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Master Thesis U.S.E.

**COVID-19 EFFECT: THE IMPACT OF CREDIT RISK AND LIQUIDITY
RISK ON COMMERCIAL BANKS' PROFITABILITY¹²**

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Abstract

This paper seeks to investigate whether the impact of credit risk and liquidity risk on the profitability of Chinese commercial banks has changed as a result of the covid-19. To this end, we adopted financial data and indicators for a total of 32 Chinese listed commercial banks from 2009 to 2021 and conducted an empirical analysis using a fixed-effects model. Our empirical findings suggested that covid-19 strengthened the negative impact of credit risk on profitability, with the most significant effect on city commercial banks and a significant effect on ROA only for joint-stock commercial banks, while it has no significant effect on state-controlled large commercial banks. We also find that covid-19 weakened the positive effect of liquidity risk on profitability, but it has a significant effect on ROA only for joint-stock commercial banks. This study provides evidence of the impact of the epidemic on commercial banks, enabling them to manage risk well and improve their risk tolerance in the post-epidemic era, as well as providing empirical evidence for future research.

Keywords: credit risk, liquidity risk, commercial bank, profitability, covid-19

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1. Introduction

Commercial banks are credit intermediaries that seek to maximize liquidity, safety, and capital efficiency by absorbing funds and making loans to earn deposits and lending spreads. Given information asymmetry and the presence of transaction costs, Levine (1997) concludes that financial institutions can promote economic growth by increasing asset liquidity and reducing transaction risk. Beginning in the early twenty-first century, the United States' housing economy appeared to be booming on the surface, as U.S. banks issued large numbers of loans for lenders to buy homes at low-interest rates and with lax scrutiny. However, interest rates skyrocketed in 2007, and many home buyers began to default on their loans because they couldn't afford them, sparking a liquidity crisis among banks. The bonds of major banks had long been spread all over the world by this time, so the crisis had spread to the entire world. This was a serious ramification of profiteering at the expense of transaction risk. Following the crisis, people realized that the current standards of financial market risk supervision could no longer meet the status quo, so the crisis gave birth to the Basel III Accord, which raised the lower limit of bank capital adequacy and expanded the coverage of risky assets, emphasized strengthening counterparty credit risk management, and introduced liquidity supervision indicators to adequately assess liquidity risk. These initiatives are intended to improve banks' risk sensitivity and ability to mitigate risk.

Following the publication of Basel III, the China Banking Regulatory Commission (CBRC) issued the Measures on Capital Management of Commercial Banks in 2012 in accordance with the requirements of Basel III. In reference to Basel III, the document redefined the method of calculating the capital adequacy ratio, added new risk exposures such as specialized loans and defaults, and improved information disclosure standards. However, banks in China experienced a liquidity crisis shortly after the new regulations were implemented in 2013. On June 20, the interbank overnight lending rate reached 13.44 percent. Although the situation was later resolved by the central bank, it revealed that China still had issues with liquidity regulation. As a result, in 2014, the CBRC issued "Measures for Commercial Banks' Liquidity Risk Management (for Trial Implementation)," which improved the liquidity risk detection system, using the net stable funding ratio, high-quality liquid asset adequacy ratio and liquidity matching ratio to measure liquidity and detect liquidity risk with a multi-dimensional tool.

The level of interest rates in China has gradually shifted from being dominated by the central bank to being determined by market supply and demand as a result of interest rate market reform. Financial institutions gained the ability to make interest rate decisions because of this reform, which not only increased their profitability but also helped to reduce their risks (Luo, 2017). However, the development of financial disintermediation has resulted in changes in social financing, and the public can now bypass commercial banks for direct financing, resulting in a relative reduction in commercial banks' status as financial intermediaries and challenges to the traditional profitability model. Commercial banks continue to seek financial innovation in order

to remain competitive. Excessive financial innovation, on the other hand, can lead to lower profitability for commercial banks with a low-risk tolerance, whereas financial innovation can improve profitability for commercial banks with a high-risk tolerance (Hu et al., 2019). As can be seen, risk tolerance is important in the development of commercial banks.

China is the second-largest economy in the world and has grown faster than the rest of the world over the past 20 years, maintaining positive growth even under the impact of covid-19. As per Imbierowicz and Rauch (2014), the majority of commercial bank failures during the recent crisis were caused by a combination of credit and liquidity risks. And the Chinese banking sector is currently hiding plenty of issues. In addition to the 2013 liquidity crisis, commercial banks' non-performing loan ratio has been increasing year after year in recent years. Figure 1 depicts a bar chart formed by the NPL ratio of commercial banks in China for each quarter from 2009 to 2021. As illustrated in the graph, the impact of funding system reform and the economic downturn has increased the NPL ratio from less than 1% in 2012 to 1.96 % in 2020, representing a rapid increase in credit risk for Chinese commercial banks during these years. With huge high liquidity risk and credit risk, it is especially important to understand their impact on commercial bank profitability in order to find ways to improve risk tolerance.

