (Etd), Net Interest Margin (NIS), shareholding ratio of the largest shareholder (Top1), and Capital adequacy ratio (Cap).

4.3. Model construction

To examine the impact of commercial banks' digital transformation on consumer finance, this study constructs a two-way fixed effects model with time and regional fixed effects. The baseline model 1 is specified as follows (equation (1)):

$$Cons_{i,t} = \alpha_0 + \alpha_2 Dig_{i,t} + \alpha_3 Fin_{i,t} + \alpha_4 Etd_{i,t} + \alpha_5 Nis_{i,t} + \alpha_6 Indep_{i,t} + \alpha_7 Cap_{i,t} + \sum Year + \sum Pro \quad (1)$$

For the mediation analysis, a stepwise regression approach is adopted. The models for examining the mechanism are specified as follows (equation (2-4)):

$$Cons_{i,t} = \beta_0 + \beta_1 Mid_{i,t} + \beta_2 Fin_{i,t} + \beta_3 Etd_{i,t} + \beta_4 Nis_{i,t} + \beta_5 Top_{i,t} + \beta_6 Cap_{i,t} + \sum Year + \sum Pro \quad (2)$$

$$Mid_{i,t} = \gamma_0 + \gamma_1 Dig_{i,t} + \gamma_2 Fin_{i,t} + \gamma_3 Etd_{i,t} + \gamma_4 Nis_{i,t} + \gamma_5 Top_{i,t} + \gamma_6 Cap_{i,t} + \sum Year + \sum Pro \quad (3)$$

$$Cons_{i,t} = \pi_0 + \pi_1 Dig_{i,t} + \pi_2 Mid_{i,t} + \pi_3 Fin_{i,t} + \pi_4 Etd_{i,t} + \pi_5 Nis_{i,t} + \pi_6 Top_{i,t} + \pi_7 * Cap_{i,t} + \sum Year + \sum Pro \quad (4)$$

For the moderating effect analysis, interaction terms between the explanatory variable and the moderating variable are added to the baseline model 1. The specification 5 is as follows (equation (5)):

$$Cons_{i,t} = \rho_0 + \rho_1 Dig_{i,t} + \rho_2 Intro_{i,t} + \rho_3 Intro_{i,t} Dig_{i,t} + \rho_4 Fin_{i,t} + \rho_4 Etd_{i,t} + \rho_6 Nis_{i,t} + \rho_7 Top_{i,t} + \rho_8 Cap_{i,t} + \sum Year + \sum Pro \quad (5)$$

In the above equations: $Cons_{i,t}$ is the dependent variable, $Dig_{i,t}$ is the explanatory variable, $Mid_{i,t}$ denotes the mediating variable, $Intro_{i,t}$ represents the moderating variable, i indexes individual banks, t indexes years, $\sum Pro$ represents regional fixed effects, and $\sum Year$ represents time fixed effects.

4.4. Measurement method based on the entropy weight method

To scientifically evaluate the development level of Consumer finance (Cons), this study adopts the framework proposed by Zhang Chenghao and Xie Taifeng (2020). Three key indicators are selected: personal loans (y1), housing mortgage loans (y2), and credit card overdrafts (y3). A comprehensive index is constructed using the Entropy Weight Method (EWM) as the dependent variable. The advantage of EWM lies in its ability to objectively determine indicator weights based on the information differences among indicators, effectively avoiding potential biases from subjective weighting.

4.4.1. Implementation Procedure of the Entropy Weight Method

The entropy weight method, a multi-attribute decision-making technique, is suitable for multi-indicator comprehensive evaluation problems. It calculates the information entropy of each indicator to objectively determine its weight, thus achieving a comprehensive evaluation. The specific steps are as follows:

(1) Construct the initial evaluation matrix: First, collect the raw data for consumer finance indicators to form the evaluation matrix.

(2) Ensure non-negativity of values: Since the entropy method computes each indicator's proportion relative to the total across all observations, it is dimensionless and typically does not require standardization. However, if the data contain negative values, a non-negative transformation must be applied. Additionally, to avoid undefined logarithmic computations during entropy calculation, an appropriate data shift may be required.

