

# Reshaping Commercial Banks' Profitability in the Era of Intelligent Finance: AI-Driven Mechanism Test and Policy Recommendations

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**Abstract:** *In the context of the continuous advancement of the digital economy strategy and the deepening of the supply-side structural reform in the financial sector, artificial intelligence technology is accelerating the reshaping of the value creation methods and profit models of the banking industry. Based on panel data of A-share listed banks in China from 2007 to 2023, this paper systematically examines the impact of artificial intelligence on the profitability of banks and its mechanism of action. The study found that the application of artificial intelligence significantly enhanced the profitability of banks, mainly through two paths: reducing operating costs and strengthening risk control. At the same time, the innovation ability of banks can enhance the profit-promoting effect of artificial intelligence, that is, the stronger the innovation ability, the more obvious the marginal benefit of artificial intelligence. Further heterogeneity analysis indicates that AI has a more significant profit-boosting effect on public banks and large banks. The economic significance analysis shows that AI not only helps improve the cost-income structure and asset quality of banks, but also enhances their sustainable profitability in the context of interest rate liberalization and fintech competition. This paper provides empirical evidence and decision-making references for banks to advance digital and intelligent transformation and for regulatory authorities to improve the digital finance policy system*

**Keywords:** Artificial intelligence; Bank profitability; Operating costs; Risk control; Innovation capability.

## 1. INTRODUCTION

At present, the new round of technological revolution and industrial transformation is accelerating. Artificial Intelligence (AI), as the core general technology of the digital economy era, is deeply embedded in the operation process of the financial system and is gradually becoming the key driving force for the high-quality development of the banking industry. At the policy level, the Financial Technology Development Plan (2022-2025) explicitly proposes to deepen the application of artificial intelligence in areas such as risk control and customer service; The Action Plan for Promoting High-Quality Development of Digital Finance in 2024 further emphasizes the construction of an "intelligent bank ecosystem" to enhance the operational efficiency and profitability sustainability of the financial system. The report of the 20th National Congress of the Communist Party of China also proposed to accelerate the development of the digital economy and promote the deep integration of digital technology with the real economy. Against this backdrop, artificial intelligence has become a key tool for the digital transformation of the banking industry [1].

As a core component of the modern financial system, the profitability of the banking sector is crucial not only for the sound operation of financial institutions themselves but also directly impacts the efficiency of financial services supporting the real economy and the stability of the financial system. However, with the ongoing advancement of interest rate liberalization [2] and the deepening trend of financial disintermediation [3], the traditional profit model of banks—dependent on loan-deposit interest spreads—is under significant pressure [4]. Meanwhile, fintech companies are leveraging their technological advantages to rapidly enter sectors such as payment settlement, consumer finance, and wealth management, further squeezing the profit margins of commercial banks [5]. In this context, how to utilize artificial intelligence to reduce costs, enhance efficiency, optimize risk management, and cultivate new profit growth drivers has become a central issue in the transformation and development of the banking industry.

From a practical perspective, AI is being widely applied in business scenarios such as intelligent customer service, intelligent risk control, precision marketing and intelligent investment advice. On the one hand, based on big data analysis and machine learning algorithms, banks can more accurately identify customer needs, optimize product pricing and marketing strategies, and improve customer conversion rates and cross-selling capabilities [6]; On the other hand, artificial intelligence can enhance the efficiency of risk identification and early warning, and reduce

the non-performing loan ratio and risk disposal costs [7]. In addition, the application of automated processes and intelligent decision-making systems has effectively reduced operating costs [8] and improved the efficiency of resource allocation. Cases have shown that banks that have taken the lead in advancing artificial intelligence have achieved certain improvements in customer service efficiency, asset quality and cost control, and have shown an upward trend in profitability.

However, the application of artificial intelligence in the banking sector still faces practical challenges such as technological adaptation, data governance, model biases, and information security [9]. Without effective data management and institutional safeguards, technological investments may fail to translate into operational performance and could even exacerbate operational risks. Therefore, systematically understanding the mechanisms and economic implications of AI's impact on bank profitability holds significant practical importance for banks to optimize their digital transformation strategies, enhance core competitiveness, and for regulatory authorities to improve the digital financial governance framework.

Existing research mainly focuses on the application of artificial intelligence in specific business scenarios of banks, with a particular emphasis on issues such as risk management, customer service, and financial technology innovation. However, research on how artificial intelligence systematically affects bank profitability is still relatively limited. On the one hand, most of the literature remains at the theoretical analysis or case study level, lacking systematic empirical tests based on long-term panel data; On the other hand, there is still insufficient discussion of the impact of heterogeneity among different types of banks and the underlying mechanisms application of automated processes and intelligent decision-making systems has effectively reduced operating costs and improved the efficiency of resource allocation. Cases have shown that banks that have taken the lead in advancing artificial intelligence have achieved certain improvements in customer service efficiency, asset quality and cost control, and have shown an upward trend in profitability.

Compared with existing studies, the marginal contributions of this paper are mainly reflected in the following three aspects:

First, from the perspective of the deep integration of the digital economy and fintech, this paper systematically sorts out the theoretical logic of how artificial intelligence affects the profitability of banks and expands the analytical framework of fintech and bank performance research.

Second, based on the data of A-share listed banks in China from 2007 to 2023, this paper comprehensively considers factors such as macroeconomic environment, money supply level and bank capital strength, empirically examines the direct impact of artificial intelligence on bank profitability and its transmission mechanism, thereby identifying the specific paths through which artificial intelligence empowers bank operating performance and quantifying its economic effects.