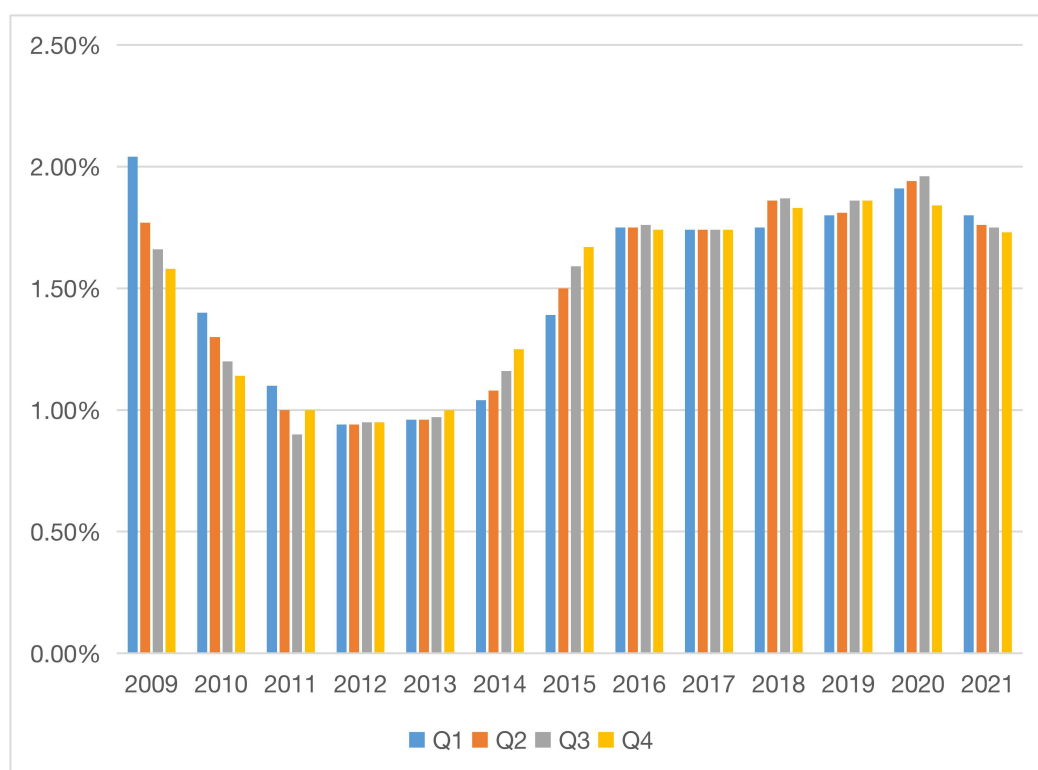


Figure 1. Histogram of quarterly data of NPL ratio of commercial banks in China, 2009-2021. Data source: China Banking Regulatory Commission.

According to Yong Tan, Floros, and Anchor's (2017)'s study of Chinese commercial banks, credit risk has a negative relationship with bank profitability. They contend that a good credit profile reduces the volume of non-performing loans, which

increases bank profitability. Regarding the impact of liquidity risk, the validation results of Liu (2019) on the impact of liquidity using three liquidity indicators: net stable funding ratio, liquidity ratio, and liquidity matching ratio show that liquidity risk is positively related to commercial bank profitability.

Furthermore, the global economy was threatened by covid-19, the global credit supply was reduced, and bank loan growth was affected by covid-19 and fell (Olak & Ztekin, 2021). Although China was the only country to achieve positive economic growth in the aftermath of the epidemic, its economy inevitably contracted and GDP growth slowed. While there have been numerous studies on the impact of credit risk and liquidity risk, few have examined the impact of both on the profitability of commercial banks using data from the aftermath of the financial crisis. It is well known that the financial crisis has caused significant changes in the global economy, and bank risk has increased as a result of the economic crisis (Baselga-Pascua et al., 2015), not to mention that the global economy has been severely impacted by covid-19, and with the advancement of various reforms in China, previous data may no longer be indicative of the current situation. In addition, there is a lack of research on the impact of the new crown epidemic, and during economic downturns, we need more clarity on how commercial banks will be affected. As a consequence, the research question in this paper is whether the impact of credit risk and liquidity risk on commercial banks' profitability will change as a result of covid-19. To investigate this question, we chose data from 2009 to 2021 to validate and update previous studies' findings and then added moderating effects on top of that to see if their relationship is affected by covid-19.

This paper's contribution is to use recent data to update the findings of previous studies and to provide evidence on the impact of covid-19 on commercial banks. Because China is experiencing a period of high prices, this study assists commercial banks in recognizing the specific impact of the epidemic, improving their sensitivity to credit risk and liquidity risk, paying more attention to the prevention of various risks in the post-epidemic era, and avoiding a new round of financial crisis in the special period. The empirical results show that covid-19 enhances the negative impact of credit risk on commercial bank profitability and the positive impact of liquidity risk on commercial bank profitability, implying that commercial banks' ability to resist risk during the epidemic should be improved.

The remainder of the paper is structured as follows: Section 2 examines previous research on the impact of credit risk and liquidity risk on commercial banks, as well as the effects of covid-19; Section 3 describes the model, variables, data, and research methodology; Section 4 presents the empirical results, and Section 5 concludes the paper.

2. Literature review

2.1. Factors affect the profitability of commercial banks

Typically, the factors affecting profitability are classified as internal and external. Almazari (2014) compares the internal factors influencing the profitability of commercial banks in Saudi Arabia and Jordan. The variables he chooses are liquidity risk, net credit facilities to total assets ratio, total investment to total assets ratio, equity-to-assets ratio, Net Credit Facilities to Total Deposits Ratio, cost-to-income ratio, and bank size, all of which have an impact on the profitability of commercial banks in Saudi Arabia and Jordan. Athanasoglou et al. (2008) examine the factors influencing profitability (ROA and ROE) of Greek banks from 1985 to 2001 and conclude that bank-specific factors such as credit risk exposure and operating expenses hurt profitability, while productivity growth has a positive impact on profitability, and macroeconomic factors such as inflation and cyclical output also have a significant impact on profitability to varying degrees. However, in their research, bank size does not affect profitability. Furthermore, Bai (2021) selects some bank-specific factors to investigate their effects on the profitability of 16 listed commercial banks in China and discovered that cost-to-income ratio, provision coverage ratio, and Tier 1 capital adequacy ratio have significant effects on profitability, whereas capital adequacy ratio, net interest margin, and NPL ratio have no significant effects.