(3) Data preprocessing: As the entropy method inherently eliminates the impact of dimensional differences among indicators, no further standardization is needed. Nevertheless, negative values should be transformed to non-negative values, and a suitable data shift should be applied to ensure the validity of logarithmic operations.

4.4.2. Weight Allocation Results

The final weights obtained are: Personal loans (y1): 20.96%; Housing mortgage loans (y2): 41.26%; Credit card overdrafts (y3): 37.78%. This result (see Table 2) indicates that, within the consumer finance domain, medium- to long-term loans are more representative, with housing loans having the most significant impact on overall consumer finance development.

Table 2. Entropy weight method results

Variable	Weight
Personal Loans	20.96%
Housing Loans	41.26%
Credit Card Loans	37.78%

4.5 Descriptive Analysis

Descriptive statistics, including sample size, mean, standard deviation, and extreme values, are reported in Table 3. The mean of the consumer finance development index (Cons) is 2.298 (standard deviation 2.502), while the mean of the bank digitalization index (Dig) is 9.4730 (standard deviation 9.8374).

Table 3. Descriptive statistics

Variable	Obs	Mean	Std.dev.	Min	Max
Cons	3,347	2.2981	2.5021	0.0010	9.3263
dig1	3,347	9.4730	9.8374	0.0010	25.6324
Liq	3,347	0.7226	3.3405	0.1082	163.7000
LTD1	3,347	1.5132	0.4753	0.1342	13.4724
Loan	3,347	24.3790	1.7665	18.8901	30.8924
Ebit	3,347	0.0313	0.0117	-0.0080	0.5490
Size	3,347	1.0708	1.4207	0.0010	6.4862
Fin	3,347	7.8537	8.0176	1.0519	38.5570

Table 3. Continued

Etd	3,347	0.0958	0.1072	0.0010	3.0792
NIS	3,347	0.7981	1.3762	0.0010	6.6200
Top1	3,347	0.1950	0.2199	0.0042	1.0000
Cap	3,347	0.1470	0.0791	-0.1114	1.8800

Pearson correlation analysis (see Table 4) indicates that Dig and Cons are significantly positively correlated at the 1% level (r = 0.509), providing preliminary support for Hypothesis 1.

Table 4. Correlation analysis

	Cons	dig1	Liq	LTD1	Loan	Ebit	Size	Fin	Etd	NIS	Top1	Cap
Cons	1											
dig1	0.509***	1										
Liq	-0.024	0.037**	1									
LTD1	-0.148***	-0.134***	0.080***	1								
Loan	0.693***	0.431***	-0.087***	-0.207***	1							
Ebit	-0.041**	-0.104***	-0.032*	0.053***	0.008	1						
Size	0.551***	0.341***	-0.011	-0.101***	0.756***	-0.032*	1					
Fin	-0.079***	-0.02	-0.005	0	-0.023	0.018	-0.012	1				
Etd	-0.103***	0.007	0.722***	0.092***	-0.222***	-0.059***	-0.050***	-0.016	1			
NIS	0.211***	0.090***	-0.025	-0.032*	0.126***	0.008	0.122***	-0.156***	-0.003	1		
Top1	0.124***	0.096***	0.122***	0.023	0.158***	-0.163***	0.444***	-0.030*	0.270***	-0.093***	1	
Cap	-0.107***	0.002	0.551***	0.132***	-0.239***	-0.074***	-0.038**	-0.041**	0.912***	0.006	0.321***	1

To rule out potential multicollinearity, the Variance Inflation Factor (VIF) was calculated for all variables. All VIF values are below the critical threshold of 10, indicating no severe multicollinearity issues (see Table 5).

