

Article

The Effect of ESG Performance on Bank Liquidity Risk

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Abstract: In recent years, investors have increasingly focused on the environmental, social, and governance (ESG) performance of businesses, driven by the rising importance of social and environmental challenges. This trend highlights the critical role of ESG factors in the financial sector. This study leverages stakeholder theory, risk management theory, and ESG investment theory, utilising financial data and ESG scores from Chinese listed banks to comprehensively analyse ESG elements and examine their impact on the liquidity risk of commercial banks. The results show that: (1) Enhanced ESG performance can mitigate liquidity risk in commercial banks by reducing the proportion of non-performing loans and improving overall financial performance. (2) By standardising and implementing sustainable business practices, ESG elements can improve commercial banks' liquidity management levels and lessen the incidence and effects of liquidity risk. As a result, it is critical to lower banks' liquidity risk and support the long-term growth of commercial banks from five angles: information disclosure, differentiated reform, digital transformation, education and training, and international cooperation.

Keywords: ESG performance; liquidity risk; sustainable finance; financial performance



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1. Introduction

ESG (environmental, social, and governance) was first formally proposed in January 2004 in the “Who Cares Wins” report as an initiative to incorporate ESG factors into the capital market. This initiative clarified the meaning of “ESG” for the first time. The report calls on financial institutions to integrate ESG factors into the operation of the capital market [1]. At the same time, companies need to disclose their ESG performance according to the needs of investors [2]. In terms of the environmental, corporations must consider the environmental impact of their operations, including energy use, waste treatment, pollution emission, natural resource protection, and climate change [2]. In terms of the social, the focus lies on the connections between the company and its workforce, suppliers, customers, and the local community. This encompasses issues like employee rights, occupational health and safety, diversity and inclusion, human rights, community engagement, and supply chain management. In terms of governance, this mainly focuses on the leadership structure and behaviour of the company, including board structure, executive compensation, audit process, shareholder rights, transparency, and fair transaction. In order to attract investors, companies must optimise their performance in three areas: environmental, social, and governance (ESG). It is believed that this approach will significantly impact the world and create a win–win situation for all parties involved [3].

ESG factors have aroused widespread concern and discussion. Especially in recent years, environmental and social issues have become increasingly prominent, and investors have paid more attention to the ESG performance of enterprises [4]. Twenty-six stock exchanges around the world have mandated the disclosure of ESG information. The “Guidelines for Investor Relations Management of Listed Companies” issued by the China Securities Regulatory Commission on 15 April 2022, identified “corporate environmental

protection, social responsibility, and corporate governance information” as the primary communication content that listed companies should focus on when engaging with investors [5]. Listed companies were mandated to provide explanations on ESG matters to investors. With the advancement of the dual-carbon goals of various countries, the importance of ESG factors will be more widely accepted and developed into a universal investment concept. At the same time, as a metric, ESG aligns with the currently popular concept of sustainable development internationally. Poor ESG performance can lead to financial risks, such as credit, market, operational, liquidity, and financing risks [6], undermining the stability of the financial system and potentially leading to systemic consequences.

Commercial banks encounter liquidity risk, posing a substantial challenge to their operations. The 2008 subprime mortgage crisis laid bare the disastrous effects of liquidity risk. After the crisis, issues such as macroeconomic policy imbalances and the lack of financial regulation prompted reflection. Effectively preventing liquidity risk has since become a focal point for the global banking industry. Liquidity risk refers to the risk that commercial banks cannot meet the depositors’ and borrowers’ short-term funding needs, resulting in fund loss and increased liquidity pressure [7]. Currently, commercial banks face two main types of liquidity risk: capital liquidity risk and market liquidity risk. Capital liquidity risk occurs when commercial banks cannot raise enough funds on time to meet the increased demand or insufficient supply of funds in the short term. Capital liquidity risk often arises from improper capital management or changes in the external environment that create a mismatch between capital supply and demand. For example, residents may withdraw funds during an economic downturn, and if commercial banks have slow capital turnover, liquidity risk will increase. Market liquidity risk refers to the risk of commercial banks facing imbalances between buyers and sellers in financial market transactions, resulting in the inability to complete transactions or obtain sufficient market liquidity. Market liquidity risk can stem from changes in supply and demand in the financial market or market participants’ panic about risk. Insufficient market liquidity may prevent commercial banks from selling assets or raising funds in a timely manner, further increasing their liquidity risk. The Basel Accord III, published in 2013, includes detailed provisions and requirements for bank liquidity risk. Banks are required to maintain a sufficiently high liquidity coverage rate to ensure they have enough high-quality liquid assets, such as cash, central bank reserves, and marketable securities, to meet their committed cash outflows and potential cash outflows within 30 days during severe short-term stress [8]. Additionally, banks must establish a robust risk management and supervision system, including conducting liquidity risk stress tests, regularly reporting liquidity risk status to supervisory agencies, and developing emergency liquidity plans.

Since the adoption of the “United Nations 2030 Agenda for Sustainable Development”, scholars and regulatory authorities around the world have increasingly acknowledged the significant connection between commercial banks’ lending and investment activities and the Earth’s climate and environment. Measures need to be implemented to decrease funding for projects that have a negative impact on the environment. ESG has become an essential consideration in the financial sector [9]. From a time dimension perspective, banks can achieve a fusion of short-term profits and long-term sustainable development by recognising the importance of ESG and fully considering ESG factors in their lending and investment decisions. On the other hand, if commercial banks prioritise profit over ESG factors in their investment and financing decisions, they could face legal and public backlash for overlooking environmental protection, social ethics, and corporate governance. This could severely negatively impact their performance, reputation, and financial condition. And because most customers have limited financial expertise, reputation and public trust are crucial for commercial banks. Poor ESG ratings can lead to public dissatisfaction and controversy, dragging the bank into the centre of public opinion and causing negative financial consequences, thereby exacerbating liquidity risk [10]. A bank’s ESG rating is influenced by both its own ESG factors and those of its business clients [11]. If clients are penalised for poor ESG performance, the banks providing loans to them face significant

risk, including the potential for loans to become unrecoverable, which in turn decreases the bank's liquidity.

ESG elements greatly influence the liquidity risk faced by commercial banks. Good ESG performance can reduce liquidity risk and improve liquidity management. Hence, it is crucial to enhance the oversight of ESG factors at both the managerial and regulatory levels. Introducing ESG indicators as a measure of liquidity risk can promote the sustainable development and sound operation of commercial banks. Additionally, commercial banks should prioritise the management and practice of ESG to minimise liquidity risk and their impact on banking operations. This study employs stakeholder theory, risk management theory, and ESG investment theory; selecting 41 banks listed on the Shanghai Stock Exchange in China. It analyses the direct impact of ESG factors on the liquidity risk of these listed banks and conducts robustness tests and endogeneity tests. The bank loan-to-deposit ratio and the Huazheng ESG score were chosen as endogenous variables to analyse the impact of ESG factors on the liquidity risk of listed banks in China. It then proposes optimised suggestions for promoting the sustainable development of commercial banks in taking on social responsibilities. This paper's marginal contributions and innovations include: (1) Integrating corporate social responsibility into the assessment indicators of commercial banks, breaking away from traditional banks' sole pursuit of economic benefits. (2) Innovatively deconstructing the ESG indicators into separate discussions of E, S, and G, and examining their distinct impacts on liquidity risk. (3) Combining the non-performing loan ratio and return on investment indicators fully validates their mediating role in the process of ESG influencing the liquidity risk of commercial banks, enriching the study of the impact mechanisms of existing financial indicators.