Due to data availability constraints, we select two bank-specific variables (cost-to-income ratio and size) and two macroeconomic variables (GDP growth and inflation) as control variables to improve the accuracy of the regression analysis.

2.2. The impact of credit risk and liquidity risk on banks' profitability

Commercial banks earn most of their profits by issuing loans in order to earn a spread, so loan revenue accounts for a large portion of commercial bank profits. This profitability model determines the commercial banks' unavoidable risks. The risk of loan non-recovery due to lender or macro factors is the disadvantage of this profitability model. The bank's liquidity does not have to be achieved through short-term loans, according to the expected income theory. The loan's liquidity is dependent on the lender's future income, which means that if the lender's future income is unstable or uncertain, it poses a threat to the bank's liquidity. While liability management theory states that banks can maintain liquidity by borrowing funds through interbank lending and repurchase agreements, this also makes banks more closely linked and vulnerable to risk spillover effects. According to convertibility theory, banks can manage liquidity by investing funds in securities that are transferable, taking advantage of the fact that these earnings can be easily sold for cash conversion. However, during an economic downturn, investors will prefer to sell rather than buy. As a result, credit risk and liquidity risk are risks that commercial banks cannot fully hedge.

Credit risk is critical to a bank's business purpose, and only effective absorption and supervision can help the bank meet its financial performance goals (Santomero, 1997). Credit risk is defined by the Basel Committee on Banking Supervision (2001) as the possibility of a partial or total loss due to outstanding loans. Nonperforming loans are

the most important factor affecting bank stability, and they are also the most representative of credit risk (Naili and Lahrichi, 2022). According to Chaibi and Ftiti (2015), while most countries experiencing banking crises have common factors affecting their credit risk, each country has its own unique factors. They compare the credit risk of French and German banks using the NPL ratio to measure credit risk and conclude that credit risk is higher in a market economy (France) than in a banking economy (Germany) (Germany). Gerald Hanweek and Lisa Rya's (2005) behavioral model of banks can demonstrate the mechanism by which credit risk affects commercial bank profitability. They contend that credit risk influences bank pricing decisions as well as the structure and volume of assets and liabilities, thereby affecting commercial banks' profitability.

A number of empirical studies demonstrate the impact of credit risk on commercial bank profitability. On the one hand, some scholars argue that there is a negative relationship between credit risk and bank profitability, i.e., the higher (lower) the credit risk, the lower (higher) the bank profitability. According to the results of Adeusi et al. (2014), the cost of non-performing and doubtful loans hurts bank financial performance. Furthermore, the relationship between managed funds and bank financial performance is significant and positive. As a result, banks can reduce credit risk by managing funds, and lowering the cost of non-performing loans, doubtful loans, and the gearing ratio in order to improve their financial performance. A study of Nigerian banks found that loan and advance ratios had the most significant positive effect on bank performance, while loan loss provision (LLP) and an increase in non-performing loans reduced bank profitability (ROA), but differences in the nature and management model of the banks did not determine the effect of credit risk on the banks' financial performance (Kolapo, Ayeni and Oke, 2012). The same study with Nigerian commercial banks found that loans and advances negatively affect the performance (Ogboi and Unuafe, 2013), which is consistent with Kolapo et al.'s findings. Tan et al. (2016) investigated the effect of risks on commercial bank profitability (ROA, ROE, and NIM) in China and found that credit risk (impaired loans/gross loans) has negative impact on banks' profitability. Some academics, on the other hand, argue that credit risk has positive impact on bank profitability, implying that the higher (lower) the credit risk, the higher (lower) the profitability. Gizaw et al. (2015) examined the 12-year performance of eight commercial banks in Ethiopia and discovered that loan loss provision is significantly and positively correlated with bank performance (ROA and ROE), implying that high credit risk can lead to high performance, which they believe this may be an indicative of management activities undertaken by bank managers to improve profitability. Buchory (2015) discovered a significant positive relationship between credit risk (NPL) and bank profitability in his study of 26 regional development banks in Indonesia (ROA). Boahene, Dasah and Agyei (2012) explore the impact of credit risk on the profitability of commercial banks in Ghana and discovered that, despite their high credit risk, commercial banks' profitability (ROE) was not negatively affected, but rather increased. They agreed that high risk equals high return, and they attributed commercial banks' high profitability in Ghana to the fact that banks charge higher

interest, fees, and commissions on loans, resulting in higher interest and non-interest income. With increased competition within the industry as a result of the interest rate market reform, banks are not able to set very high-interest rates on loans, so evidence of the situation described by Boahene et al. may be difficult to find in China, at least for products of equal risk that do not yield the same level of return.

Liquidity is both a flow concept and a capability: the former refers to the free flow of funds between financial system agents, while the latter refers to the ability to do so (central bank, commercial banks, and markets). This implies that liquidity is the ability to achieve these flows. The existence of information asymmetry and incomplete markets contributes to liquidity risk (Kleopatra Nikolaou, 2009). The inability of banks to meet short-term financial needs is referred to as liquidity risk. Liquidity also implies the ability to fund asset growth while also paying liabilities as they come due and avoiding unexpected losses (Ali Sulieman Alshatti, 2015). As a result, liquidity is a capacity that ensures banks have enough funds to deal with their day-to-day operations and risks, and liquidity risk indicates that banks lack this capacity or have insufficient capacity. The liquidity of a bank is affected by its size; the larger the bank, the less liquid it is. This is due to the fact that as a bank's size grows, it becomes more reliant on external capital, which includes the capital adequacy ratio, which has a positive impact on liquidity. When banks are more reliant on external capital, the capital adequacy ratio falls, resulting in lower lending rates and profitability, as well as lower liquidity (Pavla Vodová, 2013).