Third, in light of the differentiated development characteristics of China's banking industry, this paper further distinguishes between the property rights attributes and scale characteristics of banks and examines the heterogeneity of the impact of artificial intelligence. At the same time, the internal mechanisms are analyzed from dimensions such as operating costs, risk control and innovation capabilities to provide empirical evidence for banks to formulate differentiated digital transformation strategies.

## **2. THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES**

### **2.1 The Impact of Artificial Intelligence on Bank Profitability**

With the rapid development of fintech, artificial intelligence, with its powerful data processing and algorithm learning capabilities, has gradually permeated into core business links of banks such as credit approval, payment and settlement, customer service and asset management, driving profound changes [10] in the value creation model of banks. Traditional banking operations are highly dependent on human decision-making and empirical judgment, with certain limitations in business response efficiency, customer identification ability and risk pricing accuracy, while artificial intelligence can optimize business processes and enhance decision-making efficiency through machine learning and intelligent analysis, thereby improving banking performance.

From the perspective of resource-based theory, the data resources, technical capabilities and customer information accumulated by banks can be transformed into more competitive digital assets with the support of artificial

intelligence technology. Through intelligent customer service systems and automated operation platforms, banks can break through the time constraints of traditional physical branches and manual services, improve service efficiency and optimize resource allocation [11]. At the same time, AI can also enhance customer profiling and demand identification capabilities, increase customer stickiness and cross-selling levels, thereby expanding revenue sources.

From the perspective of transaction cost theory, AI helps reduce costs for banks in information collection, business review and process management. For example, in the credit approval process, intelligent models can replace some of the human due diligence and review processes, reducing human error and time costs [12]; In the marketing process, machine learning algorithms can make precise recommendations based on customer behavior data, improving marketing efficiency and resource utilization [13]. All of these changes contribute to improving the operational efficiency and profitability of the bank.

In addition, the application of artificial intelligence can also enhance banks' ability to cope with market competition and external shocks. In the context of interest rate liberalization and the intensifying competition in fintech, AI helps banks break through the constraints of traditional profit models, cultivate digital operational advantages, and thereby enhance profit stability and sustainable development capabilities.

Based on the above analysis, this paper proposes the following hypotheses:

H1: Artificial intelligence applications can significantly enhance bank profitability

## **2.2 The Mediating Pathway Through Which Artificial Intelligence Affects Bank Profitability**

### **1) Operating Costs**

Artificial intelligence can reduce bank operating costs through business process automation and intelligent decision-making optimization. On the one hand, in specific business operations, technologies such as OCR recognition and RPA robots can automate processes such as account settlement, bill review and cross-system reconciliation, significantly reducing human input and operational errors and improving business processing efficiency. Intelligent customer service systems, based on natural language processing technology, can provide 24/7 online service, reduce the need for human customer service configuration, and improve problem-solving efficiency through semantic recognition, thereby reducing customer churn and service costs [14].

On the other hand, at the management level, AI can optimize resource allocation based on massive business data. For example, banks can use time series models to predict business needs in different regions and time periods, dynamically adjust ATM locations, cash reserves and personnel arrangements, and reduce idle resources and ineffective expenditures. At the same time, intelligent scheduling and operational dispatching systems can enhance the operational efficiency of branches and achieve refined cost management [15].

Economically speaking, the reduction in operating costs not only directly improves the cost-income ratio, but also frees up more resources for product innovation and business expansion, thus creating a positive cycle of "cost reduction-efficiency increase-profit improvement".

Based on this, the paper proposes the following hypotheses:

H2: Artificial intelligence will enhance profitability by reducing bank operating costs.

### **2) Risk Control**

Artificial intelligence, relying on big data analysis and machine learning algorithms, can enhance banks' risk identification and dynamic monitoring capabilities, thereby optimizing risk control levels [16]. Traditional bank risk control mainly relies on static information such as financial statements and credit records, while artificial intelligence can integrate multi-dimensional information such as consumer behavior, transaction data and associated networks to build a more comprehensive customer risk profile and improve the accuracy of risk assessment.

In the pre-loan stage, machine learning models can identify potential high-risk customers and improve the

efficiency of credit approval; In the post-loan stage, intelligent monitoring systems can track borrowers' operations and capital flows in real time, identify risk signals in a timely manner and issue early warnings, thereby reducing the probability [17] of non-performing loans forming. The improvement of risk control capabilities not only helps to reduce bad debt losses and provision pressure, but also enhances the quality of bank assets and the stability of earnings.

From an economic perspective, after artificial intelligence strengthens risk management, banks' capital occupation and risk costs will decline, thereby enhancing their risk-adjusted return levels. This means that AI not only enhances the short-term profitability of banks, but also strengthens their long-term stable operation capabilities [18].

Based on the above analysis, Hypothesis 3 is proposed:

H3: Artificial intelligence will enhance bank profitability by strengthening risk control.

### 3) Innovation Ability

Bank innovation capacity determines the depth of application of artificial intelligence technology and the efficiency of value transformation. Banks with strong innovation capabilities typically have a more complete technology research and development system, a higher level of talent reserve, and a more open business innovation culture. Therefore, it is easier for them to embed AI into high-value-added business scenarios such as wealth management, supply chain finance, and cross-border finance to create new revenue sources [19].