Table 5. Multicollinearity test

Variable	VIF	1/VIF
Cap	6.4300	0.1555
Etd	6.2100	0.1611
Top1	1.1500	0.8729
NIS	1.0500	0.9566
Fin	1.0300	0.9700
dig1	1.0200	0.9782
Mean VIF	2.8100	

5. Empirical study

5.1. Baseline regression analysis

Table 6 presents the regression results based on Model (1). The first column reports results without control variables, while the second column includes control variables. The results indicate that Dig is positively associated with Cons at the 1% significance level, with a regression coefficient of 0.098. This provides strong empirical support for Hypothesis 1: enhancing the level of digitalization in commercial banks significantly promotes the development of their consumer finance business.

Table 6. Baseline regression results

	(1) Cons	(2) Cons
dig1	0.107***	0.098***
	(25.423)	(23.222)
Fin		0.001
		(0.160)
Etd		1.829**
		(2.354)
NIS		0.281***
		(9.494)
Top1		-0.521**
		(-2.310)
Cap		-6.936***
		(-6.426)
_cons	1.285***	2.131***
	(24.786)	(17.375)
N	3,347.000	3,347.000
R^2	0.379	0.424

$^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$

5.2. Robustness checks

To ensure the reliability of the research hypotheses, variable selection, and model specification, three robustness checks were conducted: Regression using a subsample from 2015–2023. Using the lagged value of the explanatory variable as a substitute variable. Applying a time-region-individual fixed effects model. All tests consistently show that the digitalization level of commercial banks (Dig) remains positively and significantly associated with consumer finance development (Cons) at the 1% significance level. These results confirm the robustness of the study's conclusions (see Table 7).

Table 7. Robustness test results

	(1) Cons	(2) Cons	(3) Cons
dig1	0.093***		0.065***
	(20.256)		(16.411)
Fin	0.003	0.001	-0.003
	(0.483)	(0.178)	(-0.702)
Etd	2.438**	2.837***	-0.641
	(2.383)	(3.073)	(-0.885)
NIS	0.328***	0.294***	0.215***
	(8.661)	(8.697)	(5.954)
Top1	-0.731***	-0.691***	-0.445
	(-2.766)	(-2.755)	(-0.819)
Cap	-7.359***	-8.429***	0.856
	(-4.803)	(-6.271)	(0.900)
L.dig1		0.081***	
		(17.040)	
_cons	2.187***	2.633***	1.611***
	(13.107)	(17.900)	(10.070)
N	2,533.000	2,922.000	3,347.000
R^2	0.389	0.386	0.742

*$p < 0.1$,**$p < 0.05$,***$p < 0.01$

5.3. Endogeneity test

Table 8. Endogeneity test results

	(1) dig1	(2) Cons	(3) dig1	(4) Cons
iv1	53.749***			
	(3.734)			
Fin	-0.018	0.008	-0.001	0.001
	(-0.829)	(0.917)	(-0.036)	(0.217)
Etd	3.570	1.018	-1.469	1.779**
	(1.103)	(1.058)	(-1.318)	(2.131)
NIS	0.502***	0.164**	0.005	0.272***
	(3.784)	(2.480)	(0.110)	(8.601)
Top1	-3.589***	0.337	-1.154***	-0.475*
	(-3.819)	(0.708)	(-3.571)	(-1.880)
Cap	-8.155*	-4.889***	4.454***	-6.798***
	(-1.809)	(-2.974)	(2.875)	(-5.362)
dig1		0.367***		0.115***
		(4.086)		(24.349)
iv2			0.007***	
			(154.147)	
_cons	2.521	0.788	6.532***	2.788***
	(1.067)	(0.985)	(39.475)	(9.393)
N	3,347.000	3,347.000	3,347.000	3,347.000
R^2	0.376	0.412	0.922	0.421

*$p < 0.1$,**$p < 0.05$,***$p < 0.01$

To address potential issues in the regression analysis—such as measurement error, omitted variables, and reverse causality—this study employs the Instrumental Variables (IV) method using a Two-stage Least Squares (2SLS) model.