If a bank's liquidity is in trouble, its operations must be in trouble as well, and this is likely to have a negative impact on the economy. Nor do Hayati Ahmad et al. suggest that high liquidity entails higher credit risk (Nor Hayati Ahmad, 2007). As a result, liquidity risk is another risk that banks must monitor and manage carefully. Liquidity can have an impact on a bank's performance, reputation, and credibility. Excessive liquidity can reduce profitability, while insufficient liquidity can complicate business operations. Therefore, effective liquidity management can keep commercial banks from having too much or too little liquidity, thus ensuring the effective operation of the bank (Ali Sulieman Alshatti, 2015). Faruque Ahamed agrees that too much liquidity reduces investment opportunities and thus profits, whereas too little liquidity creates liquidity risk and negatively influences the bank's long-term growth (Faruque Ahamed, 2021). According to Liu (2019), increasing liquid assets and decreasing current liabilities can increase the liquidity ratio, but the resulting improved capital control will affect operating costs and generate less profitable income. Many empirical studies have found that liquidity risk has a negative impact on bank profitability. Arif and Anees (2012) investigated the impact of liquidity risk on the profitability of 22 Pakistani commercial banks, and the results of multiple regressions demonstrated that liquidity risk increases due to liquidity gaps and nonperforming loans, with a negative impact on bank profitability. They argue that closing the liquidity gap can reduce banks' reliance on the repo market, which can help to mitigate the negative impact of liquidity risk. Maaka (2013) confirms this by running a multiple regression on financial data from 33 Kenyan banks, and the results show that liquidity risk has a negative relationship with these banks' financial performance,

which is attributed to the fact that banks may have to borrow from the repo market at high-interest rates when there is a large liquidity gap, increasing the cost of funding. According to Chen et al. (2018), liquidity risk has a negative impact on bank profitability in 12 developed economies (ROA and ROE). Saleh and Abu Afifa's (2020) study confirms Chen et al.'s findings exactly. They discover that liquidity risk (liquid assets/total assets) has a significant negative impact on bank profitability (ROAA and ROAE) because banks with large funding gaps will use liquid assets to meet their funding requirements. However, some research suggests that liquidity risk is positively related to profitability. Guo (2017) observes that the Chinese banking sector has more adequate liquidity from 2006 to 2015, but the profitability level shows a downward trend, and the empirical study confirms this observation that the liquidity ratio has a negative impact on bank profitability, i.e., the better the liquidity, the worse the profitability, and they argue that such an observation is not surprising. They argue that this negative effect is achieved by reducing the efficiency with which debt-based assets are used. Another study examined financial data from banks listed on the Johannesburg Stock Exchange (JSE) from 2012 to 2018, concluding that liquidity risk (current ratio, acid-test ratio, and cash ratio) has a significant positive effect on bank profitability (ROA, ROE, and NIM) (Cheng et al., 2020).

The reason for the disparity in the results of the credit risk and liquidity risk studies is most likely that commercial bank profitability is influenced by national macro factors that are not accounted for in the modeling of these studies. As a result, in order to make the empirical results more realistic, this paper also includes national macro factors as control variables when examining the effects of credit risk and liquidity risk.

Commercial banks classify loans into five levels according to the degree of risk from normal to loss, and the latter three levels with a higher degree of risk are called non-performing loans. When a loan becomes nonperforming, the loan impairment allowance rises, and loans and advances are reduced as a result, reducing assets. The impact of non-performing loans is reflected in the income statement as an increase in asset impairment losses and thus a decrease in bank profits. Furthermore, profitability and liquidity are mutually exclusive terms. Faster liquidity earns less interest income, and keeping a high level of liquidity requires the bank to keep a high level of cash assets, which can reduce the bank's profitability. As a result, we make the hypotheses listed below.

H1: Credit risk has a negative impact on commercial banks' profitability.

H2: Liquidity risk has a positive impact on commercial bank profitability.

2.3. The impact of covid-19

Despite the fact that covid-19 is only two years old, many academics have already provided evidence of its economic impact. Covid-19, according to Ozili and Arun (2020), limits economic activity from two perspectives. First, the outbreak has closed financial markets, jobs, and places of activity, and second, consumers and investors are being cautious in their consumption and investment activities due to the

uncertainty of the outbreak's progression and duration. The epidemic has directly impacted Chinese production, reducing Chinese commodity exports, and countries with which China has close trade relations have suffered as a result. The slowdown in economic activity and transportation restrictions have not only resulted in lower earnings for companies whose primary business is transportation but have also caused disruptions in the supply chain of raw materials and commodities, which have impacted companies worldwide. In addition, illiquid companies may face the problem of poor turnover due to disruptions in production and output (Priya, Cuce & Sudhakar, 2021).

