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Original Paper

The Impact of Digital Transformation on the Credit Scale of Commercial Banks

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Abstract

The digital transformation of banks has had a huge impact on the traditional credit system. This study aims to explore the impact of digital transformation on credit business and reveal its mechanism of action on credit scale. This paper takes 180 commercial banks across the country from 2011 to 2021 as the research object, considers the two mechanisms of operating efficiency and risk control ability, and empirically tests the intrinsic connection between bank digital transformation and credit scale based on the three dimensions of digital transformation. The study found that digital transformation has significantly promoted the expansion of credit scale, especially in the promotion effect of management and business digitalization. Mechanism analysis shows that digital transformation can positively affect credit scale by improving bank operating efficiency and strengthening risk control capabilities. Finally, the impact of digital transformation shows significant heterogeneity in bank characteristics. Non-state-owned and small and medium-sized banks have benefited significantly from the expansion of credit scale, while state-owned and large banks have not seen similar results. This study provides a new research perspective for optimizing the credit system and adjusting digital strategies.

Keywords

Commercial banks, Digital transformation, Credit scale, Mechanism of action, Operating efficiency, Risk control capability

1. Introduction

In the wave of digital economy, building a digital China has become a key engine to promote China's modernization and an important cornerstone for building new national competitive advantages. The digital transformation of commercial banks aims to achieve the deep integration of digital technology and financial services and build a modern financial system, which has become an inevitable choice under the current situation. The "14th Five-Year Plan and the Outline of the Long-Term Goals for 2035" clearly states the strategic deployment of "steadily developing financial technology and accelerating the digital transformation of financial institutions". Driven by national policies and

external competition, commercial banks are in urgent need of innovating their business models through digital transformation to meet the challenges of Internet giants. Therefore, exploring the relationship between the digital transformation of commercial banks and the scale of credit, as well as its influencing mechanism and heterogeneity, is of great significance for revealing the operating mechanism of digital transformation in the financial system and providing theoretical guidance for the strategic adjustment of different types of commercial banks in digital transformation.

Regarding the existing research on the impact of digital transformation on bank credit, the views of domestic scholars can be roughly divided into two aspects. On the one hand, digital transformation has a positive impact on bank credit. For example, digital transformation helps reduce banks' risk-taking level (Zhai Shengbao, Cheng Yanting, & Xie Lu, 2023), optimizes the bank credit system (Sheng Tianxiang, & Fan Zong, 2020), and improves bank operating efficiency (Kong Yuexing, Zhang Tongtong, & Yang Haifen, 2023), thereby effectively promoting the expansion of bank credit scale. On the other hand, digital transformation has potential negative effects. For example, digital finance may slow down the demand for credit of rural productive commercial banks and reduce the supply and demand of private lending (Fu Qiuzi & Huang Yiping, 2018; Pan Shuang, Wei Jianguo, & Hu Shaobo, 2020); the blind investment of small and medium-sized banks in financial technology not only increases their own operating risks, but also is not conducive to the development of credit business (Cai Puhua, Wang Wei, Zheng Ying, et al., 2021; Cai Cen, Yin Xiaoqing, & Chen Xuanjuan, 2023). In summary, it is necessary to start from the existing theoretical analysis, further empirically test the relationship between digital transformation and bank credit, and focus on the mechanism of the operating efficiency and risk control ability of commercial banks in a complex financial environment between digital transformation and bank credit.

2. Theoretical Analysis and Research Hypotheses

2.1 The Impact of Digital Transformation on Credit Scale

The credit activities between enterprises and banks are actually a game of information asymmetry (Tang Zhenyu & Chen Yao, 2001), which often prompts banks to adopt conservative strategies, thereby increasing the difficulty for small and medium-sized enterprises to obtain loans. Existing research shows that although measures such as improving the level of legal protection (Zhang Jianhua & Wang Peng, 2012), promoting the development of digital finance (Chen Yongliang & Ling Aifan, 2023), and adjusting the equity structure (Pan Min & Zhang Yiru, 2013) can optimize the bank loan system to a certain extent, these measures usually have the problems of high operational difficulty and long cycle. Therefore, the digital transformation of banks provides a new solution for improving the credit relationship between banks and enterprises.