The structure of this article is arranged as follows: Section 1, Introduction, which discusses the relevant background of this study and the significant role of ESG as a crucial indicator for sustainable development in the current financial industry. Section 2, Theoretical Foundations and Literature Review, introduces stakeholder theory, risk management theory, and ESG investment theory related to this paper. It also reviews research on ESG, bank liquidity risk, and the impact of ESG on bank liquidity risk, summarising existing shortcomings. Section 3, Theoretical Analysis and Research Hypothesis, which builds on previous studies to further analyse and propose the research hypotheses of this paper. Section 4, Research Design and Research Data, explains this study's data sources and variables. Section 5, Empirical Results and Analysis, analyses the direct impact of ESG factors on the liquidity risk of listed banks in China and conducts robustness tests and endogeneity tests. Section 6, Research Findings and Implications, highlights the conclusions drawn from the research and offers policy recommendations. Section 7, Limitations and Future Direction, points out the deficiencies of this study and suggests future research directions.

2. Theoretical Foundations and Literature Review

2.1. Theoretical Foundations

2.1.1. Stakeholder Theory

Freeman (1984) [12] proposed stakeholder theory, stating that corporate governance should not solely focus on the shareholders' interests but should comprehensively balance the collective interests of all individuals closely related to the company's actions (i.e., stakeholders). When planning activities, companies should not only use their financial performance as the evaluation standard but should also critically examine the social effects these activities bring to society as a whole, thus achieving a shift from shareholder-centric to stakeholder-centric governance. Corporate managers should strive to balance the interests of all stakeholders, based on a thorough understanding of all those closely related to corporate activities, to reduce the risk levels borne by management. When making decisions and governing, financial institutions should fully consider the comprehensive interests of stakeholders rather than focusing solely on shareholders, which can enhance their reputation and competitive advantage. Broadly, stakeholders refers to individuals or groups whose actions and interests affect or are affected by a specific company and are

closely related to the company's actions. Subsequently, scholars provided a more specific definition: stakeholders are the main legitimate individuals or groups whose interests are affected by corporate actions. Stakeholders can be categorised into internal, external, and distal stakeholders. Internal stakeholders refer to individuals or groups within the company whose interests are directly related to corporate actions, specifically including the company's employees, managers, and board members. External stakeholders are those not within the company but are directly affected by corporate actions, including the company's suppliers, creditors, debtors, and shareholders [13]. Distal stakeholders are those not within the company but are indirectly affected by corporate actions, including the company's competitors, consumers, and community residents.

The ESG mechanism fully considers the interests of other stakeholders. Enhancing ESG governance in commercial banks is a behaviour that balances the interests of all parties and enhances their sustainability, significantly improving their reputation. The good reputation commercial banks gain by practising ESG principles sends a positive signal to stakeholders about their performance in environmental protection, social responsibility, and corporate governance [14]. As a result, stakeholders associated with commercial banks, upon receiving this signal, are more likely to increase their investment in these banks, reducing the likelihood of the banks falling into financial distress.

2.1.2. Risk Management Theory

According to risk management theory, risk can be defined as any potential negative deviation from expected results caused by uncertainty. The risk management process includes identifying, assessing, quantifying, responding to, and monitoring and reporting on risks. During the risk identification stage, businesses must determine all types of risks they might face, which may come from market, credit, liquidity, operational, compliance, strategic, and reputational aspects [15]. Risk management is indispensable to corporate governance and should be integrated with the overall corporate strategy. It supports a multi-level and cross-functional approach, requiring the involvement of management, the board of directors, and other stakeholders in the risk management process. Financial institutions especially need effective risk management because they often face complex and volatile financial markets and stringent regulatory requirements. Commercial banks and other financial institutions typically implement enterprise risk management (ERM) to meet regulatory requirements, optimise capital use, enhance market confidence, and ensure robust financial performance and long-term sustainability.

In recent years, with the rise of environmental, social, and governance (ESG) standards, ESG factors are seen as key variables affecting a company's long-term risk and value. As part of risk management, financial institutions are beginning to incorporate ESG assessments to identify and quantify environmental, social, and governance risks and to evaluate the impact of these risks on the company's long-term sustainability [16]. This indicates a shift in risk management from traditional financial and operational risks to comprehensive risk management that includes non-financial risks.

2.1.3. ESG Investment Theory

In 2004, the United Nations teamed up with 20 global financial institutions to release "Who Cares Wins", introducing the "ESG" (environment, social, governance) concept for investment evaluation. Originating from early 20th-century ethical church investing, ESG principles have evolved over time into a sophisticated, regulated investment philosophy with significant growth in managed assets. Today, ESG investing has transitioned from a niche to a mainstream practice, profoundly influencing corporate strategy, capital market stability, and sustainable societal and environmental development.

As classified by the Global Sustainable Investment Alliance (GSIA), ESG investing encompasses five key strategies: screening, ESG integration, thematic investing, stewardship, and impact investing [17]. (1) Screening: This strategy involves the selection of investments that are permissible within a portfolio based on specific criteria. It is ap-

plied to achieve various goals such as maintaining an investment focus, adhering to legal and regulatory requirements, meeting investor preferences, and mitigating risk. (2) ESG integration: This approach entails the collection and assessment of ESG information to determine its materiality, subsequently incorporating relevant data into investment analysis and decisions. (3) Thematic investing: This strategy involves the creation of a portfolio composed of assets selected through a top-down approach, targeting those expected to benefit from particular medium-to-long-term trends. (4) Stewardship: Investment agencies leverage their control over clients' assets to accumulate essential rights and influence. This management is aimed at safeguarding and promoting the interests of clients and beneficiaries. (5) Impact investing: The objective of this strategy is to generate positive outcomes, such as improvements in social and environmental conditions, while also achieving financial returns. The 2022 GSIA report indicates that \$30.3 trillion is globally allocated to sustainable investing assets. The leading sustainable investment strategy worldwide is corporate engagement and shareholder action, followed by ESG integration, and negative or exclusionary screening [18].

Through ESG investing, companies can improve their performance in terms of environmental, social, and governance aspects, achieving long-term financial success and stability. A report jointly released by Oxford University and Arabesque Asset Management in 2015 (Clark et al., 2015) [19] indicated that 90% of past research showed good ESG performance helps reduce corporate financing costs; 88% of the research found a positive correlation between ESG performance and corporate profitability; and 80% of the research indicated a positive correlation between ESG performance and stock prices. Traditional investment theories tend to focus on a company's financial health and expected returns, while ESG investment theory expands this focus to a broader range. Companies with strong ESG performance often experience higher market valuation and investment returns while also reducing the risks they face [20]. Investors are increasingly aware of the importance of these factors and are incorporating this understanding into their investment decisions. This trend indicates that investors are concerned not only with short-term profits but also with whether a company can maintain sustainable development in the long term.

2.2. Literature Review

2.2.1. ESG Research Review

In 2004, the United Nations Environment Programme first introduced the concept of ESG, which stands for environmental, social, and governance. ESG refers to matters related to environmental protection, social responsibility, or corporate governance that may positively or negatively impact the financial performance or solvency of an entity, sovereign, or individual. ESG factors can affect financial institutions through both external and internal channels. Externally, the impact of ESG factors, such as climate change, can lead to direct physical effects on financial institutions. Internally, ESG factors can impact institutions' financial situation by influencing their core business activities.

ESG ratings are evaluations conducted by third-party rating agencies based on a company's performance in three areas: environmental protection, social responsibility, and corporate governance [21]. These ratings are important indicators of a company's ability to sustain long-term development. Companies with high ESG ratings perform well in environmental protection, social responsibility, and corporate governance. Through ESG ratings, investors can assess a company's performance in these areas and gain a more comprehensive and in-depth understanding of its sustainability.