For instance, some banks have leveraged AI to introduce [20] innovative [21] services such as robo-advisory and digital supply chain finance, expanding their income from intermediary business by enhancing customer experience and service efficiency. In contrast, banks with weaker innovation capabilities often only apply AI to basic process optimization, and their technology application remains at the cost reduction level, making it difficult to generate sustainable profit growth momentum.

As a result, banks' innovation capabilities may enhance the boosting effect of AI on profitability. The stronger the innovation ability, the more effectively banks can unlock the technological dividend of AI and achieve a higher level of improvement in operating performance.

Based on this, the bank's innovation capability moderates the relationship between artificial intelligence and profitability, leading to Hypothesis 4:

H4: A bank's innovation capability positively moderates the impact of artificial intelligence on profitability; the stronger the innovation capability, the more pronounced the profit-enhancing effect of AI.

In summary, AI has a systemic impact on bank profitability by directly enhancing operational efficiency and through pathways such as reduced operating costs, strengthened risk control, and enhanced innovation capabilities, forming a chain of action of "technology empowerment-efficiency optimization-risk improvement-innovation deepening-profit enhancement"

## **3. RESEARCH DESIGN**

### **3.1 Variable Description**

#### 1) Dependent Variable: Bank Profitability

Return on assets (ROA) is a classic measure of a bank's profitability, reflecting its ability to generate profits using all its assets. This paper selects ROA as the explained variable to describe the profitability level of listed banks. For the robustness test in the follow-up study, return on equity (ROE) was used for supplementary verification [22].

#### 2) Core explanatory variable: Degree of artificial intelligence application

Annual financial reports of listed banks, as important information carriers for business operations and development,

bring together key operational dynamics of the past year and future strategic directions. Among them, the frequency of words related to "artificial intelligence" can effectively reflect the bank's investment and attention in the application and layout of artificial intelligence technology. Referring to the method by Yu R et al. to measure the application of fintech through text word frequency, this paper uses text mining methods [23] to count the word frequency related to "artificial intelligence" in the annual reports of listed banks, thereby quantifying the degree of application of artificial intelligence in banks as the core explanatory variable.

### 3) Control Variables

In empirical research, the rational selection of control variables is a crucial step to ensure the accuracy of model estimates and the reliability of conclusions. It plays a role in eliminating the interference of other factors on the relationship between the core explanatory variable and the explained variable, thereby more accurately identifying the core effect. Specifically, in terms of bank characteristic variables, bank size, capital strength, loan-to-deposit ratio, and management cost are selected, and the specific measurement methods of the relevant variables will be detailed in the sample data descriptive statistics; In terms of macroeconomic variables, GDP growth rate and M2 year-on-year growth rate are included. The former reflects the macroeconomic development trend, and the latter reflects the liquidity environment [24] of the money market.

### 4) Mechanism Variable

Regarding the mechanism variables, this paper selects operating costs and risk control as mediating variables, where operating costs are measured by the cost-income ratio, which reflects the efficiency of banks in converting costs into income. The application of artificial intelligence may reduce operating costs by optimizing business processes, automating processing, etc., thereby enhancing profitability; Risk control is measured by the non-performing loan ratio. The deep application of artificial intelligence in credit approval, risk monitoring and other links can improve the accuracy of risk identification through big data analysis, change the level of risk exposure and control effect of banks, and become an important intermediate path [25] connecting artificial intelligence application and profitability. At the same time, referring to the introduction of innovation ability as a moderating variable by scholars [26] such as Li Qin, and choosing fee and commission income to measure this indicator, since fee and commission income mostly stems from innovative intermediary business of banks, it can reflect the innovative vitality of banks in product and service models, and its combination with artificial intelligence application may strengthen or weaken the impact on profitability, And referring to Jiang [27] Ting's methodological framework for testing the moderating effect through interaction terms, it aims to examine the moderating direction and extent of innovation ability on the "AI-bank profitability" relationship.

## 3.2 Model Construction

### 1) Dynamic Panel Regression Model

First, to examine the fundamental impact of artificial intelligence applications on bank profitability (ROA), we constructed the benchmark regression model as shown in Equation (1):

$$ROA_{i,t} = \alpha_0 + \alpha_1 AI_{i,t} + \sum \alpha_2 Control_{i,t} + \varepsilon_{i,t} \quad (1)$$

Specifically,  $ROA_{i,t}$  denotes the asset return rate of the  $i$ -th bank in period  $t$ ;  $AI_{i,t}$  represents the core explanatory variable quantifying the frequency of "artificial intelligence" -related terms in the bank's financial report for period  $t$ ;  $Control_{i,t}$  refers to the control variable set, including bank size, capital strength, loan-to-deposit ratio, management costs, GDP growth rate, and year-on-year M2 growth rate;  $\alpha_0$  is the intercept term,  $\alpha_1$  and  $\alpha_2$  are the estimated coefficients, and  $\varepsilon_{i,t}$  is the random disturbance term.