First, the application of digital technology in banks helps to improve internal control (Yi Luxia, Wu Fei, & Chang Xi, 2021), enhance financial services (Wang Congcong, Party Chao, Xu Feng, Zhong Lixin, & Du Wei, 2018) and operational management efficiency (Hu Jie, Han Yiming, & Zhong Yong, 2023),

and enhance the availability of loans by reducing management and operating costs. Second, banks introduce advanced technologies such as artificial intelligence and big data to effectively alleviate information asymmetry between banks and enterprises (Mu Lei & Liu Xia, 2021), improve banks' information screening and risk control capabilities (Zhang Yilin, Yu Yunjun, & Chen Zhuming, 2021), significantly reduce credit risks and enhance confidence in expanding credit. Finally, digital transformation supports banks in changing their business operation models. By strengthening the application of scenario-based service capabilities (Wu Chaoping, 2019), it helps banks find customers more accurately and efficiently and provide convenient services (Pan Xiaoming, & Qu Jun, 2018), stimulates corporate financing and entrepreneurship, and adjusts bank loan business strategies. Based on the above analysis, this paper proposes the core research hypothesis

H1: The digital transformation of commercial banks will help increase the scale of credit.

2.2 The Impact of Digital Transformation on Credit Scale through Operational Efficiency

By introducing digital technology, banks can achieve process automation, big data analysis and artificial intelligence applications, thereby promoting credit expansion and stimulating innovation in credit products.

First, as intermediary business products, credit products are an important source of bank profits. Through digital transformation, innovation in intermediary business products can be achieved (Li Qin, & Pei Ping, 2022). Through precise data marketing (Zhao Dandan, 2020), high-quality banking services and the reshaping of service processes (Gong Yijun, 2020), banks can be assisted in making optimal business decisions, thereby improving their operating efficiency. Secondly, digital technology has the advantages of reducing information asymmetry and transaction costs, which has intensified competition among traditional financial institutions such as banks, stimulating them to accelerate innovation and reform (Thorsten Beck, Tao Chen, Chen Lin, & Frank M. Song, 2016). By promoting changes in financial structure and improving financial efficiency, it has affected the operating efficiency of banks (Kong Yuexing, Zhang Tongtong, & Yang Haifen, 2023). Finally, emerging digital information technology has enriched the development of digital finance (Yang Wang, Xu Huilin, Tan Xiaofen, & Xue Xiangyu, 2020), expanded the coverage of financial services and reduced corporate financing costs, further deepened the development of rural finance, stimulated the vitality of the rural economy, and provided opportunities for improving the operating efficiency of banks (Zhang Yue, & Peng Shiguang, 2021). Overall, the digital transformation of banks has promoted the improvement of operating efficiency through different channels, making banks more confident in promoting the expansion of credit scale and achieving the coordinated growth of digital technology and credit scale. Therefore, this paper proposes the following hypothesis:

H2: Digital transformation of banks improves operational efficiency and promotes the growth of credit scale by automating processes and reducing manual intervention.

2.3 The Impact of Digital Transformation on Credit Scale through Risk Control Capabilities

In the post-epidemic era, the economic situation has become complex and severe. The fierce

competition in the financial market, the availability of credit, and the reduction of corporate financing restrictions have posed unprecedented challenges to banks. Digital transformation has promoted the vigorous development of digital finance, expanded the coverage of financial services, and increased the availability of corporate credit (Ren Yuanming & Gao Jingyi, 2023).

The traditional risk control system of banks has low data entry efficiency, actual risk control capabilities, and application software updates. Digital transformation has injected new vitality into the upgrade of risk control systems. On the one hand, the digital transformation of banks has overcome the shortcomings of traditional risk control systems by accurately collecting effective information (Guo Xiaoping & Lian Yuqing, 2020), integrating information platforms, and improving soft information processing capabilities (Xu Xiaoping, Li Hongji, & Ge Yingfan, 2021), and further enhanced risk-bearing capabilities. On the other hand, the application of financial technology can not only effectively reduce the risks of banks (Jin Hongfei, Li Hongji, & Liu Yinlu, 2020), but also improve the credit structure and maturity structure of bank credit by intensifying bank competition (Sun Xuran, Wang Kangshi, & Wang Fengrong, 2020), further prompting banks to improve their risk-bearing capabilities. Therefore, this paper proposes the following hypothesis:

H3: Bank digital transformation helps to monitor transactions and customer behavior in real time, thereby improving risk control capabilities and promoting the growth of credit scale.