Currently, ESG rating performance has become an important measure of a company's sustainability level. It has been incorporated into the capital market's information disclosure requirements in over thirty countries and regions [22]. Although there are many ESG rating systems internationally, a unified standard has not yet been established, and existing ESG rating systems still need improvement. Many ESG rating indices focus on the environmental (E) and social responsibility (S) dimensions, with relatively few metrics for assessing the corporate governance (G) dimension [23].

Numerous institutions and scholars, both domestically and internationally, have conducted extensive discussions on the establishment and consideration factors of ESG rating indices. The European Banking Authority has detailed and comprehensively screened and defined the ESG factors for companies [11]. Chinese scholars Chao Qun and Xu Qian (2019) [22] proposed relevant indicators for measuring corporate ESG performance from the perspectives of financial institutions and their service objects, considering the three aspects of environment, society, and corporate governance. Currently, the more popular international ESG rating indices include the MSCI ESG Rating Index, Bloomberg ESG Rating Index, and FTSE Russell ESG Rating Index. In China, commonly used indices include the China Securities ESG Rating Index, Bloomberg ESG Rating Index, and Wind ESG Rating Index.

2.2.2. Bank Liquidity Research Review

In the operation of commercial banks, liquidity is determined by the ability of a bank to acquire incremental funding liabilities to meet asset increases or repay debts; that is to say, a commercial bank's solvency is generally determined by the ratio of its assets to liabilities. Liquidity determines the repayment ability of a bank's asset structure within a given term. Therefore, to ensure that commercial banks have a stable repayment capacity and to maintain the safety of the financial system, it is necessary to control liquidity risk. However, as financial intermediaries, banks inherently face liquidity risk [24]. The identification and supervision of commercial bank liquidity risk are closely related to the adjustment of supervisory concepts; different supervisory concepts mean different regulatory standards, which also pose new requirements for the identification of commercial bank liquidity risk. From the perspective of the Basel Accords, the requirements of liquidity risk management have evolved from merely emphasising capital adequacy in the first Basel Accord of 1975 to enhancing comprehensive risk management constraints with Basel III in 2013. Theoretically, research on liquidity risk identification is mainly conducted from two aspects: one starts with the concept of liquidity risk in commercial banks, distinguishing different types of liquidity risks and identifying them through specific indicators; the other involves evaluating liquidity risks based on certain specific indicators. In China, since 2014, commercial banks have been using liquidity coverage ratios, liquidity ratios, loan-to-deposit ratios, etc., as indicators to regulate liquidity risk. Additionally, scholars worldwide hold various views on the identification of bank liquidity risk. Aspachs et al. (2005) [25] explored internal and external factors affecting the liquidity risk of British banks, finding that maintaining high levels of liquidity reduces the likelihood of central bank support, thus making such support a crucial basis for identifying commercial bank liquidity risk. Gao Bo and Ren Ruo'en (2015) [26] discovered from the liquidity of the loan and repurchase markets that the liquidity of these two markets can predict the systemic liquidity risk level of commercial banks to a certain extent, while Gao Jiawei (2018) [27] found that the stability of deposits can reflect the level of liquidity risk.

2.2.3. Research on the Impact of ESG on Banks' Liquidity Risk Assessment

From a financial performance perspective, most studies suggest that a high ESG (environmental, social, and governance) rating significantly enhances a bank's financial performance by increasing stakeholder satisfaction [28–30]. Wu and Shen (2013) [31] indicate that strategic choice is the main motivation for banks to fulfil corporate social responsibility and improve ESG ratings. This approach helps reduce information asymmetry with stakeholders, garner social respect, and consequently boost financial performance.

From a profitability perspective, improving a bank's ESG rating can significantly and positively impact the profitability of commercial banks by enhancing their reputation. Wang Zhongrun et al. (2023) [32] analysed 180 Chinese commercial banks and found that issuing green bonds significantly enhances the profitability of these banks. However, some scholars argue, from the "cost effect" theory, that improving ESG ratings may decrease a bank's profitability by reducing resource allocation efficiency [33].

From a risk-taking perspective, higher ESG ratings can significantly reduce the risk-taking behaviour of commercial banks. Galletta and Mazzù (2023) [34], using data from 35 countries, empirically studied the relationship between ESG ratings and bank operational risk, finding that banks with higher ESG ratings have lower operational risks. Goss and Roberts (2011) [35] believe that by fully considering environmental sustainability factors when issuing credit, banks can mitigate adverse selection and moral hazard issues, thereby reducing bad loan rates and lowering overall risk levels. Gangi et al. (2018) [36], using data from 142 banks, examined the link between corporate governance, environmental engagement, and banks' risk-taking levels measured by the Z-score. Their study found that environmentally friendly banks have lower risk levels, supporting the stakeholder perspective.

3. Theoretical Analysis and Research Hypothesis

Being among the most important financial institutions, banks have long been plagued by liquidity issues that trouble regulatory authorities. In the operation of commercial banks, liquidity is determined by a bank's ability to obtain incremental fund liabilities to meet asset growth or to repay debts, generally determined by the ratio of deposits to loans. Liquidity determines the repayment ability of a bank's asset structure within a certain period. Therefore, to ensure commercial banks have a stable repayment capacity and maintain the safety of the financial system, it is necessary to control the liquidity risk of commercial banks.

Due to the growing interest of the financial sector in the concept and practice of ESG, research perspectives on the economic impact of ESG ratings have gradually shifted to financial institutions, particularly the impact of ESG ratings on the risk of commercial banks. Based on the existing literature, risk management theory, and stakeholder theory, the impact of ESG on a bank's liquidity risk is mainly reflected in the following aspects:

Reducing individual risk sensitivity. Risk management theory posits that risk can be defined as any potential negative deviation from expected outcomes caused by uncertainty. At the risk-taking level, an improved ESG rating can significantly reduce the risk-taking of commercial banks [37]. Studies have found that an improved ESG rating can significantly reduce the operational risk, default risk, and portfolio risk of commercial banks. Commercial banks with higher ESG ratings fully consider sustainable development factors when issuing credit, reducing the proportion of high-risk enterprises in the credit business [38] and thereby minimising investment losses due to regulatory actions against related enterprise projects. Research by Gangi et al. (2018) [36], using data from 142 banks, with the connection between corporate governance and environmental engagement as a proxy for banks' practice of corporate social responsibility, and using the Z-score to measure the level of risk assumed by banks themselves, found that environmentally friendly banks have lower individual risk sensitivity.

Reasonably control risk elasticity. Research worldwide generally believes that high ESG ratings can significantly improve a bank's financial performance by enhancing stakeholder satisfaction [39–41]. This improved financial performance can bolster a bank's ability to withstand liquidity pressures. Studies also found that the issuance of green bonds by commercial banks significantly enhances the profitability of Chinese commercial banks [33]. From the perspective of stakeholder theory, this may be due to fulfilling social responsibility by issuing green bonds, enhancing a bank's attractiveness and loyalty through reputation effects, and increasing customers' trust and satisfaction with bank services [31]. This leads to a more stable deposit base and other business income, thereby reasonably controlling risk elasticity.

Based on the above analysis, this paper proposes Hypothesis H1.

H1: *ESG performance can significantly reduce the liquidity risk of commercial banks.*

Compared to non-state-owned banks, state-owned banks usually have better asset quality and larger scale, which gives them stronger resistance to market fluctuations. This enables state-owned banks to reduce their liquidity risk [42]. At the same time, state-owned banks are subject to stronger government regulation, facing more robust external resilience-based risk regulation. This also makes them stricter in implementing ESG policies. To date, many large state-owned commercial banks have integrated environmental and climate risk into their comprehensive risk management systems, incorporated ESG into the credit business risk management framework using financial technology, actively promoted the development strategy of green finance, and have a complete ESG governance structure. Six state-owned commercial banks have successively released special plans for green finance. By the end of 2022, total green loans had reached 12.55 trillion yuan, elevating the strategy of green finance to a higher level. This has further reduced the individual risk sensitivity for state-owned banks in implementing ESG policies [43].

