ESG Performance and Risk-Taking Capacity of Commercial Banks: Evidence from China

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Abstract

The study investigates the relationship between ESG performance and risk-taking capacity of commercial banks in China, using a sample of 832 observations from listed commercial banks from the first quarter of 2011 to the fourth quarter of 2023. The empirical results indicate that ESG performance significantly enhances the risk-taking capacity of Chinese commercial banks, and this conclusion remains robust after addressing endogeneity issues and conducting robustness tests. Further mechanism tests reveal that ESG performance influences risk-taking capacity through two channels: improving return on assets and promoting business diversification of commercial banks. Notably, the impact of the three dimensions of ESG (environmental, social, and governance) on risk-taking capacity differs significantly, with governance performance having the most pronounced effect. Moreover, the positive impact of ESG performance on risk-taking capacity is more prominent in banks with higher capital adequacy ratios and loan loss provision coverage ratio. This study innovatively employs arithmetic average of ESG rating scores of other banks in the province where the registration is located in the same quarter as an instrumental variable in the endogeneity test, which helps to deepen the understanding of the influence of local government fiscal strength and policy orientation on banks' ESG performance and risk-taking behavior.

Key words: Risk-Taking Capacity; ESG Performance; Return on Assets; Non Interest Income

1 Introduction

Against the backdrop of global climate change and sustainable development strategies, the awareness of environmental pollution, ecological degradation, and excessive resource consumption within Chinese society has reached unprecedented levels. With the implementation of various energy conservation and emission reduction policies, China's carbon dioxide emissions per unit of GDP have demonstrated a consistent downward trend [1]. Simultaneously, China's green finance policy system, designed to address climate change, is undergoing a profound systematic evolution. Since the establishment of the top-level design in 2016, when the People's Bank of China and six other ministries and commissions issued the 'Guidelines on Building a Green Financial System,' the framework of China's green finance policy has continually improved. In 2019, financial technology spurred innovation in ESG scoring mechanisms, allowing for the quantitative assessment of corporate carbon emission data. In 2020, real estate financial supervision became deeply integrated with ESG requirements, directing capital flows

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toward new energy sectors through the 'Three Red Lines' policy. The year 2021 witnessed an explosion of innovation, with the accelerated emergence of green financial products such as carbon quota pledge loans and carbon neutrality bonds. Notably, the regulatory framework is gradually transitioning from a focus on single-product innovation to the construction of a comprehensive risk management system.The China Banking and Insurance Regulatory Commission incorporated climate risk stress testing into the banking risk control system in 2022, further strengthened the coordinated governance of local debt and ESG risks in 2023, while advancing data governance platform construction and alignment with international standards. This evolutionary trajectory not only demonstrates China's firm determination to address climate change but also reveals practical challenges such as insufficient alignment of standard systems and the need to improve environmental data quality, providing a rich practical foundation for exploring financial institutions' environmental responsibility fulfillment mechanisms.

Within this strategic landscape, the Chinese government has taken a series of proactive measures to promote economic green transformation and sustainable development [2]. As a key channel for resource allocation, China's banking sector, with business coverage across extensive industries and numerous projects, provides essential financial support for the development of green and low-carbon industries [3]. By avoiding excessive concentration of credit resources in energy-intensive and high-pollution industries while actively supporting the development of environmental protection industries, the banking sector is facilitating the realization of national industrial structure adjustment and green development goals [4]. Therefore, Chinese commercial banks' firm commitment to ESG factors has strategic significance—their ESG performance reflects not only their response to national policy directions but also their commitment to social welfare responsibilities and environmental obligations. By strengthening ESG practices, banks can better implement national green finance policies, enhance market transparency, and strengthen public trust [5], thereby injecting sustainable momentum into high-quality economic development.

However, systematic academic research on the relationship between ESG performance and risk-taking capacity of Chinese commercial banks remains insufficient. Based on this, our study focuses on data from Chinese listed commercial banks from the first quarter of 2011 to the fourth quarter of 2023, exploring the intrinsic connection between ESG performance and risk-taking capacity, and achieving breakthrough innovations in the following aspects: First, unlike previous research which mainly focused on developed countries and other emerging markets (excluding China) [6-8], this study concentrates on large Chinese listed commercial banks, filling a significant research gap in the Chinese context; Second, in addressing endogeneity issues, this study innovatively employs the arithmetic average of ESG ratings of other banks in the same province of registration as an instrumental variable, providing a new perspective for understanding regional differences in local government fiscal capacity, policy orientation, and economic policy effectiveness; Finally, this study uniquely examines how Capital Accumulation Rate (CAR) and Loan Loss Provision Coverage Ratio (LLPCR) moderate the complex relationships between bank value, risk-taking behavior, and ESG disclosure scores from the dual dimensions of current profitability and risk structure optimization.

The theoretical and practical significance of this research lies in: deepening our understanding of the complex interactive relationship between ESG performance and risk management in Chinese commercial banks; providing empirical evidence for bank managers to formulate ESG strategies and

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risk governance policies; offering policy references for regulatory authorities to improve ESG disclosure requirements and banking risk regulatory frameworks; and constructing a new analytical framework for investors to evaluate banks' sustainable development capabilities and investment value. In the context of the global financial system's increasing emphasis on sustainable development and climate risk, the findings of this study will provide key insights into how the banking industry can maintain sound operations while fulfilling ESG responsibilities.