3. Data Sources, Model Settings, and Variable Descriptions

3.1 Data Sources and Processing

The research object of this paper is the commercial banks nationwide. Considering that 2013 is known as the first year of financial technology and the integrity of bank data, this paper selects the data of all commercial banks from 2011 to 2021 as the initial research sample. The sample includes a total of 180 commercial banks, including 6 state-owned commercial banks, 12 joint-stock commercial banks, 112 city commercial banks and 50 rural commercial banks. Data processing follows the following principles: First, samples with serious data missing are eliminated, and only bank samples with no missing annual report data for at least five consecutive years are retained; second, to avoid the influence of extreme values, this paper performs 1% and 99% Winsorize processing on all variables. Finally, 1980 observations are obtained. The annual report data of relevant listed banks are from the official websites of Shenzhen Stock Exchange and Shanghai Stock Exchange, and the rest of the financial data are from the Guotai An Database (CSMAR).

3.2 Baseline Model and Mediation Effect Model Specification

This paper constructs a fixed effect model to test the impact of commercial bank digital transformation on bank credit scale. Referring to the research of Chen Yongliang et al. (2022), the following regression model is set:

$$Lnloan_{i,t} = \alpha_0 + \alpha_1 Digital_{i,t} + \gamma X_{i,t} + \omega_i + \psi_t + \varepsilon_{i,t} \quad (1)$$

Where i represents the bank and t represents the year. The explained variable Lnloan is the bank's credit scale, measured by the logarithm of the credit balance at the end of the year. The core explanatory variable Digital represents the degree of digital transformation of bank i in year t. X represents the set of control variables. To make the statistical inference results more robust, the benchmark regression model is estimated using robust standard errors.

To further explore the impact mechanism of bank digital transformation on credit scale, we refer to existing research and construct the following mediation effect test model.

$$Mediate_{i,t} = \theta_0 + \theta_1 Digital_{i,t} + \gamma X_{i,t} + \omega_i + \psi_t + \varepsilon_{i,t} \quad (2)$$

$$Lnloan_{i,t} = \theta_0 + \theta_1 Digital_{i,t} + \theta_2 Mediate_{i,t} + \gamma X_{i,t} + \omega_i + \psi_t + \varepsilon_{i,t} \quad (3)$$

Among them, Meditae represents the mechanism variable, which in this paper represents operating efficiency (GML) and risk control capability (RISK), and the meanings of the remaining variables are the same as in model (1).

3.3 Variable Description

(1) Explained variable: industry credit scale (Lnloan)

The logarithm of the total loan balance of commercial banks at the end of the year is used as the explained variable to study the impact of commercial banks' digital transformation on the expansion of bank credit scale.

(2) Core explanatory variable: commercial banks' digital transformation (Digital)

The digital transformation index of commercial banks constructed by the Digital Finance Research Center of Peking University is used. The index consists of the total digitalization index and indicators of three dimensions, namely management digitalization (ma), business digitalization (bu) and strategic digitalization (st). The total digitalization index is the core explanatory variable of this paper.

(3) Intermediary variables: bank efficiency (GML) and risk control capability (RISK),

Bank efficiency (GML), Referring to existing studies (Wang Bing & Zhu Ning, 2011), the DEA-SBM-DDF (SBM directional distance function) model is used to measure the efficiency of commercial banks. The total assets, total number of employees and operating expenses of commercial banks are selected as input indicators, normal loans and net profits are selected as expected output indicators, and non-performing loans are selected as non-expected output indicators (Du Li & Liu Zheng, 2022). The above indicators are all logarithmized, and the Malmquist index of the global DEA model considering non-expected output is calculated using MATLAB. Finally, the measured commercial bank efficiency is expressed by GML. The larger the GML value, the higher the bank efficiency.