Based on prior research on digital transformation, the following two instrumental variables are selected:

1. Natural logarithm of the geographic distance between the bank's city and Hangzhou (IV1): For regional banks, the city of the headquarters is used; for national banks, the registered location is applied. This variable is chosen because China's banking sector exhibits clear regional segmentation, and Hangzhou, as a demonstration zone for digital financial innovation, has surrounding banks with generally higher levels of digitalization.

2. Cubed deviation of a bank's digitalization level from the provincial average (IV2): This indicator effectively captures the extent to which an individual bank deviates from the overall regional digitalization level.

Empirical results (see Table 8) indicate that the regression coefficients of the instrumental variables are 53.749 and 0.007, both statistically significant at the 1% level, and positively correlated with the bank digitalization index (Dig1). This confirms the validity of the selected instruments. In the second-stage

regression, the coefficient of digitalization (Dig) on consumer finance development (Cons) reaches 0.367 and 0.115, demonstrating that the digital transformation of commercial banks has a significant positive effect on the development of consumer finance business.

5.4. Mediation mechanism test

Based on the mediation models constructed in this study (Equations 2–4), the mediation effects are examined from four dimensions:

5.4.1. Mediation via profitability

Table 9. Mediation effect results – profitability

	(1) Cons	(2) Ebit	(3) Cons
Ebit	8.222**		5.220*
	(2.460)		(1.683)
Fin	-0.001	0.001	0.001
	(-0.167)	(1.330)	(0.121)
Etd	2.134**	-0.001	1.834**
	(2.549)	(-0.217)	(2.361)
NIS	0.338***	-0.001	0.282***
	(10.613)	(-0.625)	(9.514)
Top1	-0.732***	-0.007***	-0.484**
	(-3.001)	(-5.552)	(-2.138)
Cap	-7.729***	-0.002	-6.925***
	(-6.648)	(-0.343)	(-6.417)
dig1		0.001**	0.098***
		(2.404)	(23.137)
_cons	2.927***	0.032***	1.963***
	(17.777)	(46.928)	(12.395)
N	3,347.000	3,347.000	3,347.000
R^2	0.331	0.175	0.424

Using return on assets before interest and tax (Ebit) as the mediator, the regression results indicate: Column 1 shows that the mediator has a significant positive effect on consumer finance development (Cons) at the 5% level. Column 2 demonstrates that bank digitalization (Dig) is positively and significantly associated with the mediator at the 5% level. Column 3 includes both Dig and the mediator, and both variables significantly affect Cons. These results confirm the mediating role of profitability, providing empirical support for Hypothesis 2 (see Table 9).

5.4.2. Mediation via loan–deposit structure

Using the Loan-to-Deposit ratio (LTD) as the mediator: Column 1 shows that the mediator significantly promotes consumer finance development at the 1% level. Column 2 confirms a positive and significant relationship between Dig and LTD at the 5% level. Column 3 demonstrates that both Dig and LTD

significantly impact Cons. These results support the mediating effect of the loan–deposit structure, validating Hypothesis 3 (see Table 10).

Table 10. Mediation effect results – loan–deposit structure

	(1) Cons	(2) LTD	(3) Cons
LTD	0.019***		0.015***
	(4.058)		(3.401)
Fin	-0.001	-0.026	-0.001
	(-0.226)	(-0.906)	(-0.111)
Etd	-11.203***	97.064***	-7.874***
	(-5.767)	(11.533)	(-4.308)
NIS	0.268***	0.145	0.207***
	(8.039)	(0.980)	(6.619)
Top1	0.345	-9.091***	0.309
	(1.040)	(-6.238)	(0.997)
Cap	-3.766**	-66.802***	-4.212***
	(-2.465)	(-10.078)	(-2.944)
dig1		0.057**	0.089***
		(2.472)	(18.177)
_cons	2.136***	68.324***	1.457***
	(5.967)	(92.104)	(4.321)
N	3,347.000	3,347.000	3,347.000
R^2	0.339	0.420	0.421

5.4.3. Mediation via liquidity

Using the Liquidity ratio (Liq) as the mediator: Column 1 shows that the liquidity ratio significantly promotes consumer finance development at the 1% level. Column 2 indicates that Dig is positively and significantly correlated with liquidity ratio at the 1% level. Column 3 shows that both Dig and the mediator significantly affect Cons at the 1% level. These findings confirm the validity of the liquidity-mediated channel, supporting Hypothesis 4 (see Table 11).