2 Literature Review and Research Hypotheses

2.1 ESG Factors and Corporate Financial Performance

Research exploring the relationship between ESG factors and corporate financial performance has a considerable history. Brammer et al. [9] revealed the complex association between Corporate Social Responsibility (CSR) and financial performance in the UK market: while companies with higher CSR scores demonstrated excellent market returns, the impact of CSR on financial performance might vary between short-term and long-term horizons . To provide more comprehensive evidence, Friede et al. [10] conducted a meta-analysis of over 2,000 studies examining ESG and financial performance. Although conclusions were not entirely uniform, the overall findings suggested that ESG had a positive impact on corporate financial performance, particularly regarding long-term investment returns.

In specific market and industry contexts, the contribution of various ESG dimensions to financial performance shows notable differences. Through panel data analysis, Atan et al.[11] investigated the impact of ESG factors on Malaysian company performance, emphasizing the significant roles of different ESG dimensions. In the Indian market, Dalal and Thaker [12]found that high ESG scores significantly enhanced corporate financial performance, particularly Return on Assets (ROA). Regarding cross-industry comparisons, Xie et al. [13] examined the impact of ESG activities on financial performance, discovering that environmental and social efforts significantly improved corporate performance, although effects varied across industries.

From a temporal perspective, ESG's impact demonstrates dynamic characteristics. Giannopoulos et al. [14]studied Norwegian listed companies between 2010-2019, finding that while ESG might reduce ROA in the short term, ESG investments helped enhance Tobin's Q value in the long term, indicating potential for increasing company market value.

2.2 Research on the Impact of ESG Performance on Bank Risk Management

As ESG's role in bank risk management becomes increasingly prominent, performance across ESG dimensions has gradually emerged as a crucial tool for enhancing bank resilience and risk-bearing capacity. Izcan and Bektas [15]indicate that while improvements in ESG, particularly in environmental and social dimensions, may increase specific risks faced by banks, enhancements in the governance dimension significantly improved risk management efficiency, with notably stronger effects on high-risk banks. This governance factor's influence has been validated by Aevoae et al. [16], whose research demonstrates that higher ESG scores, especially in the governance dimension, can effectively reduce

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interconnectedness among banks, thereby enhancing systemic financial stability. Additionally, Chiaramonte et al. [17] found that during financial crises, ESG strategies exhibited positive risk mitigation effects through promoting prudent behavior and strengthening social reputation, with banks maintaining higher ESG scores demonstrating greater resilience during these periods.

From a long-term perspective, the integration of ESG practices exhibits a U-shaped relationship with bank performance and risk management. Yuen et al.[18] found that, despite the potential short-term decline in profitability due to increased costs, ESG activities enhanced banks' resilience to economic shocks in the long run, particularly during the COVID-19 pandemic. Furthermore, Di Tommaso et al. [19]and Altunbaş et al. [20] respectively noted that ESG activities could reduce default risk by mitigating risk-taking behavior and improving information disclosure. This is consistent with the stakeholder theory's emphasis on the logic of "win-win cooperation". Good ESG performance helps to increase the correlation with stakeholders, promote the stable operation of banks, and suppress the possibility of systemic risks.However, these activities may come at the cost of resource allocation, thereby exerting short-term pressure on bank value.

Specifically, different pillars of ESG play distinct roles in risk management. Curcio et al.[21]found that the social (S) and governance (G) dimensions are particularly crucial in reducing systemic risk. For U.S. banks, both Shao et al. [25] and Galletta et al. [**Error! Reference source not found.**]discovered that corporate social responsibility (CSR) activities and higher ESG scores significantly lower operational risk and the need for capital absorption. Moreover, Liu and Jin [33] demonstrated that the environmental and social dimensions play a vital role in reducing banks' non-performing loans (NPLs) and mitigating systemic risk. Similarly, Trinh et al.[28] pointed out that, following the financial crisis, banks with better CSR activities exhibited lower tail risk, and this trust mechanism built through social capital investment further enhanced banks' risk-bearing capacity.This reflects the use of ESG reports in signal transmission theory to convey transparent information, alleviate market asymmetry, enhance investor trust, and guide banks to invest prudently, ultimately reducing risks and improving resource allocation efficiency.

The risk management effects of ESG are also significant in emerging markets and across different banking business models. Gangwani and Kashiramka [26] found that higher ESG scores not only reduce financial risks (such as bankruptcy risk and leverage risk) but also enhance financial and market performance. Palmieri et al. [27]further pointed out that retail and wholesale banks can lower default risk by improving environmental (E) performance, while investment banks need to focus on improving the governance (G) dimension to achieve risk reduction.

In conclusion, ESG performance provides the necessary support for banks to take on more risks by enhancing their resilience and risk management capabilities. Therefore, this study proposes the following hypothesis:

H1: The ESG performance of commercial banks enhances their risk-taking capacity.

2.3 The Relationship between ESG Performance and Bank Financial Performance

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Existing research has demonstrated a significant positive correlation between ESG performance and banks' financial performance. For instance, Cornett et al. [28] found that banks' investment in social responsibility activities is positively correlated with financial performance, and this relationship is particularly evident in large banks. Brogi et al. [29]further pointed out that banks' environmental performance has a significant positive effect on return on assets (ROA). This suggests that by improving ESG performance, banks can enhance their profitability, providing a financial foundation for strengthening their risk-taking capacity.

However, the impact of ESG investment is not a linear relationship. Azmi et al. [30] discovered that low levels of ESG activities have a positive impact on bank value, but excessive investment may lead to diminishing marginal returns or even negative effects. Agnese et al. [31] noted that although banks facing more ESG controversies perform better in the short term on financial indicators such as ROA and ROE, further analysis reveals a negative correlation between ESG controversy scores and bank profitability, indicating that excessive controversies may undermine banks' long-term profitability. Moreover, Athari et al. [32]found an inverted U-shaped relationship between sovereign ESG performance and bank profitability, suggesting that moderate sovereign ESG investment can enhance profitability, but its effect becomes negative once it exceeds a certain threshold. These studies emphasize the need for banks to balance their ESG investments and avoid potential negative impacts caused by excessive investment when formulating ESG strategies.From the perspective of sustainable development theory, this emphasizes the balanced development of economy, environment, and society to meet contemporary needs without harming the well-being of future generations, and focuses on promoting environmental friendliness and social responsibility through green financial tools.