### 2) Intermediary Effect Testing Model

Secondly, drawing on Jiang Ting's mechanism testing approach, we first construct Equation (2) to examine whether the core explanatory variable influences the mediating variable. Subsequently, by incorporating the interaction term between the mediating variable and the core explanatory variable, we test the mechanism of action of the core explanatory variable using Equation (3).

$$Mediator_{i,t} = \beta_0 + \beta_1 AI_{i,t} + \sum \beta_2 Control_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$ROA_{i,t} = \theta_0 + \theta_1 Mediator_{i,t} AI_{i,t} + \theta_3 Mediator_{i,t} + \sum \theta Control_{i,t} + \varepsilon_{i,t} \quad (3)$$

In this context, Mediator<sub>i,t</sub> refers to the mechanism variable, specifically denoting a bank's operational costs and risk control measures, which are measured by the cost-to-income ratio and non-performing loan ratio, respectively; β denotes the coefficient.

### 3) Model for Testing the Regulatory Effect

Finally, to analyze the moderating effect of innovation capability on the relationship between "artificial intelligence and bank profitability," an interaction term was introduced into the benchmark model:

$$ROA_{i,t} = \theta_1 + \theta_2 AI_{i,t} + \theta_3 Innovation_{i,t} + \theta_4 AI_{i,t} \times Innovation_{i,t} + \theta_5 Control_{i,t} + \varepsilon_{i,t}$$

Specifically, Innovation<sub>i,t</sub> represents the innovation capability of the i-th bank in period t, measured by fee and commission income; AI<sub>i,t</sub> × Innovation<sub>i,t</sub> denotes the interaction term between the core explanatory variable and the moderating variable, with coefficient θ<sub>4</sub> indicating the direction and magnitude of innovation capability moderation—adopting the methodological framework proposed by Tang Song [28] for testing moderating effects via interaction terms.

### 3.3 Sample Data

The A-share listed banks from 2007 to 2023 were selected as research samples, and the data were mainly from the Wind database. For text data such as the frequency of financial statements, Python web crawlers combined with text mining techniques were used to extract and process expressions related to "artificial intelligence" from the annual reports of listed banks; Financial indicators such as bank size and capital strength, as well as macro data such as GDP growth rate and M2 year-on-year growth rate, are directly obtained from the corresponding sections of the Wind database. For some missing values, the "bank-annual" panel data of 43 listed banks was formed by looking up the official annual and semi-annual reports of the banks to supplement and improve. The descriptive statistics of each variable are presented in Table (1). It can be seen that the average value of return on assets (ROA) is 0.850, the maximum value is 1.475, and the minimum value is 0.148. The overall difference is small, indicating that the enterprise's asset utilization effect is good and the overall trend of financial performance is good. The average level of artificial intelligence is 1.444, which is relatively low, indicating that the artificial intelligence of the banking industry is still in the development stage. The maximum value is 4.025 and the minimum value is 0, indicating that there is a situation where banks have not undergone artificial intelligence transformation. From this perspective, there is a certain gap between industries, and there is much room for improvement in the transformation of artificial intelligence in banks.

**Table 1:** Descriptive statistics of sample data

	count	mean	sd	min	max
Total Asset Return (ROA)	377	0.850	0.300	0.148	1.475
AI	377	1.444	1.162	0.000	4.025
asset size	377	9.832	1.562	6.627	12.889
capital strength	377	0.071	0.014	0.022	0.131
Loan-to-Deposit Ratio	377	76.314	12.984	38.970	116.235
administration cost	377	0.008	0.002	0.004	0.015
capital adequacy ratio	377	13.427	2.188	5.770	30.670
GDP rate of rise	377	6.927	2.767	2.200	14.231
Year-on-year growth rate of M2	377	12.073	4.358	8.100	27.680
operating costs	377	32.009	7.924	18.930	61.410
NPLR	377	1.419	0.776	0.510	5.620
lnnov	377	4.156	2.096	-0.414	7.448

## 4. EMPIRICAL ANALYSIS

### 4.1 Correlation Analysis

Prior to conducting empirical analysis, a multicollinearity test was performed on the independent variables. Table 2 shows that the correlation coefficient between the degree of artificial intelligence application (AI) and return on total assets (ROA) is 0.194—a positive value significant at the 1% level—which demonstrates a positive and statistically significant relationship between AI adoption and bank profitability, preliminarily validating Hypothesis 1. The maximum correlation coefficients among the independent variables are all nearly below 0.8, indicating no severe collinearity issues.

Table 2: Correlation Analysis

	Total Asset Return (ROA)	AI	size	capital strength	LDR	MCost	CAR	g_GDP	g_M2	C_op	NPL R	Innov
Total Asset Return (ROA)	1											
AI	0.194**	1										
asset size	0.181**	0.243**	1									
capital strength	0.00639	0.366**	-0.0806	1								
Loan-to-Deposit Ratio	0.0110	0.455**	0.212**	0.388**	1							
administration cost	0.0327	0.329**	0.00874	0.243**	0.205**	1						
capital adequacy ratio	-0.0535	0.247**	-0.0313	0.737**	0.0285	0.215**	1					
GDP rate of rise	-0.0666	0.535**	0.00566	0.377**	0.354**	0.375**	0.169**	1				
Year-on-year growth rate of M2	0.122*	0.629**	0.00586	0.471**	0.325**	0.327**	0.291**	0.471**	1			
operating costs	0.270**	0.412**	0.168**	0.288**	0.288**	0.623**	0.0948*	0.344**	0.379**	1		
NPLR	0.207**	0.106*	0.0305	0.0120	0.0338	0.0117	-0.0133	0.181**	-0.0145	0.00811	1	
Innov	0.193**	0.241**	0.975**	0.102*	0.210**	0.0949*	-0.0826	0.0289	0.00913	0.136**	0.0236	1

## 4.2 Baseline Regression

Baseline regression analysis examines the impact of explanatory variables on the dependent variable. The first column in Table 3 presents the regression results without control variables, showing a regression coefficient of 0.050 that is statistically significant at the 1% level, indicating that banks' adoption of AI transformation significantly enhances profitability. The second column presents the regression results with control variables included, yielding a coefficient of 0.057, also significant at the 1% level. Thus, Hypothesis 1 is confirmed.