In comparison, non-state-owned banks are smaller in scale, and their asset quality and risk management capabilities cannot match those of state-owned banks [44]. They have a higher sensitivity to individual risk and, due to less government regulation, they face less external resilience-based risk regulation. Compared with state-owned banks, non-state-owned banks started their ESG development later and have a lower comprehensive level. Still, they are also actively promoting the coordinated development of green finance and inclusive finance under government guidance. An increasing number of local banks are focusing on green finance as a key part of their development, actively practising the concept of sustainable development and striving to improve their ESG construction.

In this case, the ESG score of non-state-owned banks is particularly important. If a non-state-owned bank has a high ESG rating, it may attract more investors, thereby increasing the liquidity of its assets. The reputation enhancement effect of conducting ESG activities becomes even more significant. Conversely, if its ESG score is low, investors may doubt it, affecting risk identification and loan business.

Based on the above analysis, this paper proposes Hypothesis H2.

H2: *The impact of ESG performance on the liquidity risk of commercial banks varies with property rights.*

This article selects the non-performing loan ratio (NPL) as an intermediary variable. The non-performing loan ratio measures the proportion of non-performing loans in the total loan assets of commercial banks. A loan is considered non-performing if it cannot be recovered within a certain period (usually 90 days) or if it cannot be recovered in accordance with the contractual principal and interest. The higher the non-performing loan ratio, the higher the bank's default risk. The non-performing loan ratio is an important ex-post indicator that measures a bank's risk-bearing capacity. By fully considering the sustainable development of the environment when granting credit, banks can reduce adverse selection and moral hazard issues they face, thereby reducing the bank's risk level by reducing the non-performing loan ratio [36]. Banks with higher ESG ratings also shift more of their credit business to enterprise projects related to the green economy and supported by government departments, further enhancing the safety of their investments and reducing their own risk exposure.

This article selects return on assets (ROA) as the intermediary variable, measuring the profitability of commercial banks. Return on assets (ROA) is the ratio of a commercial bank's net profit to its total assets, with a higher ROA indicating stronger profitability for the bank [45]. Companies with good ESG performance are usually able to achieve better financial performance. Good financial performance can increase an enterprise's credit rating, thereby reducing its bonds' interest rate and financial costs. At the same time, good financial performance can also improve enterprises' profitability, thereby increasing their stock's attractiveness and improving their liquidity [46].

Hence, robust ESG performance can significantly mitigate the liquidity risk faced by commercial banks by decreasing the non-performing loan ratio and enhancing overall financial performance. Such improvements contribute to the stable functioning of the bank and bolster its competitiveness within the financial market, thereby reinforcing its appeal to investors.

Based on the above analysis, this paper proposes Hypothesis H3.

H3: *ESG performance can reduce the liquidity risk of commercial banks by cutting down the non-performing loans and improving financial performance.*

The article selects the digital transformation index as a moderating variable. The digital transformation index of Peking University measures three aspects of banks: strategic digitalisation, business digitalisation, and management digitalisation [46]. Strategic digitalisation focuses on how banks integrate digital technology into their long-term development planning; business digitalisation concentrates on how banks use digital tools to improve efficiency and service quality in daily operations; and management digitalisation refers to using digital tools to optimise internal management and decision-making processes.

From the perspective of factor allocation, digital technologies can accelerate the dynamic distribution of core resources such as capital, labour, and information in banking services. Specifically:

In terms of capital allocation, digital tools and platforms can enable more precise asset and liability management, optimising the bank's capital adequacy ratio and capital efficiency [47]. For example, by using advanced data analysis and machine learning models, banks can more accurately predict loan default rates and investment risk, thereby optimising the allocation and utilisation of capital in situations of lower risk.

In terms of labour allocation, through automation and artificial intelligence technologies, banks can reduce reliance on traditional manual processing and improve staff work efficiency [48]. For instance, an automated credit approval process can quickly complete the review of loan applications, freeing up loan officers' time to deal with more complex issues, thus enhancing overall labour productivity.

In terms of information processing, digital transformation greatly accelerates the speed of information collection, processing, and analysis, enabling banks to use real-time data in decision-making processes. This not only improves the accuracy of data-driven decisions, helps banks reduce manual input errors, and enhances compliance checks in areas such as anti-money laundering and customer identity verification through preset rules and models but also strengthens the prediction of market trends, aiding banks in timely strategy adjustments to respond to market changes [49].

From the perspective of information sharing, digital transformation, by enhancing the transparency and accessibility of information, has significantly improved the problem of information asymmetry, which is basically consistent with the stakeholder theory principles mentioned earlier. Under traditional models, information asymmetry often leads to misjudgements in credit decisions and risk accumulation. Digital technologies such as big data analysis and blockchain can ensure the real-time updating and accuracy of information; banks can monitor changes in credit and market dynamics of loan subjects in real-time, providing early warning of potential risks [50]. Furthermore, digitalisation enables banks to provide more personalised services, better meet customer needs, further improve customer satisfaction, and enhance the competitiveness of the bank.

Based on the above analysis, this paper proposes Hypothesis H4.

H4: *Level of digital transformation has a moderating effect between ESG performance and liquidity level of commercial banks.*

4. Research Design and Research Data

4.1. Sample Selection and Data Sources

This article selects 54 banks listed on the Shanghai Stock Exchange in China as of 2023 as the research sample. This study concentrates on 41 publicly listed banks, having excluded those lacking ESG-related data. The financial metrics of these commercial banks are assessed using data obtained from the Wind database. The Digital Transformation Index of banks is obtained from the Digital Finance Research Center of Peking University. Regarding ESG scoring, the China Securities ESG Rating Index uses a nine-level “AAA-C” rating to rate banks’ overall ESG level and the sub-levels of environment E, social responsibility S, and corporate governance G. The better the bank’s performance in environmental protection, social responsibility, and corporate governance, the higher its ESG rating. The data cover all listed companies in China’s A-shares, with a time span from 2009 to 2022, covering a wider range and complete data. Therefore, this article uses the ESG score from China Securities. Considering the impact of data outliers, this study conducted tail-trimming at the 1% level on all sample data, obtaining a total of 285 valid data points.

4.2. Variable Selection

4.2.1. Dependent Variable: Loan-to-Deposit Ratio (LTD)

According to prior research, credit maintenance fees serve as a crucial indicator for assessing bank liquidity risk [51]. Therefore, the loan-to-deposit ratio was chosen as the explanatory variable. A high reserve ratio means that the credit balance is significantly higher than the deposit balance, which may indicate that banks are overly focused on financing capital transactions and may entail short-term risks. If customers execute substantial withdrawals upon maturity, the bank may face challenges in meeting this cash demand, consequently elevating the liquidity risk.

4.2.2. Core Explanatory Variable: HZESG

This paper uses the Huazheng ESG rating index as the core explanatory variable to measure banks’ environmental protection, social responsibility, and corporate governance performance. The Huazheng ESG rating index is developed by referencing mainstream foreign ESG rating systems and incorporating the local characteristics of China’s financial market, providing a comprehensive rating of the ESG levels for all listed companies in China. It also conducts sub-item assessments of the ESG levels of listed companies across three dimensions: environmental protection, social responsibility, and corporate governance. The Huazheng ESG rating covers all listed companies and can be traced back to the first quarter of 2009, making the data both timely and representative. The Huazheng ESG rating index rates banks’ overall ESG levels and their sub-item levels in environmental (E), social responsibility (S), and corporate governance (G) on a nine-point scale from “AAA” to “C”. This paper converts the “AAA-C” nine-point scale into a nine-point system, where banks with better performance in environmental protection, social responsibility, and corporate governance score higher.