Table 11. Mediation effect results – liquidity

	(1) Cons	(2) Liq	(3) Cons
Liq	0.057***		0.040***
	(3.423)		(2.587)
Fin	-0.001	-0.001	0.001
	(-0.105)	(-0.070)	(0.163)
Etd	-0.338	43.095***	0.099
	(-0.306)	(49.470)	(0.097)
NIS	0.340***	-0.051	0.283***
	(10.679)	(-1.527)	(9.568)
Top1	-0.767***	-0.387	-0.505**
	(-3.160)	(-1.529)	(-2.242)
Cap	-6.045***	-29.700***	-5.744***
	(-4.784)	(-24.549)	(-4.897)
dig1		0.013***	0.098***
		(2.734)	(23.092)
_cons	3.135***	0.963***	2.093***
	(25.311)	(7.007)	(16.949)
N	3,347.000	3,347.000	3,347.000
R^2	0.332	0.612	0.425

5.4.4. Mediation via business scale

Table 12. Mediation effect results – business scale

	(1) Cons	(2) Loan	(3) Cons
Loan	0.950***		0.840***
	(40.564)		(35.452)
Fin	-0.001	0.001	-0.001
	(-0.275)	(0.424)	(-0.074)
Etd	0.597	1.467***	0.597
	(0.871)	(3.020)	(0.901)
NIS	0.108***	0.214***	0.101***
	(4.048)	(11.577)	(3.931)
Top1	-0.021	-0.680***	0.050
	(-0.104)	(-4.824)	(0.262)
Cap	0.229	-8.005***	-0.208
	(0.236)	(-11.867)	(-0.222)
dig1		0.048***	0.058***

Table 12. Continued

		(18.023)	(15.421)
_cons	-21.014***	24.972***	-18.856***
	(-34.720)	(325.757)	(-31.368)
N	3,347.000	3,347.000	3,347.000
R^2	0.553	0.546	0.583

Using the natural logarithm of total loans (Loan) as the mediator: Column 1 shows that business scale significantly affects consumer finance at the 1% level. Column 2 confirms a significant positive relationship between Dig and business scale at the 1% level. Column 3 demonstrates that both variables significantly influence Cons. These results validate the mediating role of business scale, providing empirical support for Hypothesis 5 (see Table 12).

5.5. Moderation analysis

This study employs Model 5 to examine the moderating effects of bank size by including the interaction term between bank size and digitalization level. Based on Model 1, the moderation effect is tested empirically. The results (see Table 13) indicate: First, the interaction between bank size and digitalization level exhibits a significant negative effect on consumer finance development at the 1% significance level. This finding confirms Hypothesis 6, suggesting that larger bank size diminishes the positive impact of digitalization on consumer finance. Second, the interaction between upgraded consumption structure and digitalization level fails to reach statistical significance at the 10% level, indicating that Hypothesis 7 is not empirically supported.

Table 13. Moderation effect regression results

	(1) Cons	(2) Cons
dig1	0.080***	0.120***
	(16.275)	(5.379)
Size	0.833***	
	(19.111)	
dig1× Size	-0.006***	
	(-2.603)	
Fin	0.001	0.001
	(0.067)	(0.139)
Etd	1.314*	1.797**
	(1.837)	(2.312)
NIS	0.132***	0.280***
	(4.712)	(9.441)
Top1	-1.914***	-0.505**
	(-8.847)	(-2.236)
Cap	-4.176***	-6.878***
	(-4.180)	(-6.369)

Table 13. Continued

Ind		2.367
		(1.327)
dig1× Ind		-0.056
		(-1.006)
_cons	1.502***	1.232*
	(12.831)	(1.794)
N	3,347.000	3,347.000
R^2	0.513	0.424