Regarding specific ESG dimensions, environment (E) and governance (G) are considered to have a stronger positive impact on bank performance. Bătae et al. [33] pointed out that banks' environmental performance is significantly positively correlated with ROA, while social responsibility (S) may negatively affect financial performance in some cases. Cao et al. [34]further demonstrated that ESG investments in the environmental and governance dimensions could enhance banks' overall capabilities by improving efficiency. Simultaneously, Sun et al.'s [35] research showed that banks with fewer ESG controversies perform better in risk-adjusted return on capital (RAROC). This evidence suggests that good ESG performance, especially in the environmental and governance dimensions, can support banks in taking on more risks by increasing profitability.

The relationship between ESG performance and banks' business diversification is also noteworthy.ESG driven business innovation is seen as an important path for banks to break through traditional spread dependence and build sustainable income models. According to the OECD [36]report, leading commercial banks around the world have increased the proportion of intermediary business income to 30% -50% by issuing innovative tools such as green bonds, carbon finance products, and ESG themed wealth management, effectively reducing the proportion of capital consuming businesses. The empirical study by Battiston et al. [37] shows that for every 10% increase in ESG related business revenue, the ROA volatility of banks during financial crises can be reduced by 1.2 percentage points, demonstrating the positive effect of income diversification on risk buffering. It is worth noting that customers of this type of business have high stickiness and can form a stable stream of fee income, thereby enhancing the bank's ability to cope with liquidity shocks .

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Optimizing the revenue structure of commercial banks not only directly improves profitability, but also indirectly supports sustainable growth rates by enhancing customer loyalty and social influence, forming a positive cycle of "risk diversification return growth".Based on this, this study proposes the following hypotheses:

H2: The ESG performance of commercial banks can enhance risk-taking capacity by improving profitability.

H3: The ESG performance of commercial banks can optimize risk structure by increasing the proportion of non interest income(NII).

3 Research Design

3.1 Sample Selection and Data Sources

This study focuses on 16 representative large commercial banks in China, using quarterly data from the first quarter of 2011 to the fourth quarter of 2023 as the initial research sample. Data with missing financial information were excluded. To avoid the impact of outliers on the regression results, the continuous variable data at the commercial bank level were winsorized at the top and bottom 1%, resulting in a final sample of 832 observations. The ESG score data and bank financial data were obtained from the CSI Index official website and the CSMAR database, respectively.

3.2 Variable Description

3.2.1 Dependent Variable——Long-term Debt-to-Asset Ratio

Commercial banks' risk-taking is closely related to factors such as asset allocation, capital adequacy ratio, liquidity, credit policy, and market environment. Therefore, non-performing loan ratio, debt-to-asset ratio, overdue loan ratio, Z-score, and risk-weighted asset ratio are often used as the main proxy indicators for measuring commercial banks' risk-taking [38-39]. To better measure commercial banks' risk resilience in the context of unexpected events, this study follows the approach of Farah, I. [40] and selects the long-term debt-to-asset ratio as a proxy for commercial banks' risk-taking.

3.2.2 Independent Variable——ESG

This study uses the CSI ESG score data provided by Shanghai CSI Index Information Services Co., Ltd. as a proxy variable for measuring the ESG performance of Chinese commercial banks [41]. The CSI ESG score ranges from 0 to 10, with higher values indicating better ESG performance.

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3.2.3Mechanism Variables

This study uses return on assets (ROA) as a proxy for asset profitability and non interest income (NII) as a proxy for commercial banks' business diversification[42-43].

3.2.4Control Variables

To eliminate the interference of other variables on the relationship between the independent and dependent variables and ensure the accuracy of the research results, this study analyzes from the perspectives of asset operation efficiency, overall bank asset size, debt level, and asset competitiveness. The debt-to-asset ratio (D/A), total assets (TA),Sustainable Growth Rate(SGR),Banking Industry Climate Index(BIPI),and DIB Internal Control Index(ICI) are selected as control variables[44].The definitions of the variables are presented in Table 1.

Table 1. Regression variables

Tape	Variable		Description
Dependent variable	**LDA**	Long-term Debt to Asset	Measured by the ratio of long-term liabilities to total assets.Long-term debt to asset ratio is negatively correlated with risk-taking ability
Independent variable	**ESG**	ESG Score	The score is based on the CSI ESG rating system, which assigns a score of "1-10" to listed banks.
	E	Environmental Score	Environmental performance score of the corporation by CSI.
	S	Social Score	Social performance score of the corporation by CSI.
	G	Governance Score	Corporate governance performance score of the corporation by CSI.
Control variables	**TA**	Total Assets	Natural log of the total assets of the banks.
	D/A	Debt-to-Asset Ratio	$\frac{\text{Total Liabilities}}{\text{Total Assets}}$
	SGR	Sustainable Growth Rate	$\frac{\text{ROE} \times \text{Retention Ratio}}{1-(\text{ROE} \times \text{Retention Ratio})}$
	BIPI	Banking Industry Climate Index	$\text{BIPI} = \sum_{i=1}^{n} w_i \times \text{Sub}-\text{Index}_i$