Convert the converted results to logarithmic format to remove the unit influence of the results and maintain multiple data relationships. This procedure aligns with the assumptions inherent in statistical models.

4.2.3. Intermediary Variables: Non-Performing Loan Ratio (npl), Profitability (ROA)

This article refers to the research by Pan et al. (2022) [52] and selects the non-performing loan ratio (NPL) as a mediating variable. The non-performing loan ratio is equal to the total amount of non-performing loans divided by the total amount of loans, where non-performing loans mainly include three categories: substandard loans, doubtful loans, and loss loans. The non-performing loan ratio is an important ex-post indicator that measures the risk-bearing capacity of banks; the higher the ratio, the greater the default risk of the bank. As can be deduced from the previous analysis, the ESG rating primarily affects the default probability of Chinese commercial banks, thereby changing the level of

risk undertaken by these banks. Therefore, this article chooses the non-performing loan ratio as a mediating variable to reflect the banks' risk bearing.

Revenue is usually measured with a corporate asset return rate (ROA) that reflects the ability to generate profits. The higher the ROA, the higher the profitability of firms because it can directly reflect the economic effects of business. The ROA helps to assess the impact of ESG ratings on corporate profitability and the relationship between management efficiency and bank liquidity risk.

4.2.4. Moderating Variable: Peking University Bank Digital Transformation Index (PKUDBI)

This article refers to the study by Xie et al. (2023) [53] and selects the digitalisation level of banks as a moderating variable. As can be deduced from the previous analysis, the digitalisation level of banks can affect the banks' performance in operations, management, risk control, and other aspects, which may, in turn, affect the liquidity risk of banks. This paper uses the digital transformation index as a moderating variable, which helps to control other factors that may affect the research results. It focuses on exploring the relationship between ESG factors and bank liquidity risk and the role of digital transformation in this process.

4.2.5. Control Variables

Moreover, previous research has identified numerous factors influencing banks' liquidity risk. In light of their relevance and availability in this study, the final control variables comprise:

Non-interest income ratio (NIR). Brunnermeier et al. (2012) [54] used a difference-in-differences approach to study the relationship between non-interest income and systemic risk in commercial banks, finding that an increase in the proportion of non-interest income increases the liquidity risk of commercial banks. Hidayat et al. (2012) [55], while examining the incentives and remuneration of bank risk and non-interest income controls among executives, discovered that increased non-interest income raises the operational risk of commercial banks.

Proportion of independent shareholders (INDEP). A higher proportion of independent shareholders usually implies better corporate governance, as independent shareholders can offer more objective supervision and decision-making [56]. This can enhance a bank's risk management, potentially reducing liquidity risk.

The share of the top 10 shareholders (TOP10). The proportion of the top ten shareholders indicates the concentration of top shareholders in bank shares. Hao et al. (2016) [57] studied the factors influencing the efficiency of 14 listed commercial in China, finding that a high concentration can mean greater shareholder influence, which may lead to bank operations favouring the interests of a few shareholders, potentially increasing operational risk and affecting their liquidity status.

Non-performing loan provision coverage ratio (PLLCR). The provision for loan loss coverage ratio is the ratio of the total provisions set up by a bank to cover possible loan losses to the total amount of non-performing loans. Sun Tianqi (2016) [58] analysed the non-performing loan provision coverage ratio of five listed banks in China and found that a higher coverage ratio suggests that a bank is well-prepared for potential loan losses and is usually seen as having a strong ability to withstand risk. Such banks are more robust in the face of sudden liquidity demands and have a lower liquidity risk.

Growth rate of bank's registered province GDP (PGDPG). The growth rate of provincial GDP reflects the health of the region's economy. Economic growth is often associated with increased credit demand, improved asset quality, and better income prospects, all of which can directly affect a bank's capital flows and liquidity situation, thereby reducing liquidity risk.

Consumer price index (CPI). CPI is a key indicator for measuring the inflation rate. High inflation can lead to interest rate rises, affecting the cost of a bank's liabilities (such as deposit rates) and leading to asset–liability mismatches, thereby increasing liquidity

risk. Furthermore, the payment capacity of consumers and businesses may decline in a high-inflation environment, further affecting the bank's liquidity.

All variables are presented in Table 1. The characteristic variables at the bank level include NIR, INDEP, and TOP10. The regulatory factor is the PLLCR. The macro-influencing factors are the CPI and PGDPG.

Table 1. Variable Explanation.

Variable Type	Indicator	Variable Symbol	Measurement Method
Explained variable	Loan-to-Deposit Ratio	LTD	Bank Loans/Bank Deposits
Core explanatory variable	Hua Zheng ESG Score	HZESG	Natural Logarithm After Conversion
Mediating Variables	Non-Performing Loan Ratio	NPL	Total Non-Performing Loans/Total Loans
	Profitability	ROA	End-of-Period Net Profit/End-of-Period Total Assets
Moderating Variable	Peking University Bank Digital Transformation Index	PKUDBI	Natural Logarithm of Peking University's Digital Inclusive Finance Index
Control Variables	Non-Interest Income Ratio	NIR	Non-interest Income/Total Income
	Proportion of Independent Shareholders	INDEP	Number of Independent Shareholders/Total Number of Company Shareholders
	The Share of the Top 10 Shareholders	TOP10	Number of Shares Held by the Top 10 Shareholders/Total Company Share Capital
	Non-Performing Loan Provision Coverage Ratio	PLLCR	Bank Provisions for Non-performing Loans/Total Non-performing Loans
	Growth Rate of Bank's Registered Province GDP	PGDPG	China National Bureau of Statistics
	Consumer Price Index	CPI	China National Bureau of Statistics

4.3. Model Building

This article primarily analyses the effect of ESG performance on banks' liquidity risk and selects ESG assessments published by the Huazheng ESG rating agency as core explanatory variables. The definition of Model (1) is as follows:

$$LTD_{it} = \alpha_0 + \alpha_1 hz ESG_{it} + \sum Controls + year_i + individual_t + \varepsilon_{it} \quad (1)$$

Within this context, the t specifically indicates the t -th year ($t = 2009\text{--}2022$), while i denotes the i -th bank ($i = 1\text{--}41$). To eliminate the dimensional disparities between different datasets, comparatively large values (absolute figures) are transformed using natural logarithms. In contrast, relative values, such as proportional or percentage data, remain unaltered. In Equation (1), the explained variable is represented by the bank's deposit-to-loan ratio. The explanatory variable consists of ESG data subjected to logarithmic transformation, while control variables are incorporated to account for other influencing factors within the model. The fixed impact of the year is represented by $year_i$. The fixed impact of the individual is represented by $individual_t$. It aims to control for change in variations across different years and individuals.

The α_1 coefficient in the Model (1) is predicted in this paper to be significantly negative, meaning that banks with better ESG performance have lower deposit-to-loan ratios. This suggests that banks which have better ESG performance tend to be more cautious and more focused on long-term sustainability, adhere to the fair lending principle, and refrain from over-issuing credit, which will lead to comparatively low loan and deposit levels.