Table 3: Impact of Artificial Intelligence on Bank Profitability: Main Regression

	(1) Total Asset Return (ROA)	(2) Total Asset Return (ROA)
AI	0.050*** (3.82)	0.057*** (2.93)
asset size		0.032*** (3.05)
capital strength		2.688 (1.28)
Loan-to-Deposit Ratio		-0.004** (-2.56)
administration cost		10.668 (1.37)
capital adequacy ratio		-0.026** (-2.25)
GDP rate of rise		0.001 (0.14)
Year-on-year growth rate of M2		-0.004 (-0.93)
_cons	0.778*** (32.11)	0.871*** (4.42)
N	377	377
r2	0.038	0.090
r2 a	0.035	0.070

### 4.3 Mediation Effect Analysis

Table 4 presents the results of testing the mediating effects of operating costs and risk control. The first and third columns show the regression results of explanatory variables on mediating variables (Equation 2): artificial intelligence has negative effects on both operating costs and risk control at the 5% significance level, with coefficients of -0.94 and -0.115 respectively, indicating that AI reduces bank operating costs; thus, Hypothesis 2 is confirmed, and it also demonstrates that AI effectively enhances bank risk control capabilities, validating Hypothesis 3. The second and fourth columns present the regression results of explanatory and mediating variables on the dependent variable (Equation 3), showing positive impacts of artificial intelligence on bank profitability at the 5% level. The table indicates that AI improves bank profitability by reducing operating costs and strengthening risk control.

**Table 4:** Mediation Effect Test

	(1) C op	(2) Total Asset Return (ROA)	(3) NPLR	(4) Total Asset Return (ROA)
AI	-0.942** (-2.49)	0.042** (2.24)	-0.115** (-2.25)	0.048** (2.50)
asset size	-0.890*** (-4.38)	0.018* (1.73)	0.031 (1.12)	0.034*** (3.35)
capital strength	-219.175*** (-5.39)	-0.839 (-0.41)	4.778 (0.87)	3.066 (1.49)
Loan-to-Deposit Ratio	0.047 (1.57)	-0.003** (-2.17)	0.005 (1.32)	-0.003** (-2.33)
administration cost	2095.646*** (13.92)	44.396*** (4.87)	-19.784 (-0.97)	9.105 (1.20)
capital adequacy ratio	1.262*** (5.62)	-0.006 (-0.50)	-0.019 (-0.62)	-0.028** (-2.42)
GDP rate of rise	-0.101 (-0.75)	-0.001 (-0.10)	0.068*** (3.75)	0.006 (0.91)
Year-on-year growth rate of M2	0.131 (1.40)	-0.002 (-0.51)	-0.030** (-2.35)	-0.007 (-1.43)
operating costs		-0.016*** (-6.30)		-0.079*** (-4.04)
NPLR				-0.079*** (-4.04)
_cons	19.393*** (5.07)	1.183*** (6.10)	0.839 (1.63)	0.937*** (4.84)
N	377	377	377	377
r2	0.509	0.179	0.070	0.129
r2 a	0.499	0.159	0.050	0.108

### 4.4 Regulatory Effect Analysis

Table 5 presents the results of testing the moderating effect of innovation capability. The moderation effect primarily concerns the significance of the interaction term: if its coefficient has the same sign as that in the baseline regression, it indicates a positive moderating effect; otherwise, it indicates a negative moderating effect. As shown in the table, a positive coefficient suggests that bank innovation capability positively moderates the impact of artificial intelligence on profitability—that is, stronger innovation capability enhances the significant effect of AI on bank profitability. Thus, Hypothesis 4 is confirmed.

**Table 5:** Test of Regulatory Effect

	Total Asset Return (ROA)
AI	-0.001 (-0.02)
c.AI#c.lnnov	0.013* (1.73)
lnnov	-0.006 (-0.16)
asset size	0.018 (0.38)
capital strength	2.643 (1.25)
Loan-to-Deposit Ratio	-0.004*** (-2.81)
administration cost	7.609 (0.90)
capital adequacy ratio	-0.028**

	(-2.36)
GDP rate of rise	-0.000
	(-0.01)
Year-on-year growth rate of M2	-0.005
	(-0.97)
_cons	1.134***
	(2.88)
N	377
r2	0.098
r2 a	0.073

#### 4.5 Robustness Test

##### 1) Replace Variable

The robustness test in the first column of Table 6 involves replacing the dependent variable with return on equity (ROE) and conducting regression analysis. As shown in Column 1 of Table 6, the results remain statistically significant even after substituting the dependent variable, further validating the robustness of this study's findings.

##### 2) Excluding special samples

Given the impact of the 2020 COVID-19 pandemic on listed banks during the sample period, this study enhances research reliability by employing existing methodologies and retesting with data excluding periods after 2020. The regression results in Column 2 of Table 6 demonstrate that artificial intelligence's effect on bank profitability remains statistically significant at the 1% level, with a coefficient of 0.099. This confirms the robustness and reliability of our findings.