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			w_i: Weight of each sub-index (e.g., asset quality, profitability, liquidity, capital adequacy). Sub-Index$_i$: Normalized scores for individual metrics (e.g., NPLR, ROA, loan growth).
	ICI	DIB Internal Control Index	$ICI = \sum_{i=1}^{n} w_i \times X_i$ w_i:Weight assigned to each dimension (determined by expert judgment). X_i: Standardized score for each dimension (e.g., Control Environment,Risk Assessment, Control Activities,Information&Communication, Monitoring).
Mechanism variables	**ROA**	Return on Assets	$\frac{\text{Net Income Before Financing Costs}}{\text{Total Assets}}$
	NII	Non-Interest Income to Total Revenue Ratio	$\frac{\text{ROE} \times \text{Retention Ratio}}{1-(\text{ROE} \times \text{Retention Ratio})}$

3.3 Model Design

This study establishes the following two-way fixed effects model:

$$LDA_{it} = \alpha_0 + \alpha_1 ESG_{it-1} + \alpha Con_{it-1} + \delta_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In model (1), the dependent variable LDA_{it} is the current period's long-term debt-to-asset ratio of commercial banks, and the explanatory variable ESG_{it-1} is the previous period's ESG performance of commercial banks. Con_{it-1} is a vector set of control variables, including debt-to-asset ratio (D/A), total assets (TA), ,Sustainable Growth Rate(SGR),Banking Industry Climate Index(BIPI),and DIB Internal Control Index(ICI). δ_i represents individual fixed effects, λ_t represents time fixed effects, and ε_{it} is the random disturbance term. To mitigate the endogeneity problem caused by reverse causality as much as possible, take the logarithm of some data, the variance of variables is reduced and the gap is more stable, especially for data with a right skewed long tail distribution, which has a significant effect.

To test whether ESG performance can also enhance commercial banks' risk-taking capacity and optimize risk structure through the mechanism of improving asset profitability and business

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diversification[19], this study constructs the following model (2) and model (3) based on model (1). Among them, ROA is the return on assets, reflecting the profitability of the company's assets, and NII is the non interest income, reflecting the company's business diversification capability and revenue structure. The other variables are consistent with model (1).

$$ROA_{it} = \alpha_0 + \beta_1 ESG_{it-1} + \alpha Con_{it-1} + \delta_i + \lambda_t + \varepsilon_{it} \quad (2)$$

$$NII_{it} = \alpha_0 + \gamma_1 ESG_{it-1} + \alpha Con_{it-1} + \delta_i + \lambda_t + \varepsilon_{it} \quad (3)$$

4 Empirical Study

4.1 Descriptive Statistical Analysis

According to the statistical results in Table 2, the mean value of the long-term debt-to-asset ratio is 6.6%, with a minimum value of 0.1% and a maximum value of 20.1%, indicating that the long-term debt-to-asset ratio of Chinese commercial banks fluctuates widely. The average ESG performance of commercial banks is 8.13, with a minimum value of 6.51 and a maximum value of 8.86. The average environmental performance (E) of commercial banks is 7.27, with a minimum value of 5.86 and a maximum value of 9.08. The average social performance (S) of commercial banks is 7.86, with a minimum value of 6.06 and a maximum value of 9.04. The average governance performance (G) of commercial banks is 8.72, with a minimum value of 5.61 and a maximum value of 9.65.

In the Morgan Stanley Capital International (MSCI) ESG rating system, an ESG score above 7.143 is considered a "leading" level[45]. The average ESG score of 8.13 for Chinese commercial banks indicates an overall good performance. However, there is a significant divergence among the three pillars of ESG performance in commercial banks, with the governance (G) dimension performing the best, followed by the social (S) dimension, and the environmental (E) dimension performing the worst.

Table 2. Descriptive Statistics

Variables	Symbols	N	Mean	SD	Min	Max
Long-term Debt to Asset	LDA	832	0.0663	0.0524	0.0011	0.2012
ESG Score	ESG	832	8.132	0.387	6.511	8.859
Total Assets	TA	832	10.87	1.108	7.755	13.01

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Debt-to-Asset Ratio	D/A	832	0.929	0.0109	0.902	0.967
Sustainable Growth Rate	SGR	832	0.0871	0.0418	0.0181	0.2161
Banking Industry Prosperity Index	BIPI	832	70.31	6.543	60.50	85.40
DiBo Internal Control Index	ICI	832	652.0	102.9	279.6	975.5
Environmental Score	E	832	7.272	0.594	5.860	9.078
Social Score	S	832	7.858	0.583	6.059	9.037
Governance Score	G	832	8.723	0.562	5.605	9.652
Return on Assets	ROA	832	0.0125	0.0031	0.0046	0.0195
Non Interest Income Proportion	NII	832	25.94	7.814	9.435	51.09

4.2 Baseline Regression Results

Table 3 presents the baseline regression results for model (1). Column (1) shows the simple OLS regression results, while column (2) provides the estimates after controlling for individual fixed effects and time fixed effects without introducing control variables. Column (3) displays the simple OLS regression results with the addition of control variables, and column (4) reports the estimates after simultaneously controlling for individual and time fixed effects. The results from columns (1) to (3) indicate that the coefficients for the commercial banks' ESG performance variable are -0.0185, -0.0072, and -0.0144, respectively, all significant at the 1% level. The estimated result in column (4) is -0.0065, also significant at the 1% level, supporting hypothesis H1.