*$p < 0.1$,**$p < 0.05$,***$p < 0.01$

5.6. Heterogeneity test

Table 14. Heterogeneity analysis results

	State-owned	Non-State-owned	Eastern Region	Central & Western Region
	Cons	Cons	Cons	Cons
dig1	0.888**	0.093***	0.098***	0.097***
	(2.280)	(21.791)	(17.987)	(15.258)
Fin	0.470**	0.001	0.010	-0.005
	(2.543)	(0.132)	(1.149)	(-0.840)
Etd	-6.037	1.770**	2.201**	0.557
	(-0.148)	(2.276)	(2.502)	(0.208)
NIS	-0.605	0.276***	0.188***	0.586***
	(-1.538)	(9.302)	(5.312)	(10.337)
Top1	-6.013**	-0.251	-0.946***	1.093**
	(-2.283)	(-1.089)	(-3.633)	(2.045)
Cap	2.173	-6.932***	-7.302***	-3.474
	(0.217)	(-6.403)	(-5.890)	(-1.380)
_cons	-11.346	2.060***	2.456***	1.112***
	(-0.933)	(16.945)	(15.718)	(4.212)
N	65.000	3,282.000	2,251.000	1,096.000
R^2	0.550	0.377	0.396	0.477

*$p < 0.1$,**$p < 0.05$,***$p < 0.01$

Heterogeneity is examined along two dimensions: regional distribution and bank attributes. The results (see Table 14) show that: State-owned banks demonstrate a more pronounced effect of digital transformation in promoting consumer finance development. Differences across eastern, central, and western regions are relatively minor, suggesting that the regional effect is less pronounced than the institutional effect.

6. Research conclusion and policy implication

6.1 Main findings

1. The digitalization process of commercial banks has a significant promoting effect on the development of consumer finance. The regression coefficients of the core variable remain stable and are significant at the 1% level. Model estimates show that for every 1-percentage-point increase in digitalization, the development level of consumer finance increases by approximately 0.098 percentage points.

2. Mechanism analysis indicates that bank digital transformation primarily promotes consumer finance development through three channels: enhancing profitability, optimizing liquidity management, and expanding credit scale. Among these, the mediating effect of credit scale expansion is the most prominent, suggesting that digital-driven reforms in credit approval and risk management systems are the core driving force for the growth of consumer finance.

3. Moderating effect tests show that bank size has a negative moderating effect on the relationship between digitalization and consumer finance, i.e., an increase in the number of bank branches reduces the marginal contribution of digitalization to consumer finance. In contrast, the moderating effect of regional consumption structure upgrading is not significant.

4. Heterogeneity analysis shows that state-owned banks have a clear advantage in promoting consumer finance through digital transformation, benefiting from their unique resource and institutional advantages. At the regional level, differences between eastern, central, and western regions are not significant, indicating that the consumption upgrade effect brought by digitalization is generally applicable across regions.

6.2 Policy recommendations

1. Accelerate the digital transformation of the banking sector and improve the financial technology infrastructure system.

2. Optimize the allocation of bank digital resources, with a focus on supporting innovation in credit business.

3. Implement differentiated digital transformation strategies according to bank scale.

4. Strengthen regional coordination of digital development and reduce the digital divide.

Enhance the coordinated development of financial institutions in terms of profitability, liquidity, and credit management efficiency to construct a transmission mechanism for the effects of digital transformation. Implement differentiated strategies to optimize the policy matching of digital upgrades for various types of banks. For state-owned banks, this involves maintaining profitability while streamlining redundant branches. For non-state-owned banks, it requires strengthening technical support and talent cultivation to enhance digitalization capabilities. Promote coordinated regional fintech development to improve policy applicability and implementation effectiveness. Considering that the impact of digital reform on consumer finance is similar across regions, it is recommended to build regional fintech sharing platforms to more effectively allocate resources and strengthen nationwide digital coordination effects.

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