Scholars have also provided an answer regarding the epidemic's impact on commercial banks. By increasing non-performing loans, Covid-19 can increase commercial banks' credit risk. Covid-19 is responsible for the economic downturn. From a business standpoint, a large number of businesses fail and are unable to repay their loans, resulting in an increase in non-performing loans. Individually, as a result of the economic downturn, businesses generally lay off employees in order to cut operating costs, which, combined with the bankruptcy of some businesses, eventually leads to an increase in unemployment, and some individuals carrying debts lose their ability to repay, resulting in an increase in NPLs (Liu, 2021). Wang (2021), by scoring each regulatory indicator of 36 Chinese commercial banks, then assigning safety, liquidity, profitability, and growth indicators, and finally calculating a weighted score for each indicator to assess commercial banks' financial performance. A comparison of the 2019 and 2020 scores reveals a 30.59 percent decrease in the NPL ratio score compared to 2019, indicating a significant increase in NPLs as a result of the epidemic's impact. The overall increase in liquidity indicators (liquidity coverage ratio and deposit to loan ratio) indicates that commercial banks are consistently preparing more liquidity funds in response to uncertain risks. Furthermore, the scores of profitability indicators (ROE, NIM, and EPS) are all lower in 2020 than in 2019, implying that the sudden epidemic harmed commercial banks' profitability.

The limitation of Wang's (2021) study is that it does not use empirical analysis to deal with the data, and we can only see changes in each indicator before and after the epidemic, but we cannot be certain that these changes are caused by the epidemic, and there may be other factors that were not taken into account that also caused the decline in commercial bank profitability. Furthermore, the majority of existing empirical researches focus on the impact of the epidemic on economic, financial, or risks of commercial bank, and no research has provided evidence on the relationship between covid-19 impact risk and commercial bank profitability. According to Wang (2021), the NPL ratio tends to rise after the outbreak, implying an increase in credit risk, despite the fact that commercial banks are more liquid than before the outbreak. We make the following assumptions if H1 and H2 are proven:

H3: COVID-19 strengthens the negative impact of credit risk on financial performance.

H4: COVID-19 strengthens the positive impact of liquidity risk on financial performance.

3. Methodology and data

3.1. Research design

The purpose of this paper is to investigate whether covid-19 affects the relationship between credit risk and liquidity risk, respectively, and the profitability of Chinese listed commercial banks. Before that, the impact of credit risk and liquidity risk, respectively, on the profitability of Chinese commercial banks will be investigated to determine the direction of their impact on bank profitability, i.e. positive or negative impact. This paper employs a quantitative research method to select financial data and financial indicators from 5 state-controlled commercial banks (SOCBs), 10 joint-stock commercial banks (JSCBs), and 17 city commercial banks (CITY), for a total of 32 Chinese listed commercial banks from 2009 to 2021, and uses stata15.0 to conduct panel data regressions for all banks and three types of characteristics of banks, respectively. We first used descriptive statistics to determine the mean, standard deviation, minimum and maximum values of each variable, and then used correlation analysis to determine the presence of multicollinearity among the variables. We used the Hausman test to determine the best regression model, then chose a fixed-effects model for data regression analysis and discussed the results.

3.2. Models and variables

The first step is to investigate the impact of credit and liquidity risk on commercial bank profitability. This step is based on the model proposed by Wisdom and Isiaka (2018) in their study "Risk management and financial performance of deposit money banks in Nigeria," which employs return on assets (ROA) to measure bank profitability, non-performing loan ratio (NPL) and capital adequacy ratio (CAR) to measure credit risk, and leverage ratio (LR) and loan deposit ratio (LDR) to measure liquidity risk. This model has been modified. We use two indicators, ROA and ROE, to measure commercial banks' profitability as explanatory variables, and only the non-performing loan ratio (NPL) and current ratio (CR) to measure credit risk and liquidity risk, respectively, as explanatory variables, referring to the models used in the studies by Yu et al. (2019) and Guo (2017). We also introduce two bank-specific control variables (size and cost-to-income ratio) and two country macro-control variables (GDP growth and inflation rate) to make the regression results more realistic. Consequently, the epidemic was generated as a COVID dummy variable. Finally, we built the two models shown below:

$$\begin{aligned}
 ROA = & \beta_0 + \beta_1 NPL_{i,t} + \beta_2 CR_{i,t} + \beta_3 CIR_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 GGDP_{i,t} + \beta_6 INF_{i,t} \\
 & + \beta_7 COVID_{i,t} + \mu_{i,t}
 \end{aligned}
 \tag{1}$$

$$\begin{aligned} \text{ROE} = & \beta_0 + \beta_1 \text{NPL}_{i,t} + \beta_2 \text{CR}_{i,t} + \beta_3 \text{CIR}_{i,t} + \beta_4 \text{SIZE}_{i,t} + \beta_5 \text{GGDP}_{i,t} + \beta_6 \text{INF}_{i,t} \\ & + \beta_7 \text{COVID}_{i,t} + \delta_{i,t} \end{aligned} \quad (2)$$

The second step investigates the impact of covid-19 on the relationship between two risks and the profitability of Chinese commercial banks. In this step, we will refer to the model used by Shen et al. (2018) in their study "The Impact of the COVID-19 Pandemic on Firm Performance." We add the interaction terms NPL*COVID for credit risk and covid-19 and CR*COVID for liquidity risk and covid-19 to models (1) and (2) and examine the coefficients of the interaction terms to determine the impact of the epidemic. As a result, we created the model shown below:

a. The impact of covid-19 on the relationship between credit risk and profitability:

$$\begin{aligned} \text{ROA} = & \beta_0 + \beta_1 \text{NPL}_{i,t} * \text{COVID} + \beta_2 \text{NPL}_{i,t} + \beta_3 \text{COVID}_{i,t} + \beta_4 \text{CR}_{i,t} + \beta_5 \text{CIR}_{i,t} \\ & + \beta_6 \text{SIZE}_{i,t} + \beta_7 \text{GGDP}_{i,t} + \beta_8 \text{INF}_{i,t} + \mu_{i,t} \end{aligned} \quad (3)$$