**Table 6: Robustness Test**

	(1) Return on Equity (ROE)	(2) Total Asset Return (ROA)
AI	0.586* (1.91)	0.099*** (3.60)
asset size	0.722*** (4.40)	0.031** (2.19)
capital strength	-133.156*** (-4.05)	2.422 (0.82)
Loan-to-Deposit Ratio	-0.034 (-1.42)	-0.004 (-1.54)
administration cost	626.896*** (5.15)	6.521 (0.59)
capital adequacy ratio	0.076 (0.42)	-0.035** (-2.07)
GDP rate of rise	0.315*** (2.90)	-0.002 (-0.13)
Year-on-year growth rate of M2	0.218*** (2.89)	0.001 (0.16)
_cons	8.144*** (2.63)	0.938*** (3.36)
N	377	257
r2	0.399	0.139
r2 a	0.386	0.111

#### 4.6 Endogeneity Test

In exploring the impact of artificial intelligence on the profitability of banks, although this paper has controlled the relevant variables as much as possible, it still faces the challenge of endogeneity. First of all, the application of AI as a strategic investment behavior of banks may have an inverse causal relationship with the profitability of banks, that is, banks with strong profitability may have more resources and motivation to carry out AI-related investments, rather than AI alone affecting profitability; Secondly, the factors influencing the profitability of banks are complex and there may be situations that have not been fully considered, such as the implicit customer resource endowment of banks, regional financial ecological environment, etc. These factors will affect the regression results and their accuracy. Therefore, considering the intercausal and omitted variables that may cause endogeneity in this study, a two-stage regression model of instrumental variables is intended to be used for re-estimation. The industry annual mean of bank AI application was chosen as the instrumental variable because it had a certain influence on the explanatory variable, the degree of bank AI application, satisfying the correlation; It does not directly affect

the profitability of the individual bank being explained and is exogenous. The relationship between the instrumental variable and the explanatory variable in the first stage of the study, with a coefficient of 0.985, is significant at the 1% level, indicating that the industry annual average of the application of artificial intelligence in banks promotes the transformation of artificial intelligence in banks, as shown in Table 7. The second stage is the regression results of the explanatory variable and the explained variable, with a coefficient of 0.074 and significant at the 1% level, indicating that artificial intelligence has a positive effect on the profitability of banks. And the statistic of the weak instrumental variable is 366.933, greater than 16.38, indicating that the selected instrumental variable is appropriate. Therefore, the regression results obtained here are consistent with the previous ones, demonstrating the stability of the research results.

**Table 7: Endogeneity Test**

	stage I AI	stage II Total Asset Return (ROA)
AI_Mean	0.985*** (19.16)	
asset size	0.042** (2.10)	0.030*** (2.76)
capital strength	-5.740 (-1.45)	2.904 (1.39)
Loan-to-Deposit Ratio	-0.002 (-0.78)	-0.004*** (-2.72)
administration cost	-22.458 (-1.53)	11.049 (1.44)
capital adequacy ratio	0.009 (0.43)	-0.028** (-2.38)
GDP rate of rise	-0.002 (-0.14)	0.003 (0.39)
Year-on-year growth rate of M2	-0.008 (-0.78)	-0.002 (-0.47)
AI		0.074*** (2.70)
_cons	0.358 (0.96)	0.862*** (4.42)
N	377	377
R2		0.088
adj. R <sup>2</sup>		0.069
F	366.933	4.375

#### 4.7 Heterogeneity Test

Considering that the implementation effect of AI transformation in listed banks may be affected by differences in bank property rights attributes and organizational characteristics, this paper conducts heterogeneity analysis [29] from two dimensions: company attributes and enterprise size. First, the sample banks were grouped and regressed by corporate attributes, and the regression results are shown in Table 8.

The results show that the regression coefficient of the sample of central state-owned banks in column (1) is 0.072, indicating that the application of artificial intelligence has a positive promoting effect on their profitability, but the impact is relatively limited; The regression coefficient of the sample of local state-owned banks in column (2) was 0.032, which also showed a positive effect, but the promoting effect was weaker; The regression coefficient of the public bank sample in column (3) is 0.092, and it is significant at the 5% statistical level, indicating that artificial intelligence can significantly enhance the profitability of public banks, and the marginal promoting effect is more obvious.

The results suggest that there are significant differences in the empowerment effect of artificial intelligence on banks of different ownership natures. Compared with state-owned banks, public banks have a higher degree of marketization, more flexible operating mechanisms, and relatively shorter decision-making chains. Therefore, they can respond more quickly to changes in market demand and accelerate the application of AI technology in business scenarios such as credit approval, customer marketing, and risk management, thereby more efficiently converting technology investment into operating performance. At the same time, public banks are more focused on profit orientation and resource allocation efficiency in the process of digital transformation, and the advantages of cost savings, customer expansion and risk identification brought by artificial intelligence are more likely to be reflected in the improvement of profitability.

In contrast, central state-owned banks and local state-owned banks, despite having strong capital strength and data resources, have relatively low application efficiency and business transformation speed of artificial intelligence technology due to factors such as more organizational hierarchy, relatively complex internal decision-making processes, and strong stability of business structure, resulting in the marginal improvement effect on profitability not being fully released. In addition, some state-owned banks undertake certain policy-based financial functions, and their business goals are not limited to maximizing profits, which to some extent weakens the impact of artificial intelligence on short-term profit indicators.