This paper uses *npl* and *ROA* as intermediary variables of *hzesg*. Subsequently, four regression models are progressively developed to explore the intermediary mechanism of ESG factors on bank liquidity risk.

$$npl_{it} = \beta_0 + \beta_1 hzesg_{it} + \sum Controls + year_i + individual_t + \varepsilon_{it} \quad (2)$$

$$ROA_{it} = \gamma_0 + \gamma_1 hzesg_{it} + \sum Controls + year_i + individual_t + \varepsilon_{it} \quad (3)$$

$$LTD_{it} = \zeta_0 + \zeta_1 hzesg_{it} + \zeta_2 npl_{it} + \sum Controls + year_i + individual_t + \varepsilon_{it} \quad (4)$$

$$LTD_{it} = \kappa_0 + \kappa_1 hzesg_{it} + \kappa_2 ROA_{it} + \sum Controls + year_i + individual_t + \varepsilon_{it} \quad (5)$$

According to the prediction Model (1), the bank's liquidity risk can be considerably reduced by good ESG performance, as indicated by the significantly negative coefficient α_1 . Further, we predict that better ESG performance can lower the banks' *LTD* by lowering *npl* and raising *ROA*, as shown by the significantly negative coefficient β_1 of the Model (2) and the significantly positive coefficient γ_1 of the Model (3). The coefficients of κ_1 and κ_2 in the predictive Model (5) are significantly negative.

This study examines the moderating effect of digital transformation and ESG on the effect of ESG on the liquidity of commercial banks using the digital transformation index as a moderating variable. The moderating effect model is shown in (6).

$$LTD_{it} = \eta_0 + \eta_1 hzesg_{it} + \eta_2 pkudbi_{it} + \eta_3 pkudbi_{it} * hzesg_{it} + \sum Controls + year_i + individual_t + \varepsilon_{it} \quad (6)$$

5. Empirical Results and Analysis

5.1. Descriptive Statistics and Correlation Analysis

There are 285 valid samples in this experiment, and Table 2 gives descriptive statistical features. Descriptive statistics use the original data to make the data more logical and understandable. According to the results, the *LTD* ratios of the sample banks have significant differences. For the explained variable, the maximum and minimum values are 116.23 and 38.97, the average and standard deviation values are 77.032 and 12.956. Simultaneously, the skewness of *LTD* is 0.470, indicating most banks have a higher *LTD* ratio.

Table 2. Descriptive Statistics of Variables.

	Obs	Mean	Std. Dev.	Min	Max
hzesg	285	5.435	0.774	3	7
hzesg_e	285	3.424	1.149	1	7
hzesg_s	285	5.457	1.178	3	7
hzesg_g	285	6.917	0.806	1	9
ltd	285	77.032	12.956	38.97	116.23
npl	285	0.0338	0.172	0	1.78
pkudbi	285	95.634	40.201	3	184
roa	285	0.144	0.043	0.06	0.25
nir	285	23.419	8.696	5.82	51.09
coir	285	30.035	4.985	18.93	59.01
indep	285	0.369	0.048	0.1	0.56
top10	285	0.662	0.208	0.25	0.99
pllr	285	261.578	97.179	132.44	567.71
pggdpg	285	7.086	2.144	1.2	13.9
cpi	285	2.27	1.007	0.9	5.4

For the explanatory variable *hzesg*, the maximum and minimum values are 7 and 3, the average and standard deviation values are 5.435 and 0.774. The skewness of *hzesg* is -0.653 . This means the majority of banks have higher ESG scores, as seen by the greater number of values on the right side of the average.

The primary variables' Pearson correlation matrix is shown in Table 3. It is found that *hzesg* is negatively correlated with *nir* but significantly positively correlated with the INDEP and TOP10. They have good relevance and can proceed to the next step of regression.

Table 3. Correlations.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>hzesg</i>	1							
<i>nir</i>	−0.098 *	1						
<i>indep</i>	0.0460 ***	−0.0200	1					
<i>top10</i>	0.0240 ***	0.247 ***	0.154 ***	1				
<i>pllc</i>	0.180 **	−0.240 ***	−0.00300	−0.372 ***	1			
<i>pggdpg</i>	0.0210 ***	0.00500 **	0.00100 ***	0.0480 ***	0.00900 **	1		
<i>cpi</i>	0.0340	−0.0940	0.0570 *	0.00500	0.141 *	0.0360 **	1	
<i>pkudbi</i>	−0.289 ***	−0.111 ***	0.106 ***	0.195 **	−0.151 ***	0.065	0.187 **	1

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.2. Benchmark Regression and Sub-Item Regression Results

Based on the result of the Hausman test, a model incorporating individual and year-fixed effects is subsequently selected for the regression analysis. Table 4, Column (1) displays the regression findings without the addition of control variables, while Column (2) displays the results with control variables and year control. In addition, this study breaks down the primary explanatory variable into three distinct variables (environmental, social, and governance) for independent regression analysis. The results can be seen in columns (3), (4), and (5) of Table 3.

Table 4. Baseline Regression Results (1–2), Sub-item Regression Results (3–5).

	(1)	(2)	(3)	(4)	(5)
	<i>ltd</i>	<i>ltd</i>	<i>ltd</i>	<i>ltd</i>	<i>ltd</i>
<i>hzesg</i>	−0.363 *** (0.0504)	−0.174 *** (0.0350)			
<i>hzesg_e</i>			−0.0101 (0.00692)		
<i>hzesg_s</i>				0.0031 (0.0851)	
<i>hzesg_g</i>					−0.0314 ** (0.0826)
<i>nir</i>		0.151 *** (0.0345)	0.214 *** (0.0712)	0.204 *** (0.0693)	0.164 *** (0.0412)
<i>pllc</i>		−0.0154 *** (0.00317)	−0.0241 *** (0.00625)	−0.0193 *** (0.00753)	−0.0173 *** (0.00426)
<i>pggdpg</i>		−1.066 *** (0.114)	−1.142 *** (0.213)	−1.092 *** (0.186)	−1.126 *** (0.137)
<i>cpi</i>		0.0103 *** (0.000736)	0.0175 *** (0.00693)	0.0184 *** (0.000686)	0.0127 *** (0.00953)
<i>indep</i>		0.0950 ** (0.0468)	0.1160 ** (0.0528)	0.0974 ** (0.0496)	0.102 ** (0.0582)
<i>top10</i>		0.115 ** (0.0480)	0.162 ** (0.0620)	0.189 ** (0.0713)	0.093 ** (0.0341)
Constant	2.146 *** (0.0370)	1.965 *** (0.0469)	2.031 *** (0.0374)	2.215 *** (0.0362)	1.984 *** (0.0572)
Observations	285	285	285	285	285
Number of id	41	41	41	41	41
R-squared	0.176	0.680	0.413	0.420	0.610

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$.

The multiple regression result of Model (1) demonstrates that the model's adjusted R-squared is 0.68 when the year and individual effects are taken into account, meaning that the model's goodness of fit is 68% and the sample's estimation error is 32%. The p -value is less than 0.01, and the F-test value is 70.98. This indicates that the fixed-effect model is statistically significant. At the 1% significance level, the coefficient of the primary explanatory variable, ESG (hzesg), is -0.174 . This substantial negative impact validates H1 by indicating that ESG scores negatively impact LTD. This could be because commercial banks with high ESG scores have an easier time acquiring deposits, which lowers a bank's loan-to-deposit ratio index. The control variables nir, pllcr, pggdpg, cpi, indep, and top10 are all statistically significant. Of these, pllcr and pggdpg have a significant negative impact. The data indicate that the following factors have a significant positive impact: the nir, cpi, indep, and top10. This validates previous research and is consistent with the assumptions made when selecting variables in the preceding part of the text.