$$\begin{aligned} \text{ROE} = & \beta_0 + \beta_1 \text{NPL}_{i,t} * \text{COVID} + \beta_2 \text{NPL}_{i,t} + \beta_3 \text{COVID}_{i,t} + \beta_4 \text{CR}_{i,t} + \beta_5 \text{CIR}_{i,t} \\ & + \beta_6 \text{SIZE}_{i,t} + \beta_7 \text{GGDP}_{i,t} + \beta_8 \text{INF}_{i,t} + \delta_{i,t} \end{aligned} \quad (4)$$

b. The impact of covid-19 on the relationship between liquidity risk and profitability:

$$\begin{aligned} \text{ROA} = & \beta_0 + \beta_1 \text{CR}_{i,t} * \text{COVID} + \beta_2 \text{CR}_{i,t} + \beta_3 \text{COVID}_{i,t} + \beta_4 \text{NPL}_{i,t} + \beta_5 \text{CIR}_{i,t} \\ & + \beta_6 \text{SIZE}_{i,t} + \beta_7 \text{GGDP}_{i,t} + \beta_8 \text{INF}_{i,t} + \mu_{i,t} \end{aligned} \quad (5)$$

$$\begin{aligned} \text{ROE} = & \beta_0 + \beta_1 \text{CR}_{i,t} * \text{COVID} + \beta_2 \text{CR}_{i,t} + \beta_3 \text{COVID}_{i,t} + \beta_4 \text{NPL}_{i,t} + \beta_5 \text{CIR}_{i,t} \\ & + \beta_6 \text{SIZE}_{i,t} + \beta_7 \text{GGDP}_{i,t} + \beta_8 \text{INF}_{i,t} + \delta_{i,t} \end{aligned} \quad (6)$$

where, $i = 1, \dots, N$ denotes the bank and $t = 1, \dots, T$ denotes the time period. Return on assets (ROA) and return on equity (ROE) are the dependent variables, which represent banks' financial performance. The credit risk is measured by the non-performing ratio (NPL), while liquidity risk is measured by the current ratio (CR), a high current ratio means that the bank has good liquidity and therefore low liquidity risk. Non-performing ratio (NPL) and current ratio (CR) are the explanatory variables. Cost income ratio (CIR) and SIZE are bank-specific control variables, where, the cost-income ratio (CIR) is the ratio of operating expenses to operating income, and SIZE is calculated by taking the logarithm of total assets. GDP growth (GGDP) and inflation rate (INF) are macro variables of China, which are also the control variables. COVID is a dummy variable for the period of COVID-19 which is the years 2020 and

2021, it is a control variable in models (1) and (2), but in models (3), (4), (5), and (6) it is a moderating variable. NPLCOVID is the interaction term between non-performing ratio (NPL) and COVID, its coefficient represents the effect of COVID-19 on the relationship between non-performing ratio (NPL) and financial performance. LRCOVID is the interaction term of liquidity ratio (LR) and COVID and the coefficient represents the impact of COVID-19 on the relationship between liquidity ratio (LR) and financial performance.

The definitions and measurements of dependent variables and independent variables are shown in Table 1 and Table 2, respectively:

Table 1. Descriptions of dependent variables

Variables	Definition	Measurement
ROA	Return on assets. Net profit that can be generated per unit of assets.	Net income/Total assets
ROE	Return on equity. Measurement of return on companies' investment.	Net income/Shareholders' equity

Table 2. Descriptions of independent variables

Variables	Description	Measurement
<i>Bank specific variables</i>		
NPL	Non-performing loans	Non-performing loans / Total loans
CR	Current ratio	Current assets / Current liabilities
CIR	Cost-to-income ratio	Operating cost / Operating income
SIZE	Size of the bank	Logarithm of bank total assets
<i>Macro variables</i>		
GDP growth rate	Annual changes in GDP	$(GDP_t - GDP_{t-1}) / GDP_{t-1} * 100\%$
Inflation rate	Annual rate of increase in the general price level	Consumer Price Index

3.3. Data source

For this study, we chose the annual financial data and financial indicators of 5 state-controlled large commercial banks, 10 joint-stock commercial banks, and 17 city commercial banks, for a total of 32 listed commercial banks in China from 2009 to 2021. We chose this time period because it includes the time when covid-19 was present, and we chose a longer time period before the epidemic to make the results more representative. The bank data used in this study are primarily from the wind database and CSMAR, with additional information from the China Banking Regulatory Commission and individual bank annual reports, as well as macroeconomic data from the World Bank. To avoid losing degrees of freedom, we end up with unbalanced panel data due to the absence of some data for some banks.

3.4. Descriptive statistics

Table 3 displays the descriptive statistics for the variables corresponding to the data of the 32 Chinese commercial banks chosen for this paper from 2009 to 2021. Because some of the banks have missing values, we exclude them and then use stata15.0 to perform descriptive statistics on the data. After removing the missing values, the sample size is 379. Among the profitability indicators, The mean of ROA for all banks is 0.99 percent, and SOCBs' mean is 1.103 percent, which is higher than the overall mean, and the average of JSCBs and CITY's ROA is lower than the overall mean, respectively. Furthermore, the maximum of 1.757 percent and the minimum of 0.42 percent are both found in CITY, indicating that not only does the ROA of CITY vary widely, but also that the overall ROA of all commercial banks is low and the average is more affected by the low value. The standard deviation of ROE in all banks is 4.566, with a maximum and minimum of 27.45 percent and 5.76 percent, respectively, indicating that return on equity (ROE) varies greatly among commercial banks, especially among CITY. Regarding bank-level explanatory variables, the minimum non-performing loan ratio (NPL) is 0.2%, while the maximum reaches 13.97% with the largest standard deviation of urban commercial banks, which indicates that the loan quality and risk level of CITY vary widely, and some of them have a large number of non-performing loans. The maximum Cost-to-income ratio (CIR) in JSCBs is 66.44 percent, which is higher than the China Banking Regulatory Commission's standard of 45 percent, indicating that the operating expenses of some JSCBs are too high or the operating income is too low, which may explain why the ROA of joint-stock commercial banks is lower than the other two types of banks. The commercial banks' asset sizes (SIZE) are not very different, and the average of the three types of banks is relatively close, with the maximum being less than 1.5 times the minimum. Finally, according to macroeconomic indicators, the minimum value of GDP growth (GGDP) is 2.3 percent, while the maximum value reaches 10.6 percent, indicating that the growth rate of China's economy has been more volatile during the