Table 3. Regression result

Variable	LDA	LDA	LDA	LDA
ESG	-0.0185***	-0.0072***	-0.0144***	-0.0065***
	(0.0047)	(0.0039)	(0.0039)	(0.0035)
TA			-0.0245***	0.1004***
			(0.0016)	(0.0078)
D/A			-1.4043***	-0.1646
			(0.1799)	(0.1904)

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SGR			-0.2131***	-0.1873**
			(0.0393)	(0.0796)
BIPI			-0.0023***	0.0009***
			(0.0003)	(0.0003)
ICI			-0.0032	0.0056**
			(0.0011)	(0.0042)
Constant	0.2164***	0.0720**	1.9492***	-0.8660***
	(0.0379)	(0.0322)	(0.1703)	(0.1703)
N	832	832	832	832
R-sq	0.024	0.631	0.375	0.734

Note: Standard errors are reported in parentheses. ***, **, and * significant at 1%, 5%, and 10%, respectively.

4.3 Endogeneity Issues

4.3.1 Employing ESG Variable Data with Longer Lags

Although using one-period lagged data for the explanatory variables can alleviate endogeneity issues caused by reverse causality to a certain extent, considering that this study utilizes quarterly panel data, we further analyze the explanatory variables with lags of 2, 3, and 4 periods, following the approach of Liu, J.[46]. The results are presented in columns (1) to (3) of Table 5. The findings reveal that the coefficients of the commercial banks' ESG performance variable remain negative and significant at the 1% level.

4.3.2 Adding Relevant Control Variables

The shareholding ratio of the largest shareholder is related to the nature of shareholders and governance structure, reflecting the concentration of equity in commercial banks, and has an impact on policy implementation and risk mitigation levels [47]. To mitigate potential endogeneity issues caused by the omission of the shareholding ratio of the largest shareholder at the commercial bank level, we further control for shareholding ratio of the largest shareholder (SIS). The results are presented in column (4) of

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Table 5. The findings indicate that the coefficient of the commercial banks' ESG performance variable remains negative and significant at the 5% level.

4.3.3 Instrumental Variable Approach

In order to alleviate the potential endogeneity issues in the model, this article uses instrumental variable method, corrected least squares virtual variable estimation method, and propensity score matching method to solve them. Firstly, in order to alleviate the problem of reverse causality, the arithmetic mean of ESG rating scores of other banks in the province where the registration is located in the same quarter is used as the instrumental variable, and two-stage least squares method is used for analysis. On the one hand, in the process of fulfilling social responsibility, companies in the same industry and region have a same group effect[47], and the ESG level of the bank's location will affect its own ESG level, meeting the requirements of relevance; On the other hand, the average ESG level of other banks in the region does not directly affect the bank's own risk-taking level, meeting the requirements of exogeneity. The regression results are shown in column (3) of Table 4, and the model passed the weak instrumental variable test and the instrumental variable identifiability test.

As shown in columns (5) and (6) of Table 4, the first-stage regression results are significant at the 1% level with a positive coefficient, while the second-stage regression results are significant at the 1% level with a coefficient of -0.0281. The p-value is close to 0, the R-squared is 0.632, and the F-statistic is 80.53, which is greater than the empirical value of 10, rejecting the null hypothesis of weak instrumental variables. Furthermore, the instrumental variable satisfies the exogeneity requirement. Therefore, using the local fiscal budget revenue of the headquarters' location in the same year as an instrumental variable is robust, making the estimation results more reliable.

Table 4.Analysis of Endogeneity Issues

Variables	LDA	LDA	LDA	LDA	ESG	LDA
ESG				-0.0065*		-0.0281***
				(0.0035)		(0.0033)
ESGit-2	-0.0106***					
	(0.0035)					

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ESGit-3		-0.0117***				
		(0.0035)				
ESGit-4			-0.0130***			
			(0.0036)			
Mean_ESG					0.9955**	
					(0.0298)	
SIS				-0.0021**		
				(0.0009)		
TA	0.1009***	0.0990***	0.0993***	0.1015***	-0.0078**	0.0755***
	(0.0083)	(0.0086)	(0.0089)	(0.0080)	0.0307	(0.0034)
D/A	-0.2518	-0.2681	-0.2737	-0.1723	-0.9518	0.1410
	(0.2005)	(0.2058)	(0.2095)	(0.1910)	0.02981	(0.1366)
SGR	-0.2222***	-0.2403***	-0.2562***	-0.1899**	0.1724**	-0.0150
	(0.0799)	(0.0816)	(0.0863)	(0.0798)	0.2348	(0.0258)
BIPI	0.0010***	0.0011***	0.0011***	0.0009***	-0.0033***	0.0001**
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	0.0019	(0.0002)
ICI	0.0000	0.0000	0.0000	0.0000**	0.0003*	0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	0.0009	(0.0000)
Constant	-0.7443***	-0.7059***	-0.7207***	-0.8684***	-0.4082***	-0.8684***
	(0.1746)	(0.1820)	(0.1911)	(0.1704)	(0.2709)	(0.5421)
N	816	800	784	832	832	832
R-sq	0.735	0.731	0.724	0.732	0.851	0.632

Note: Standard errors are reported in parentheses. ***, **, and * significant at 1%, 5%, and 10%, respectively.

4.4 Robustness Tests

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4.4.1 Using Annual Sample Data

We further estimate model (1) using annual data of listed commercial banks from 2011 to 2023. The results are presented in column (1) of Table 6. The coefficient of the commercial banks' ESG performance variable is -0.0127, significant at the 10% level, providing additional evidence that improved ESG performance of commercial banks enhances their risk-taking capacity.