Risk control capability (RISK), The most common Z-Score index is used to measure the bank's risk control capability. The larger the Z value, the smaller the enterprise's financial risk and the stronger the bank's risk resistance. The specific calculation method is as follows:

$$Z-Score_{i,t}=\frac{ROA_{i,t}+(\frac{E}{A})_{i,t}}{\sigma(ROA)_i} \tag{4}$$

(4) Control variables

This paper refers to Tang Shenfeng's research (2024) and selects the following control variables: the logarithm of the bank's total assets (AZ) and the total number of employees (STAFF) to control the impact of the bank's asset size and number of employees on the credit scale; the bank's return on equity (ROE), net interest margin (NIP) and net profit growth rate (NPG) to control the impact of the bank's profitability on the credit scale; the asset-liability ratio (ALR) to control the impact of the bank's debt level on the credit scale; the shareholding ratio of the top ten shareholders (PRPO) to control the impact of the bank's equity situation on the credit scale; and the GDP deflator is used to illustrate the current macroeconomic situation.

4. Analysis of Empirical Results

4.1 Benchmark Regression Results

First, an empirical test is conducted based on the baseline regression model (1), and the regression results are shown in Table . Column (1) shows the results of the regression of the total digitalization index when no control variables are added; columns (2) to (5) show the regression results of the total digitalization index, management digitalization, business digitalization and strategic digitalization after adding control variables.

The regression results of column (1) show that when no control variables are added, the coefficient of the total digitalization index is 0.0041 at a significance level of 1%, indicating that the digital transformation of banks has a positive impact on the expansion of credit scale in general. After adding control variables, the coefficient of the total digitalization index decreases to 0.0013, but it is still significantly positive. The index regression results of the three dimensions of digital transformation are different. The regression coefficients of management digitalization and business digitalization are both significantly positive, which is consistent with Hypothesis 1, and the values are higher than the regression coefficient of the total digitalization index. However, the regression coefficient of strategic digitalization is not significant. We explored the reasons from the perspective of index construction. The text analysis method extracts content related to financial technology from the bank's annual report to reflect the degree of emphasis on digitalization by the bank. However, text analysis is more of a subjective speculation, so it is difficult to reflect the specific extent of the impact of digital technology on the scale of bank credit. This result also triggered our thinking: the digital transformation of banks should not only focus on the integration of digital technology and financial services, but also implement the coordination of the management system. The two should go hand in hand. Only by making full use of the bank's existing resources can the strategic goal of digitally promoting finance, serving finance, and achieving finance be achieved.

Table 1. Benchmark Regression Results Test

Variable	(1) Lnloan	(2) Lnloan	(3) Lnloan	(4) Lnloan	(5) Lnloan
Digital	0.0041***	0.0013***			
	(13.76)	(6.42)			
ma			0.0250***		
			(2.61)		
bu				0.0616***	
				(5.64)	
st					0.0006
					(0.10)
Control	NO	YES	YES	YES	YES
ID Fixed	YES	YES	YES	YES	YES
YEAR Fixed	YES	YES	YES	YES	YES
Observations	1980	1980	1980	1980	1980
Adjust R^2	0.9829	0.9933	0.9932	0.9933	0.9932

4.2 Endogenous Treatment

This paper mainly has an endogenous problem caused by reverse causality: the digital transformation of banks will promote the expansion of credit scale, and the larger the credit scale of a bank, the better its operating conditions, and the more resources and capabilities it has for digital transformation.

There is a certain time lag effect in the role of digital transformation of banks. This paper regresses the bank's credit scale on the core explanatory variables with a lag of one to three periods. The regression results are shown in columns (1) to (3) of Table 2. The coefficients of the bank's digital transformation index with a lag of one and two periods are positive at the 1% significance level, while the coefficient with a lag of three periods is not significant. This shows that the lag effect of bank digital transformation is short and has no significant impact on the credit scale after a long period of time. The above results once again prove that the core conclusion of this paper is robust and reliable. Secondly, drawing on the approach of Li Tang (2020), the instrumental variable of bank digital transformation is constructed based on the research ideas of Lewbel (1997). This method does not require the use of external factors to construct instrumental variables. The difference between the total bank digital transformation index and the mean of the digital transformation index classified by bank type is used as the instrumental variable. After considering endogeneity, the impact coefficient of bank digital transformation has decreased but is still significantly positive, indicating that the research conclusions are robust and reliable.