Table 3. Descriptive statistics

characteristic	variable	Mean	SD	Min	Max
SOCB	ROA	1.103	0.191	0.772	1.475
	ROE	16.28	4.028	10.35	23.44
	NPL	1.406	0.358	0.850	2.910
	CR	46.95	9.984	27.60	72.92
	CIR	30.10	3.957	22.30	43.11
	SIZE	30.33	0.537	28.83	31.19
	GGDP	7.392	1.966	2.300	10.60
	INFLATION	2.200	1.381	-0.700	5.600
	COVID	0.154	0.364	0	1
	JSCB	ROA	0.934	0.230	0.477
ROE		16.36	4.676	6.590	26.65
NPL		1.179	0.474	0.200	2.140
CR		47.95	11.43	28.68	75.58
CIR		33.02	8.776	12.38	66.44
SIZE		28.78	0.820	25.82	30.16
GGDP		7.298	1.961	2.300	10.60
INFLATION		2.176	1.307	-0.700	5.600
COVID		0.146	0.355	0	1
CITY		ROA	0.988	0.248	0.420
	ROE	15.97	4.680	5.760	27.45
	NPL	1.285	1.182	0.330	13.97
	CR	54.29	14.28	32.75	114.9
	CIR	30.33	4.893	18.93	43.85
	SIZE	26.73	0.982	24.47	28.75
	GGDP	7.221	1.983	2.300	10.60
	INFLATION	2.229	1.286	-0.700	5.600
	COVID	0.178	0.384	0	1
	Total	ROA	0.990	0.240	0.420
ROE		16.15	4.566	5.760	27.45
NPL		1.271	0.896	0.200	13.97
CR		50.98	13.15	27.60	114.9
CIR		31.16	6.420	12.38	66.44
SIZE		28.01	1.644	24.47	31.19
GGDP		7.276	1.969	2.300	10.60
INFLATION		2.207	1.306	-0.700	5.600
COVID		0.164	0.370	0	1

time period studied in this paper. The inflation rate (INFLATION) has a minimum value of -0.7, indicating that deflation occurred during the time period studied.

4. Regression results

Before performing the regression analysis, we perform correlation analysis on six models to determine whether there is multicollinearity between the variables in order to avoid inaccurate regression model parameter estimation due to multicollinearity. The method we used was a variance inflation factor test by stata15.0. Lower VIFs indicate less correlation between variables, and a VIF of less than 5 is considered a good signal. Since models (1) and (2), models (3) and (4), models (5) and (6) have the same independent variables, respectively, only models (1), models (3), and models (5) are selected for testing.

Table 4. Results of the multicollinearity test for model (1)

Variable	VIF	1/VIF
GGDP	1.530	0.655
COVID	1.510	0.664
CR	1.400	0.716
CIR	1.150	0.873
SIZE	1.110	0.903
INFLATION	1.040	0.964
NPL	1.020	0.979
Mean	VIF	1.250

Table 5. Results of the multicollinearity test for model (3)

Variable	VIF	1/VIF
COVID	2.350	0.426
nplcovid0	2.260	0.442
ggdp	1.570	0.635
cr	1.540	0.651
cir	1.430	0.698
size	1.180	0.848
npl	1.110	0.903
inflation	1.040	0.963
Mean	VIF	1.560

Table 6. Results of the multicollinearity test for model (5)

Variable	VIF	1/VIF
crcovid0	1.830	0.546
COVID	2.330	0.429
cr	1.440	0.693
ggdp	1.620	0.616
cir	1.150	0.873

size	1.110	0.899
inflation	1.040	0.962
npl	1.030	0.974
Mean	VIF	1.440

Table 4 shows that the VIFs of the variables in the model (1) are all less than 5, indicating that there is a lower likelihood of correlation between the variables and thus no need to be concerned about multicollinearity in the regression analysis. However, the VIFs of the interaction terms, explanatory variables, and moderating variables in models (3) and (5) are greater than 5, indicating that they are highly multicollinear. As a result, we centered these variables before running the variance inflation factor test. Tables 5 and 6 show the VIFs of the variables after centering the variables for models (3) and (5), respectively.

The Hausman test is used to determine whether to use a fixed-effects or a random-effects model for regression analysis. The Hausman test has the following rules: If the original hypothesis is to choose the random-effects model, if the p-value is significant at a 5% confidence level, the original hypothesis is rejected and the alternative hypothesis is accepted and the fixed effects model is chosen; if the p-value is not significant at 5% confidence level, the original hypothesis is accepted and the random-effects model is chosen. We ran Hausman tests on the model (1) and model (2), and the results are shown in Tables 7 and Table 8, respectively.

Table 7. Hausman (1978) specification test - model (1)

	Coef.
Chi-square test value	47.697
P-value	0

For model (1), the p-value (0) < 5%, which means the p-value is significant at a 5% confidence level, so the alternative hypothesis is accepted and the fixed effect model is chosen.