From an economic perspective, the conclusion suggests that whether AI technology can effectively translate into bank profit growth depends not only on the technology investment itself, but also on the efficiency of organizational governance and the degree of market-oriented operation. This means that in the process of advancing intelligent transformation, banks need to simultaneously optimize their internal management mechanisms and business collaboration systems in order to improve the resource allocation efficiency and value transformation ability of artificial intelligence technology.

**Table 8: Company Attribute Heterogeneity Test**

	(1) Return on Total Assets (ROA) of Central State-Owned Enterprises	(2) Return on Total Assets (ROA) of local state-owned enterprises	(3) Return on Total Assets (ROA) of Public Enterprises
AI	0.072 (1.50)	0.032 (1.21)	0.092** (2.54)
asset size	0.016 (0.25)	0.037 (1.30)	0.058** (2.17)
capital strength	-1.148 (-0.16)	0.471 (0.18)	8.823** (2.29)
Loan-to-Deposit Ratio	-0.004 (-0.67)	-0.005** (-2.54)	-0.007** (-2.10)
administration cost	-35.421 (-1.24)	23.305* (1.94)	9.865 (0.61)
capital adequacy ratio	-0.018 (-0.52)	-0.021 (-1.43)	-0.031 (-1.53)
GDP rate of rise	0.032* (1.77)	-0.006 (-0.68)	-0.004 (-0.38)
Year-on-year growth rate of M2	-0.013 (-1.23)	-0.013** (-1.98)	0.016* (1.75)
_cons	1.482 (1.33)	1.085*** (3.10)	0.260 (0.66)
N	108	136	133
r2	0.077	0.175	0.166
r2 a	0.003	0.123	0.112

Further, this paper conducts a subsample regression analysis of listed banks based on differences in enterprise size. With reference to existing studies, the sample banks were grouped based on the median total assets. Banks with assets above the median were classified as large banks, and those with assets below the median as medium and small banks. The regression results are shown in Table 9.

The results show that the regression coefficient of the sample of small and medium-sized banks in column (1) is 0.057, but it does not pass the significance test, indicating that the promotion effect of artificial intelligence transformation on the profitability of small and medium-sized listed banks is not yet obvious; The regression coefficient of the sample of large banks in column (2) was 0.061 and significant at the 1% statistical level, indicating that artificial intelligence can significantly enhance the profitability of large listed banks. The results suggest that there is a significant scale heterogeneity in the profit effect of AI, and the larger the bank, the stronger the value transformation ability of AI technology.

The reasons for the above differences may be mainly reflected in the following aspects.

First, large banks have stronger financial strength and technological investment capabilities, and can continuously invest resources in artificial intelligence technology research and development, system construction, and application scenario expansion. For example, it is easier for large banks to build an integrated digital system covering intelligent risk control, precise marketing, intelligent customer service and data middle platform, thereby optimizing business processes and improving [30] operational efficiency. In contrast, small and medium-sized banks, constrained by capital and under cost pressure, have relatively limited investment in artificial intelligence, and the application of technology is more confined to local business links, making it difficult to form large-scale

synergy and thus having a relatively weak [31] effect on enhancing profitability.

Second, AI technology has a strong data-dependent feature, while large banks have accumulated richer customer data, transaction data and risk data over the long course of operation, providing a good data foundation [32] for machine learning model training. Backed by the advantages of data scale and dimensions, large banks are able to conduct more precise customer profiling, credit assessment and market forecasting, thereby improving resource allocation efficiency and risk identification capabilities. In contrast, small and medium-sized banks have relatively insufficient data accumulation, the training effect of AI models is limited, and the marginal benefits of technology application are difficult to fully release.

Thirdly, the business layout of large banks has become more diversified, typically covering multiple fields such as corporate finance, retail finance, investment banking and wealth management. Artificial intelligence technology can create a synergy and empowerment effect across different business segments. For example, improving customer acquisition and precision marketing efficiency in retail business, optimizing project screening and risk pricing in investment banking business, and strengthening pre-loan review and post-loan monitoring in risk management to create multi-channel profit growth. By contrast, the business structure of small and medium-sized banks is relatively simple, mainly relying on regional traditional deposit and loan business, and the business scenarios that artificial intelligence can optimize are limited. Therefore, it is difficult for technology investment to translate into significant profit increments in the short term.

From an economic perspective, the conclusion suggests that the boosting effect of AI technology on the profitability of banks is not entirely determined by the technology itself, but is closely related to the banks' resource endowment, data base and the complexity of their business. Large banks, with their economies of scale and data advantages, are more likely to form a positive cycle of "technology input-efficiency improvement-profit improvement", while small and medium-sized banks may face the realistic constraint of "high input, low conversion". This means that in the process of promoting intelligent transformation, small and medium-sized banks should pay more attention to differentiated digital strategies, reduce the cost of technology application through fintech cooperation, cloud platform sharing and regional scenario innovation, and improve the adaptability and input-output efficiency of artificial intelligence technology.