Table 2. Endogenous Treatment

Variable	(1) Lnloan	(1) Lnloan	(3) Lnloan	(4) Lnloan	(5) Lnloan
L.Digital	0.0010***				
	(5.29)				
L2.Digital		0.0007***			
		(3.47)			
L3.Digital			0.0003*		
			(1.74)		
Lewbel_IV				0.0012***	
				(6.42)	
Lndigital					0.0017***
					(7.46)
Anderson canon.corr. LM statistic					1810.83***
Cragg-Donald Wald F statistic					21000
					[16.38]
Control	YES	YES	YES	YES	YES
ID Fixed	YES	YES	YES	YES	YES
YEAR Fixed	YES	YES	YES	YES	YES
Observations	0.9941	0.9947	0.9954	0.9933	0.9999
Adjust R^2	1800	1,620	1,440	1980	1980

4.3 The Mechanism by Which Bank Digital Transformation Affects Credit Scale

The theoretical analysis in the previous article pointed out that digital transformation increases the scale of bank credit by improving the operating efficiency of banks. To verify this hypothesis, this paper uses the method of mediating effect test to examine how the digital transformation of banks affects the scale of credit.

Since the two indicators of total bank assets and total number of employees are used in the calculation of GML, these two variables are removed from the model in the process of mechanism analysis to prevent multicollinearity. In addition, the calculated GML value range is around 0.9, which is quite different from the order of magnitude of the core explanatory variables. Therefore, the explanatory variables are logarithmized, and the test results are shown in Table 3. Column (2) shows the impact of bank digital transformation on operating efficiency. It can be found that there is a significant positive correlation between the two, indicating that the digital transformation of banks has indeed significantly improved the operating efficiency of banks. After adding GML to the benchmark regression model, the results are shown in Column (3). Although the coefficient of Lndigital is slightly smaller than the

coefficient corresponding to the benchmark regression result, it still has a positive impact on the expansion of credit scale at the 1% significance level. At the same time, the regression coefficient of GML is 2.0692 and is significant at the 1% level, indicating that the operating efficiency of banks has promoted the expansion of credit scale. Therefore, combining the results of columns (1) to (3), we find that bank operating efficiency is an important channel through which bank digital transformation affects credit scale, thus verifying hypothesis 2.

According to the mediation effect test results in Table 3, the influence coefficient of variable Lndigital on risk control ability is significantly positive, indicating that digital transformation has significantly enhanced the bank's risk resistance. Further testing of model (3) shows that the regression results are consistent with the theoretical predictions of this paper. The coefficients of variables Lndigital and Z-Score are both positive at a significance level of 1%. The above results show that digital transformation has improved the risk control capabilities of banks and indirectly promoted the increase in bank credit scale. This result provides a factual basis for hypothesis 3 of this paper.

Table 3. Mechanism Test

Variable	GML			Z-Score		
	(1)	(2)	(3)	(4)	(5)	(6)
	Lnloan	GML	Lnloan	Lnloan	RISK	Lnloan
Lngidital	0.0678***	0.0753***	0.0695***	0.0678***	0.0766**	0.0013***
	(8.75)	(7.33)	(9.03)	(8.75)	(2.13)	(6.31)
GML			2.0692***			
			(4.91)			
RISK						0.0003**
						(2.17)
Control	YES	YES	YES	YES	YES	YES
ID Fixed	YES	YES	YES	YES	YES	YES
YEAR Fixed	YES	YES	YES	YES	YES	YES
Observations	1980	1980	1980	1980	1980	1980
Adjust R^2	0.9864	0.1120	0.9865	0.9864	0.2516	0.9934

4.4 Heterogeneity Analysis

1. Differentiating bank ownership

State-owned banks and non-state-owned banks differ in their business objectives and sources of funds, which directly or indirectly affect their development plans and credit scale. This paper divides banks into two groups, state-owned and non-state-owned, for regression analysis. The results are shown in columns (1) and (2) in Table 4. It can be seen that the digital transformation of banks has a significant

promoting effect on the expansion of the credit scale of non-state-owned banks, and it is established at the 1% significance level. In the group of state-owned banks in column (1), the regression coefficient of digital transformation is not significant. This shows that the digital transformation of banks can more significantly promote the expansion of the credit scale of non-state-owned banks. The potential reason may be that non-state-owned banks have institutional advantages and can respond flexibly in a complex market environment. In addition, non-state-owned banks are operating for profit. When facing greater performance growth pressure, they have more internal innovation motivation to seek transformation and upgrading. On the contrary, while state-owned banks are supported by the state, they are also restricted by specific social responsibilities and support plans, which weakens the role of digital transformation in promoting the expansion of their credit scale.