Meanwhile, the separate regression results of Model (1) show that the environmental rating E and social responsibility rating S do not significantly affect the liquidity of commercial banks. Improving the corporate governance rating G can significantly reduce the liquidity risk of commercial banks. The mitigating effect of improved ESG rating on the liquidity risk level of commercial banks is mainly driven by corporate governance. According to risk management theory, commercial banks with higher ratings in the G dimension, i.e., those with excellent performance in corporate governance, have stronger abilities to prevent and control risk and are less likely to encounter liquidity risk. The corporate governance of commercial banks mainly includes effective management, efficient and transparent decision-making processes, enhancing the diversity of the board of directors, and reducing corruption and bribery. Management and shareholders are key to implementing sustainable development concepts and strategies. Therefore, consistent with risk management theory, banks with higher governance ratings will earn a good reputation and gain recognition from the entire society and stakeholders. Moreover, banks with higher governance ratings have efficient governance models, which can reduce mistakes in daily operations and investment decisions, lower the likelihood of commercial banks facing risk, and reduce their liquidity risk levels.

5.3. Robustness Test

5.3.1. Endogenous Analysis

From the theoretical logic analysis, it can be seen that the impact of the ESG score on the liquidity risk of commercial banks is likely to be lagging. That is, there is a certain reverse causality. This will lead to a biased effect on the regression results. Therefore, in order to eliminate the possibility of this reverse causality, the core explanatory variables are lagged by one period in this study to try to solve the existing endogeneity problem. The results are listed in Table 5.

It can be seen from Table 4 that the results of hzesg lag for one period are still significant at the 1% level, indicating that the lag effect has not affected the main research results. The results of the benchmark regression have a certain degree of reliability. At the same time, this significance shows that the relationship between the ESG score and bank liquidity risk is significant and lasting. A bank's ESG score does have an important and credible negative correlation with its liquidity risk.

5.3.2. Eliminate the Influence of Extreme Values

The distribution of some data may have some extreme values or outliers that affect the stability of the model. Therefore, in order to eliminate the influence of outliers in this study, the explanatory variables and explanatory variables are truncated by 1%, and the possible regression biases are corrected by removing extreme values. The results are listed in Table 5.

Table 5. Lag Effect Test (1–2), Exception Handling (3–4).

	(1)	(2)	(3)	(4)
	Ltd	ltd	ltd	ltd
L.hzesg	−0.381 *** (0.0493)	−0.104 *** (0.0384)	−0.359 *** (0.0489)	−0.174 *** (0.0338)
nir		0.215 *** (0.0373)		0.159 *** (0.0334)
pllcr		−0.0187 *** (0.00339)		−0.0151 *** (0.00306)
pggdpg		−1.079 *** (0.138)		−1.030 *** (0.110)
cpi		0.00975 *** (0.000823)		0.0101 *** (0.000710)
indep		0.0825 (0.0508)		0.0677 (0.0455)
top10		0.0948 * (0.0532)		0.111 ** (0.0465)
Constant	2.167 *** (0.0362)	1.929 *** (0.0513)	2.144 *** (0.0359)	1.973 *** (0.0453)
Observations	244	244	285	285
R-squared	0.227	0.677	0.182	0.686
Number of id	37	37	41	41

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

It can be seen from Table 5 that the results are still significant after the tail reduction process, which shows that the estimation results of the benchmark regression model are not affected by extreme values or outliers and are stable and reliable. This also further confirms Hypothesis H1: ESG performance can significantly reduce the liquidity risk of commercial banks. This result will not change due to the existence of individual outliers in the data set. This provides reliable support for the research results of this article.

5.4. Heterogeneity Test

Due to the significant differences in the nature of commercial banks, their liquidity will also have a certain degree of heterogeneity due to different natures. Therefore, according to the nature of the bank, this article divides the sample into state-owned banks and non-state-owned banks and performs regression analysis and comparison in groups. The results are listed in Table 5. It can be seen from Table 6 that whether it is a state-owned or non-state-owned bank, the ESG score has a significant negative impact on the bank's liquidity risk. For state-owned banks, the coefficient of hzesg is −0.148, and the result is significant at the 10% significance level. For non-state-owned banks, the coefficient of hzesg is −0.410, and the result is significant at the 1% significance level. In comparison, the negative impact of ESG on the liquidity of non-state-owned banks is stronger than that of state-owned banks. The reason may be that the asset products of non-state-owned banks are more flexible and are often affected by the willingness and preference of financial investors and residents. The negative impact is obvious, while state-owned banks have stable asset scale and asset funding sources, and the stability is more obvious. The negative effect of ESG on them is lower. However, on the whole, the impact of the ESG score on the two types of banks is relatively insignificant, which is reflected in the correlation coefficient of less than 1 in the empirical results.

Table 6. Heterogeneity Test.

	State-Owned	Non-State-Owned
	ltd	ltd
hzesg	−0.148 * (0.0831)	−0.410 *** (0.0593)
CONTROL	Control	Control
Constant	1.973 *** (0.0609)	2.186 *** (0.0436)
Observations	63	222
R-squared	0.054	0.205
Number of id	6	35

Standard errors in parentheses. *** $p < 0.01$, * $p < 0.1$.

5.5. Mediating Effect Analysis

Based on the earlier analysis, the ESG score will improve financial performance and lower the non-performing loan ratio, which will affect commercial banks' liquidity. This research tests the intermediary mechanism of these two types of elements using the intermediary effect model in order to test H3. Regression analyses for models (2), (3), (4), and (5) will be conducted independently, and Table 7 displays the findings.

Table 7. Mediation Effect Analysis.

	(1)	(2)	(3)	(4)
	npl	Roa	ltd	ltd
hzesg	−0.097 *** (0.0216)	0.143 *** (0.0229)	−0.106 *** (0.0241)	−0.0952 ** (0.0361)
npl			0.236 *** (0.312)	
roa				−0.392 *** (0.0872)
nir	0.0347 *** (0.00731)	−0.124 *** (0.0212)	0.0563 *** (0.0244)	0.0735 ** (0.0318)
indep	−0.0436 * (0.0368)	0.0751 ** (0.0364)	0.0845 * (0.0831)	0.0761 * (0.0341)
top10	−0.0152 ** (0.0276)	0.0217 *** (0.114)	0.0379 ** (0.0524)	0.0621 * (0.0415)
pllr	0.126 *** (0.172)	0.0134 *** (0.00200)	−0.00935 ** (0.00837)	−0.00862 ** (0.00512)
pggdpg	−0.0248 *** (0.0461)	0.832 *** (0.0724)	−0.379 *** (0.0647)	−0.496 *** (0.163)
cpi	−0.00411 *** (0.000372)	−0.00616 *** (0.000479)	0.00385 *** (0.000836)	0.00495 *** (0.000874)
Constant	1.092 *** (0.163)	−0.0187 (0.0182)	0.984 *** (0.186)	1.206 *** (0.202)
Observations	285	285	285	285
Number of id	41	41	41	41
R-squared	0.518	0.693	0.702	0.761

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7, column (1), shows that the regression coefficient of hzesg on npl is −0.097, and column (3) shows the regression coefficient of npl on ltd is 0.236, both passing the 1% level of significance test. This indicates the presence of a complete mediating effect, suggesting that improving ESG performance helps reduce the bank's non-performing loan ratio, thereby reducing its liquidity risk. Table 7, column (2), shows that the regression coefficient of hzesg on roa is 0.143, and column (4) shows the regression coefficient of roa on ltd is −0.392, both passing the 1% level of significance test. Additionally, this shows a full mediating influence on financial performance, indicating a higher level of

financial efficiency for banks with high ESG scores. This implies that banks with strong ESG performance are better regarded and trusted by the market, drawing in more deposits and investments and lowering the risk to liquidity. Strong ESG performance enables banks to reduce the percentage of non-performing loans, hence lowering liquidity risk. In a similar vein, banks that score highly on ESG have greater financial efficiency, which is a reflection of their excellent risk management and capital allocation skills. These banks play a significant role in optimising their asset–liability structure, managing business process risks, and improving specialised process management, ultimately enhancing their financial performance and reducing liquidity risk.