**Table 9: Test for Enterprise Size Heterogeneity**

	(1) Return on Total Assets (ROA) of small and medium-sized banks	(2) Return on Total Assets (ROA) of large banks
AI	0.057 (1.52)	0.061*** (2.64)
asset size	-0.033 (-0.50)	0.001 (0.04)
capital strength	-0.267 (-0.08)	3.968 (1.35)
Loan-to-Deposit Ratio	-0.002 (-0.85)	-0.004** (-2.13)
administration cost	9.589 (0.62)	11.922 (1.24)
capital adequacy ratio	-0.029* (-1.95)	0.002 (0.10)
GDP rate of rise	-0.004 (-0.36)	0.010 (1.12)
Year-on-year growth rate of M2	-0.019** (-2.26)	0.003 (0.53)
_cons	1.718** (2.43)	0.589** (2.24)
N	92	285
r <sup>2</sup>	0.248	0.063
r <sup>2</sup> a	0.176	0.035

## 5. CONCLUSION AND POLICY

### 5.1 Conclusion

First, the application of artificial intelligence by banks can improve their profitability. Empirical analysis shows a significant positive correlation between the extent of AI application in banks and profitability, and the results are reliable after robustness and endogeneity tests, consistent with previous research conclusions. With the help of

artificial intelligence technology, banks can improve efficiency and quality in various aspects such as business process optimization, risk management, and customer service, thereby promoting profit growth.

Second, the impact of AI on banks' profitability varies depending on the size of the bank. For small and medium-sized banks, the promotion effect of AI application on their profitability is more significant, and the coefficient shows a statistically significant positive correlation; For large banks, the impact of AI applications on profitability is relatively insignificant. Small and medium-sized banks, which are smaller in size and have shorter decision-making chains, can apply AI technology to business scenarios more quickly, respond quickly to market demands, use AI to precisely acquire customers, optimize service processes, and reduce operating costs, thereby significantly enhancing profitability [34]. Although large banks are rich in resources, they have complex internal structures and cumbersome processes. The integration and application of artificial intelligence technology require more coordination costs, and the original business models of large banks are mature. The marginal benefits brought by artificial intelligence are not as significant [35] as those of small and medium-sized banks in the short term.

Third, the impact of AI on banks' profitability varies depending on the nature of the banks. The application of AI has a more significant boosting effect on profitability in non-state-owned banks, while in state-owned banks it is relatively less prominent. Non-state-owned banks have a high market sensitivity and strong innovation drive, and are more eager to gain competitive advantages and profits from AI applications. They will increase investment in AI technology, talent, etc., and efficiently promote the implementation of AI strategies in business, thereby having a greater positive impact [36] on profitability. The management system of state-owned banks is relatively complex, the decision-making process is long, and the response speed to market changes is relatively slow. In terms of the depth and breadth of artificial intelligence application, there is a gap with non-state-owned banks in the short term, so the effect on promoting profitability is relatively less obvious [37].

## 5.2 Policy Proposal

### 1) Government level

a) The government should establish and improve relevant policies for the application of artificial intelligence in banks and create a favorable development environment. First, the government should have a clear understanding of the current situation of AI applications in the banking industry and formulate reasonable policies to guide the implementation of AI strategies in banks. The government should have a deep understanding of the application scenarios and development needs of artificial intelligence in the banking industry, and through the formulation of relevant tax preferential policies, offer tax breaks to banks that actively carry out the application of artificial intelligence; Establish industry guidance funds and special subsidy funds to relieve the financial pressure on banks in areas such as artificial intelligence technology research and development, equipment procurement, and talent cultivation. At the same time, taking into account regional differences, for banks in the central and western regions where financial resources are relatively scarce, policy support can be appropriately inclined to help them carry out artificial intelligence applications.

b) Science and technology are the primary productive forces driving the application of artificial intelligence in banks. The government should provide sufficient financial support and infrastructure guarantees for the research and development of core artificial intelligence technologies in the banking industry. The government can take the lead in conducting research on core artificial intelligence research projects, increase the number of projects, provide financial support to banks and related research institutions, encourage them to increase research and development investment, and promote breakthroughs in core artificial intelligence technologies. At the same time, accelerate the construction and popularization of information networks such as 5G to create a solid technical foundation for the application of artificial intelligence in banks. In addition, the government should increase investment in the training of fintech talents, increase opportunities for banks to cooperate with universities and research institutions, and jointly cultivate fintech talents with innovative capabilities to provide talent support for the application of artificial intelligence in the banking industry.

### 2) Bank level

a) Banks need to fully recognize the necessity and importance of AI applications, seize opportunities and proactively implement AI strategies. Bank executives should have innovative thinking and formulate AI application strategies that are in line with their own development based on actual circumstances such as the nature and scale of their property rights. Propose targeted development strategies for banks of different sizes and natures.

Within the bank, focus on investment in artificial intelligence, strengthen infrastructure construction, actively introduce mature artificial intelligence technologies, improve the talent management system, enhance the bank's level in artificial intelligence hardware and software, and try to solve technical and talent difficulties in the application of artificial intelligence as much as possible.

b) Banks need to use artificial intelligence technology to optimize business processes and improve the efficiency of business completion. For example, in business processes such as customer account opening and loan approval, artificial intelligence is used to process information quickly and shorten business processing time. At the same time, integrate production factors and reduce operating costs. In addition, with the help of AI for precise marketing and personalized customer service, by analyzing customer data, understanding customer needs, providing customized financial products and services to customers, enhancing customer satisfaction and loyalty, and thereby boosting profitability. Artificial intelligence can also be used to enhance risk management. Through technologies such as big data analysis, credit risks, operational risks, etc. can be identified and prevented more accurately to reduce risk losses and ensure the stability of the bank's profits.

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## **CONFLICT OF INTEREST**

The authors declare no conflicts of interest relevant to this study.

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