2. Differentiating bank sizes

To verify the heterogeneity of banks of different sizes, this paper refers to the "Financial Industry Enterprise Classification Standards" and divides the samples into large banks, medium banks and small banks according to the classification standards of banking deposit financial institutions according to total assets, and conducts group regression analysis. The results are shown in columns (3) to (5) of Table 4. Among them, the regression coefficient of digital transformation for large banks is not significant, while the regression coefficients for medium and small banks are positive at the 1% significance level. The reason is that banks of different sizes differ in resource endowment, loan structure and transformation path. The loan structure of large banks is relatively stable, and digital transformation is difficult to further optimize its loan structure to achieve credit expansion. In addition, large banks have greater organizational inertia and less flexible funds, which increases the resistance to digital transformation. Therefore, digital transformation has no obvious promoting effect on the expansion of the credit scale of large banks. In contrast, the loan structure of small and medium-sized banks is more flexible and has stronger innovation motivation. Digital transformation improves loan approval efficiency by reducing the degree of information asymmetry, greatly increasing the possibility of small and micro enterprises obtaining loans. At the same time, banks with small scale, weak liquidity and low capital adequacy ratio are more sensitive to competitive changes and are more likely to seek credit expansion. Therefore, digital transformation has a significant role in promoting the credit expansion of small and medium-sized banks.

Table 4. Heterogeneity Analysis

Variable	(1) SOE=1 Lnloan	(2) SOE=2 Lnloan	(3) large Lnloan	(4) medium Lnloan	(5) small Lnloan
Lndigital	0.017	0.023***	-0.0001	0.0006***	0.0017***
	(0.36)	(4.11)	(-0.36)	(5.51)	(7.72)
Control	YES	YES	YES	YES	YES
ID Fixed	YES	YES	YES	YES	YES
YEAR Fixed	YES	YES	YES	YES	YES
Observations	0.9975	0.9905	0.9986	0.9968	0.9832
Adjust R^2	66	1,914	65	154	1,761

5. Research Conclusions and Policy Implications

This paper studies the impact of bank digital transformation on credit scale. Using manually collected commercial bank financial data from 2013 to 2021 and the Peking University Commercial Bank Digital Transformation Index, this paper empirically examines the role of digital transformation on credit scale and its mechanism and heterogeneous effects. The results show that: First, digital transformation significantly promotes the expansion of commercial bank credit scale, and this conclusion has been verified by robustness tests and endogenous problem processing. Second, the impact of digital transformation on credit scale is heterogeneous, and the credit scale expansion effect on non-state-owned banks and small and medium-sized banks is more significant, while state-owned banks and large banks have a relatively fixed business model, and the role of digital transformation in promoting their credit scale growth is limited. Third, the mechanism analysis shows that the digital transformation of commercial banks can promote the increase of credit scale by improving operating efficiency and risk resistance.

Based on the above conclusions, this paper puts forward the following suggestions to promote the digital transformation of banks and deepen financial service reforms:

First, the government should take effective measures in the digital transformation of the banking industry. To this end, the government should increase financial support for the digital transformation of banks and provide necessary financial guarantees. At the same time, the government should actively promote the application of digital technology in the financial field to improve the efficiency and innovation capabilities of the entire financial system.

Second, the digital transformation practice of the banking industry should take into account factors such as the bank's ownership structure. As an important pillar of the national financial system, large state-owned banks should focus on implementing digital protection measures and strengthening information security mechanisms during the digital transformation stage to ensure the stable operation

of credit business. The goal of small and medium-sized banks in digital transformation is more focused on profitability. They should optimize the platform structure, promote intermediate product innovation, improve operational efficiency and service effectiveness, while maintaining effective control of risks and ensuring asset quality.

Third, in the context of intensified industry competition, banks should focus on improving operating efficiency and risk control capabilities. The core of digital transformation is to improve operating efficiency and ensure that banks have agile and efficient operating capabilities in a highly competitive environment. At the same time, strengthening risk control capabilities is crucial to ensuring the financial stability of banks. Banks should integrate advanced technologies, establish a sound risk management system, accurately identify and assess potential risks, and effectively formulate corresponding risk prevention measures.

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