4.4.2 Replacing the Dependent Variable

We further test the robustness of our findings by employing an alternative measure of risk-taking capacity. Following Erdemlioglu D (2019)[48] and Frezatti F [49], we use commercial banks' non-performing loan ratio (NPI) as a proxy for risk-taking capacity, which is a core indicator for measuring asset quality and risk resistance ability. It directly reflects the proportion of loans with default risk in the bank's loan portfolio, and has a decisive impact on the bank's capital adequacy, profitability, and long-term stability..We re-estimate model (1) using this alternative dependent variable. The results, presented in column (2) of Table 6, show that the coefficient of the commercial banks' ESG performance variable is -0.1800, significant at the 1% level, confirming the robustness of our main conclusion.

4.4.3 Shortening the Sample Period

Following the approach of Caporale G M [50], we exclude data from the third quarter of 2015 and the third quarter of 2020 to the fourth quarter of 2022 to avoid the impact of stock market shocks and the COVID-19 pandemic. We then re-estimate our model using this shortened sample period. The regression results, shown in column (3) of Table 6, indicate that the coefficient of the ESG performance variable remains significant at the 1% level, further supporting the robustness of our findings.

4.4.4 Employing Clustered Robust Standard Errors

Considering the potential correlation of error terms across different periods for the same commercial bank, which may lead to autocorrelation issues, we conduct a cluster test at the individual bank level. Following the approach of Lagasio V [51], we further estimate our model using clustered robust standard errors at the individual bank level. The results, reported in column (4) of Table 6, show that the

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coefficient of the commercial banks' ESG performance variable is -0.0189, significant at the 1% level, confirming the robustness of our main finding.

In summary, the various robustness tests consistently yield the conclusion that commercial banks' ESG performance is significantly associated with enhanced risk-taking capacity, demonstrating the reliability and robustness of our results. These tests, which include using annual sample data, replacing the dependent variable, shortening the sample period, and employing clustered robust standard errors, collectively strengthen the validity of our main findings and provide additional support for our hypothesized relationship between ESG performance and risk-taking capacity in the commercial banking sector.

Table 5.Robustness Check

Variables	LDA	NPI	LDA	LDA
ESG	-0.0127*	-0.1800***	-0.1101***	-0.0189***
	(0.0069)	(0.0314)	(0.0396)	(0.0049)
TA	4.9393***	0.1379**	2.8847***	0.0281***
	(1.3683)	(0.0697)	(0.5976)	(0.0079)
D/A	0.0622***	-5.9642***	0.1013***	-0.8092
	(0.0177)	(1.7016)	(0.0089)	(0.5624)
SGR	0.2837***	-2.9213***	2.2153***	-0.1033***
	(0.0875)	(0.7111)	(0.3903)	(0.0214)
BIPI	0.0395	-0.0156***	0.0001	-0.0010*
	(0.0341)	(0.0028)	(0.0005)	(0.0006)
ICI	-0.6093	-0.0003***	0.0752**	0.0000
	(0.7333)	(0.0001)	(0.0317)	(0.0000)
Constant	-4.7269***	8.2072***	-3.4775***	0.7290
	(1.0995)	(1.5213)	(0.4967)	(0.5172)
N	208	832	636	832
R-sq	0.721	0.936	0.767	0.659

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Note: Standard errors are reported in parentheses. ***, **, and * significant at 1%, 5%, and 10%, respectively.

4.5 Mechanism Tests

4.5.1Profitability Mechanism

Following the research of Saiz et al.[52], we use commercial banks' return on assets (ROA) as a proxy for current profitability and employ the aforementioned model (2). The empirical results, presented in columns (1) and (2) of Table 6, show that the coefficient of commercial banks' ESG performance is positive and significant at the 1% level, indicating that good ESG performance helps improve commercial banks' return on assets.

This result suggests that improving ESG performance not only enhances banks' financial conditions and strengthens investor and depositor confidence, providing enterprises with more funding sources, but also increases enterprises' confidence when facing uncertainties, generating moral capital and reducing their own risk-taking levels. Therefore, ESG performance enhances commercial banks' risk-taking capacity through the channel of increasing return on assets, supporting our hypothesis H2.

4.5.2Optimize income structure Mechanism

In the strategic transformation and sustainable development of commercial banks, business diversification is driving banks to shift from traditional interest rate drive to value creation drive. By expanding innovative businesses such as green finance, inclusive finance, and science and technology innovation finance, banks can not only open up growth points for non interest income such as fee income and asset management fees, but also diversify their risk exposure by relying on diversified business layouts, and build a "light capital, low volatility, and high resilience" risk-taking structure. This ESG oriented business model innovation not only aligns with the global trend towards carbon neutrality, but also significantly enhances the profitability stability and market competitiveness of banks in complex economic cycles by optimizing their revenue structure and risk costs.As a result, banks can enhance their business optimize risk structure in the ESG field.

Drawing on the research of Isnurhadi et al. [53], we use the non interest income (NII) as a proxy for commercial banks' Business diversification capability and estimate model (3). The results are presented in columns (3) and (4) of Table 6. In column (4), the coefficient of commercial banks' ESG performance

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is positive and significant at the 1% level. This result indicates that good ESG performance can improve commercial banks' sustainable growth rates.

ESG oriented non interest income can enhance the diversification quality of commercial banking business, optimize risk structure, and strengthen risk resistance ability. Therefore, the empirical results support our hypothesis H3, which posits that ESG performance enhances commercial banks' risk-taking capacity by improving their sustainable growth capability.optimize risk structure by increasing the non interest income(NII).