5.6. Analysis of Regulatory Effects

Considering the external and policy characteristics of digital transformation in the development process of commercial banks, it is likely to play a role in the liquidity of commercial banks together with ESG. This study incorporates the interaction items of Peking University’s digital transformation level and ESG into the benchmark regression for analysis. The results are presented in Table 8.

Table 8. Moderation Effect Analysis.

	(1)	(2)
	Ltd	ltd
hzesg	−0.174 *** (0.0350)	−0.125 *** (0.0359)
pkudbi		0.028 ** (0.0138)
pkudbi_hzesg		−0.559 *** (0.1997)
nir	0.151 *** (0.0345)	0.113 *** (0.0389)
pllr	−0.0154 *** (0.00317)	−0.015 *** (0.0031)
pggdpg	−1.066 *** (0.114)	−0.806 *** (0.1381)
cpi	0.0103 *** (0.000736)	−0.002 *** (0.0087)
indep	0.0950 ** (0.0468)	0.072 ** (0.0459)
top10	0.115 ** (0.0480)	0.095 ** (0.0476)
Constant	1.965 *** (0.0469)	1.826 *** (0.0583)
Observations	285	285
Number of id	41	41
R-squared	0.720	0.726

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$.

Column (2) of Table 8 shows that in Model (6), the correlation coefficient of the adjustment item pkudbi_hzesg (the interactive item of the digital transformation index and ESG score) is −0.559, which passes the 1% significance test and is negative. Compared to the baseline regression results, after considering the interaction term of digital transformation, the regression coefficient of ESG decreased from −0.175 to −0.125. In other words, it has prevented the detrimental effect of ESG performance on commercial banks’ liquidity, hence confirming H4. Hypothesis H4 may be confirmed by the fact that a bank with a high ESG score performs well in terms of environmental protection, social responsibility, and governance, which improves the reputation of commercial banks in terms of non-financial indicators and lowers some liquidity concerns. In addition, the continuous application of digitalisation has released the vitality of the development of commercial banks and

promoted the forward-looking, sustainable, and scientific development of banks under the “New Basel Accord.” This, in turn, provides a strong foundation for commercial banks to optimise product business lines, broaden the scope of financial services, and enhance financial market share.

6. Research Findings and Implications

6.1. Conclusion of the Study

This study conducted an in-depth discussion on the effect of ESG performance on bank liquidity risk and reached the following conclusions:

- (1) From the perspective of baseline regression, banks with better ESG performance exhibit greater stability and resilience when facing liquidity challenges. The G dimension is the main driving factor in mitigating bank liquidity risk among the three dimensions of ESG.
- (2) From the perspective of heterogeneity testing, the impact of ESG performance on commercial banks' liquidity risk varies heterogeneously. The liquidity of non-state-owned banks is more negatively affected by ESG factors than state-owned banks.
- (3) From the perspective of mediation effects, ESG performance can reduce the liquidity risk of commercial banks by lowering the non-performing loan ratio and improving financial performance. Banks with better ESG performance tend to have lower non-performing loan ratios and better financial performance, and the reduction in non-performing loan ratios and enhancement of financial performance helps to improve the bank's risk resistance and liquidity management levels.
- (4) From the perspective of regulatory effects, the level of digital transformation has a negative regulatory effect on the ESG factor. In other words, it inhibits the negative impact of ESG performance on the bank liquidity risk.

6.2. Policy Recommendations

Based on the findings of this study, the following policy recommendations are made.

- (1) Accelerate the development of ESG disclosure mechanisms for commercial banks. Research indicates that good ESG performance can significantly mitigate the liquidity risk faced by commercial banks. Regulatory bodies should encourage banks to develop and implement comprehensive ESG policies, as well as to conduct regular ESG reporting and assessments. Concurrently, regulatory authorities should establish corresponding ESG indicators and standards to serve as benchmarks for evaluating bank liquidity risk. This strategy will enhance ESG performance and consequently reduce liquidity risk levels.
- (2) Continue to advance the differentiated reform of liquidity risk systems in Chinese commercial banks. Considering the heterogeneity of property rights in the liquidity risks of commercial banks, it is necessary to fully focus on controlling liquidity risks under market-oriented reforms. Based on consolidating the stable loan-to-deposit ratio of state-owned banks, promote the integration of ESG factors and bank liquidity risks adaptively. In state-owned banks, the foundational role of finance should be fully utilised to analyse and formulate a series of policy documents related to social responsibilities, enhance the social reputation of the banking entities, and effectively play a leading role. In non-state-owned banks, while meeting the basics of commercial banking, the undertaking of corporate social responsibility should be given significant attention, combining internal education with external publicity to build a comprehensive system of service awareness and social responsibility. Especially regarding the social responsibilities of commercial banks with different ownership structures in developing countries, provide policy references that are mutually beneficial in terms of social and economic performance.
- (3) Continuously solidify the guiding role of digital transformation in commercial banks. Global commercial banks should start by enhancing the value of informatisation and establishing digital internal control management processes for commercial banks.

Through data sharing and technological innovation, the regulatory role of ESG performance can be played out in the liquidity level of commercial banks. This will help improve banks' monitoring and forecasting capabilities regarding ESG factors, provide more accurate and reliable information for liquidity risk management, and achieve digital information interoperability and mutual benefits in the global financial system, creating an integrated global financial market.

- (4) Actively promote the government and regulatory agencies' efforts in educating and training on liquidity risk and ESG. On the one hand, it is necessary to provide comprehensive training and guidance programs for the ESG evaluation system to help bank personnel better understand and apply ESG factors, thereby enhancing their ability to manage liquidity risk. On the other hand, it is important to promote the public dissemination of ESG-related knowledge and improve awareness and understanding of ESG ratings throughout society.
- (5) Continuously strengthen international cooperation among banks and promote the global adoption and implementation of ESG factors. By enhancing cross-border collaboration and sharing information, a unified ESG standard and guidelines will be established to enhance the overall ESG level and liquidity risk management capabilities of the global banking industry.

7. Limitations and Future Direction

This article objectively studies issues related to liquidity risk management in commercial banks from the perspectives of current situations, theory, and empirical evidence. However, there are still areas that need improvement in subsequent research:

- (1) Regarding sample selection—since the founding years of major commercial banks vary, and some disclose information in their annual reports only for a relatively short period, combined with missing data, this study only selected data from 2009 to 2022, excluding banks with severe data deficiencies, ultimately retaining 41 banks. This may, to some extent, affect the completeness and rigour of the results.
- (2) Concerning the theme of this study, the article focuses on liquidity risk management of commercial banks. However, it only addresses risks associated with insufficient liquidity without discussing issues of excess liquidity.
- (3) Inconsistent ESG scoring criteria are an issue when evaluating how ESG elements affect bank liquidity risk management. Different institutions have significant variations in the criteria and methods for assessing ESG, which may lead to variability and comparability issues in research results. Additionally, the presence of “greenwashing” could further distort the truthfulness and effectiveness of ESG scores.

Future research should be conducted thoroughly in the following areas: First, establish a more comprehensive framework for commercial bank liquidity risk management, focusing on improving the reliability of ESG scores. Second, the extent and mechanisms of the impact of economic globalisation on international cooperation in liquidity risk management should be considered. Lastly, effective international commercial bank cooperation enhances the efficiency of financial regulation and reduces the risk of cross-border spread of financial liquidity crises.

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