In conclusion, this study verifies the impact pathways of commercial banks' ESG performance on risk-taking capacity from two perspectives: the profitability mechanism and the risk structure mechanism. The empirical results show that good ESG performance can enhance banks' profitability by optimizing asset allocation and improving return on assets. Moreover, the improvement of ESG performance can also promote banks to develop innovative business models and enhance their non interest income.The combined effects of these two mechanisms explain the enhancing effect of ESG performance on commercial banks' risk-taking capacity, enriching the research in related fields. These findings have important implications for commercial banks in strengthening ESG management and balancing ESG performance with risk-taking.

Table 6.Mechanism Verification

Variables	ROA	ROA	NII	NII
ESG	0.0015***	0.0004***	2.2497***	2.0513***
	(0.0003)	(0.0002)	(0.6962)	(0.6904)
TA		0.0025***		17.2478***
		(0.0003)		(1.5327)
D/A		-0.1435***		-52.5459
		(0.0084)		(37.4300)
SGR		0.0622***		19.1477
		(0.0035)		(15.6432)
BIPI		-0.0000		-0.1136*
		(0.0000)		(0.0618)

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ICI		0.0000		0.0005
		(0.0000)		(0.0024)
Constant	0.0000	0.1186***	44.2356***	-113.7003***
	(0.0022)	(0.0075)	(5.6679)	(33.4646)
N	832	832	832	832
R-sq	0.047	0.8665	0.041	0.5791

Note: Standard errors are reported in parentheses. ***, **, and * significant at 1%, 5%, and 10%, respectively.

5 Further Analysis

5.1 Decomposition of ESG Indicators

To further examine the differentiated impact of the three main pillars of ESG—environmental (E), social (S), and governance (G)—on commercial banks' risk-taking capacity, we employ model (1) and replace the ESG indicator with the rating values of each of the three dimensions of ESG for regression. The results are shown in Table 7.

The results in column (1) show that the coefficient of the environmental dimension is 0.0130, which is significant at the 1% level, indicating that improving environmental performance reduces commercial banks' risk-taking capacity. The results in column (2) show that the coefficient of the social dimension is 0.0002 but not significant, suggesting that social performance is not significantly correlated with risk-taking capacity. The results in column (3) show that the coefficient of the governance dimension is -0.0146, which is significant at the 1% level, implying that good corporate governance helps enhance risk-taking capacity.

Column (4) simultaneously includes environmental, social, and governance variables. The signs and significance of the coefficients for the environmental and governance dimensions are consistent with the aforementioned results, while the social dimension remains insignificant, further verifying the above conclusions.

The research results suggest that at the current stage, the impact of commercial banks' ESG performance on risk-taking capacity mainly comes from the contribution of the corporate governance

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dimension. In contrast, environmental factors may have a certain negative impact on risk-taking, while the role of social factors is not significant. These research conclusions are basically consistent with the findings of Di Tommaso C [19].The main reason for this may be that China's economy is still in the primary stage of green transformation. According to the descriptive statistics in Table 1, the average scores of domestic commercial banks in environmental, social, and governance aspects are only 7.272, 7.858, and 8.723, respectively. The overall environmental performance is relatively low, and it will take time to gain wide recognition from market investors.

On the other hand, green finance, by incorporating environmental issues into financial service decisions, has significant positive externalities. However, commercial banks need to pay certain costs for this in the short term[54]. Internalizing environmental dividends into their own competitive advantages relies on investors' widespread acceptance of the concept of sustainable development, which is a relatively long process. Particularly under the guidance of current environmental protection policies, commercial banks may increase their own default risk by issuing green credit through measures such as interest concessions.

From the perspective of information asymmetry theory, due to the complexity of green projects, banks have a natural disadvantage in identifying and supervising their risks, which can easily lead to adverse selection and moral hazard problems, thereby affecting banks' sound operations[55]. Therefore, during the transitional period of the economy's green transformation, the impact of ESG driving factors on commercial banks' risk-taking may exhibit certain stage characteristics and a dynamic evolution process.In the future, this mechanism should be deeply analyzed at the empirical level to provide decision-making references for promoting the healthy development of green finance. At the same time, it is necessary to focus on enhancing commercial banks' sense of responsibility and ability to fulfill responsibilities in the environmental and social fields. While exerting governance effects, the coordinated role of various ESG dimensions should be optimized to ultimately achieve sustainable development goals.

Table 7.Structural Decomposition of ESG Indicators

Variables	LDA	LDA	LDA	LDA
E	0.0130***			0.0149***
	(0.0019)			(0.0019)

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S		0.0002		0.0007
		(0.0021)		(0.0020)
G			-0.0146***	-0.0171***
			(0.0024)	(0.0023)
TA	0.1061***	0.1012***	0.0987***	0.1039***
	(0.0076)	(0.0078)	(0.0076)	(0.0074)
D/A	-0.1353	-0.1530	-0.1881	-0.1735
	(0.1853)	(0.1908)	(0.1862)	(0.1791)
SGR	-0.1867**	-0.2043**	-0.1569**	-0.1322*
	(0.0770)	(0.0797)	(0.0777)	(0.0752)
BIPI	0.0009***	0.0009***	0.0008***	0.0009***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
ICI	0.0000	0.0000*	0.0000**	0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Constant	-1.0895***	-0.9361***	-0.7508***	-0.9011***
	(0.1633)	(0.1672)	(0.1652)	(0.1604)
N	832	832	832	832
R-sq	0.743	0.730	0.745	0.762

Note: Standard errors are reported in parentheses. ***, **, and * significant at 1%, 5%, and 10%, respectively.

5.2 Analysis of Moderating Effects

5.2.1 Analysis of the Moderating Effect Based on Capital Accumulation Rate

Previous research has shown that commercial banks' ESG performance can enhance risk-taking capacity by improving return on assets. However, return on assets measures capital use efficiency and profitability, while the speed of capital accumulation may play a more crucial role in the relationship between ESG and risk-taking.

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A higher capital accumulation rate, on the one hand, means that commercial banks have more resources to invest in the ESG field, improving their ability to fulfill social responsibilities [34][56]. On the other hand, rapid capital accumulation also enhances banks' counter-cyclical risk resilience, creating conditions for them to carry out risky business. At the same time, sufficient capital can also expand the scope and depth of financial services, helping banks obtain more profits and form a virtuous cycle of capital accumulation, ultimately increasing the level of risk-taking.

To verify the above theoretical inference, following Anginer D [57], we use the capital accumulation rate (CAR, i.e., the ratio of the increase in owners' equity at the end of the year to the total owners' equity at the beginning of the year) as a proxy variable for the capital structure of commercial banks. We add CAR and its interaction term with ESG, M1 (ESG×CAR), to model (1). The estimation results are shown in column (1) of Table 8.

The coefficient of the interaction term between ESG and CAR is 0.0077, which is significant at the 1% level. This indicates that the capital accumulation rate positively moderates the enhancing effect of ESG on commercial banks' risk-taking capacity.

5.2.2 Analysis of the Moderating Effect Based on Loan Loss Provision Adequacy Ratio

The adequacy ratio of loan loss provision is a core indicator for risk prevention and stable operation of commercial banks, which directly affects their risk resistance ability and financial stability. A sufficient and reasonable level of loan loss reserve not only reflects the bank's ability to accurately identify risks and prudent management philosophy, but also effectively enhances the financial system's ability to respond to credit risks, and builds a safety barrier for sustainable development in economic cycle fluctuations.

The adequacy ratio of loan loss provision is a key mechanism for commercial banks to buffer risks and cross cycles. The dynamically balanced provision coverage level not only demonstrates the forward-looking thinking of banks in establishing countercyclical capital management capabilities, but also lays a regulatory compliance foundation for balancing social responsibility performance and operational resilience by strengthening the effectiveness of risk mitigation tools. Therefore, this indicator is likely to play an important role as a risk mitigation variable in the ESG risk transmission chain, transforming

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environmental and social risk exposure into a safety cushion for sustainable operations through the elastic adjustment mechanism of capital buffering

To verify this inference, following the research of Bai and Kim[58], we use commercial banks' loan loss provision adequacy ratio (LLPAR) as a proxy variable for their profitability sustainability. We incorporate LLPAR and its interaction term with ESG, M2 (ESG×LLPAR), into model (1). The regression results are shown in column (2) of Table 8.The coefficient of the interaction term between ESG and LLPAR is -0.0748, which is significant at the 5% level. This indicates that interest income positively moderates the enhancing effect of ESG on commercial banks' risk-taking capacity. Moreover, the coefficient of ESG is -0.0072, which is significant at the 5% level, confirming that the higher the interest income level, the stronger the risk-taking capacity of banks.Variable M2 has a significant strengthening or promoting effect on the relationship between ESG and LDA.

In light of the above, this study empirically reveals the positive moderating effects of capital accumulation rate and loan loss provision adequacy ratio in the process of ESG enhancing commercial banks' risk-taking capacity. These findings further enrich the research on the impact of ESG on bank risk-taking and provide some enlightenment for commercial banks to strengthen ESG construction, optimize capital and income structures, and balance social responsibility with their own development under the new situation.

Table 8.Adjustment Effect Analysis

Variables	LDA	LDA
ESG	-0.0077**	-0.0072**
	(0.0036)	(0.0035)
LLPAR	0.0062**	
	(0.0036)	
M1	-0.0053***	
	(0.0041)	
CAR		-0.0250**
		(0.0112)
M2		-0.0748**

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		(0.0363)
TA	0.0979***	0.1018***
	(0.0078)	(0.0078)
D/A	-0.2928	-0.2248
	(0.1917)	(0.1918)
SGR	-0.2049**	-0.1269
	(0.0798)	(0.0815)
BIPI	0.0008***	0.0008***
	(0.0003)	(0.0003)
ICI	0.0000*	0.0000*
	(0.0000)	(0.0000)
Constant	-0.7142***	-0.8168***
	(0.1739)	(0.1708)
N	832	832
R-sq	0.736	0.737

Note: Standard errors are reported in parentheses. ***, **, and * significant at 1%, 5%, and 10%, respectively.

6 Conclusion

This study investigates the impact of Chinese listed commercial banks' ESG performance on their risk-taking capacity and its underlying mechanisms using panel data from the first quarter of 2009 to the fourth quarter of 2023. The empirical results show that Chinese commercial banks' ESG performance can significantly enhance their risk-taking capacity, and this conclusion remains valid after addressing endogeneity issues and conducting robustness tests. Further mechanism tests reveal that ESG performance affects risk-taking capacity through two pathways: increasing return on assets and promoting the business diversification of commercial banks. It is worth noting that the impact of the three dimensions of ESG (environmental, social, and governance) on risk-taking capacity varies significantly, with the improvement in governance performance having the most significant effect.

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Moreover, the positive impact of ESG performance on risk-taking capacity is more prominent in banks with higher capital adequacy ratios and loan loss provision adequacy ratio.

In summary, the banking industry should attach great importance to ESG investment management and actively carry out ESG risk screening to improve risk response and undertaking capabilities. At the same time, banks should strive to internalize ESG concepts into their business management by strengthening ESG investment, enhancing reputation, reducing non-systemic risks, and promoting high-quality economic development with superior ESG financial services. Furthermore, banks should also start from the three dimensions of environment, social, and governance to further strengthen ESG management and achieve sustainable development while balancing ESG performance and risk-taking.

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