Table 8. Hausman (1978) specification test - model (2)

	Coef.
Chi-square test value	27.82
P-value	0

For model (2), the p-value (0) < 5%, which means the p-value is significant at a 5% confidence level, so the alternative hypothesis is accepted and the fixed effect model is chosen.

The primary goal of this section is to investigate the effects of credit risk and liquidity risk on commercial bank profitability. Table 9 and Table 10 display the regression results for models (1) and (2), which were estimated using the fixed effects model. As shown in the table, the regression coefficients of credit risk (NPL) on ROA and ROE

are -0.0664 and -1.078, respectively, when the sample is all banks, both significant at the 1 percent confidence level, implying that each unit increase in NPL reduces ROA by 0.0664 units and ROE by 1.078 units, implying that an increase in credit risk reduces commercial bank profitability, which verifies hypothesis H1. In model (1), the regression coefficient of current ratio (CR) is -0.00198, which is significant at the 5% confidence level, meaning that each unit increase in CR reduces ROA by 0.00198 units; in the model (2), the regression coefficient of CR is -0.0834, which is significant for ROE at the 1% confidence level, meaning that each unit increase in CR decreases ROE by 0.00834 units; According to the regression results, the lower the profitability, the better the liquidity of commercial banks, in other words, the lower the liquidity risk, which supports hypothesis H2. At the 1% level of confidence, SIZE, INFLATION, and COVID are all significant, with SIZE and COVID having a negative impact on ROA and ROE, respectively. At the 1 percent level, the cost-to-income ratio (CIR) is negatively associated with ROA but has no effect on ROE. Finally, at the 1 percent level, the GDP growth rate (GGDP) has a significant positive effect on ROE but not on ROA.

Table 9. Regression results for model (1)

	(1) All banks	(2) SOCB	(3) JSCB	(4) CITY
VARIABLES	ROA	ROA	ROA	ROA
NPL	-0.0664*** (0.00854)	-0.219*** (0.0390)	-0.380*** (0.0496)	-0.0601*** (0.00974)
CR	-0.00198** (0.000800)	-0.00209 (0.00167)	5.08e-05 (0.00123)	-0.00234** (0.00117)
CIR	-0.00821*** (0.00234)	-0.0129 (0.00776)	-0.00607** (0.00291)	-0.00862** (0.00408)
SIZE	-0.142*** (0.0214)	-0.259*** (0.0755)	0.0979** (0.0454)	-0.163*** (0.0283)
GGDP	0.00382 (0.00503)	-0.00367 (0.00763)	-0.0137* (0.00824)	0.00589 (0.00757)
INFLATION	0.0295*** (0.00524)	0.000214 (0.00828)	0.00405 (0.00949)	0.0270*** (0.00818)
COVID	-0.0674*** (0.0226)	-0.0926*** (0.0316)	-0.231*** (0.0380)	-0.0206 (0.0346)
Constant	5.330*** (0.640)	9.802*** (2.424)	-1.113 (1.311)	5.699*** (0.825)
Observations	379	65	123	191
R-squared	0.534	0.792	0.627	0.559
Number of code	32	5	10	17

Standard errors in parentheses

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

The sign and significance of the variables changed when we run the regressions separately for each of the three types of commercial banks. When ROA is used as a measure of profitability (as shown in Table 9), NPLs continue to have a significant negative impact on ROA for all three types of banks, with SOCBs and JSCBs suffering the most. Only for CITY does CR have a significant impact on ROA, which may be due to the increased cost for CITY commercial banks to maintain high liquidity. Notably, GDP growth has a significant impact on the ROA of JSCBs, which we attribute to the fact that JSCBs are more independent than the other two types of banks because they are not controlled by the government, and thus the asset generated by loans is more sensitive to economic changes. The effect of NPL is the same as previous when profitability is measured by ROE (as shown in Table 10). CR has no significant effect on SOCBs' ROE, indicating that SOCBs' profitability (both ROA and ROE) is not sensitive to liquidity risk, which may be due to the fact that SOCBs are state-controlled and have a higher risk-bearing capacity.

Table 10. Regression results for model (2)

	(1)	(2)	(3)	(4)
VARIABLES	All banks ROE	SOCB ROE	JSCB ROE	CITY ROE
NPL	-1.078*** (0.174)	-2.590*** (0.627)	-7.457*** (1.004)	-0.848*** (0.190)
CR	-0.0834*** (0.0163)	-0.0271 (0.0268)	-0.0467* (0.0249)	-0.0794*** (0.0228)
CIR	0.0274 (0.0478)	0.126 (0.125)	-0.198*** (0.0590)	0.133* (0.0796)
SIZE	-1.809*** (0.438)	-7.578*** (1.214)	-0.346 (0.919)	-1.200** (0.552)
GGDP	0.305*** (0.103)	0.0711 (0.123)	0.0380 (0.167)	0.142 (0.148)
INFLATION	0.392*** (0.107)	0.348** (0.133)	-0.397** (0.192)	0.415** (0.160)
COVID	-1.596*** (0.462)	-0.0271 (0.508)	-4.516*** (0.770)	-1.068 (0.674)
Constant	68.78*** (13.08)	246.0*** (38.98)	45.11* (26.55)	47.67*** (16.09)
Observations	379	65	123	191
R-squared	0.597	0.921	0.769	0.539
Number of code	32	5	10	17

Standard errors in parentheses

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

Source: Author computation from computer output.

Based on the results of the regression analysis of models (1) and (2), we conclude that credit risk is significantly and negatively associated with profitability, whereas the relationship between liquidity risk and profitability is positive. This section then adds a moderating effect to this by generating an interaction term between risk and covid-19 to investigate the effect of covid-19 on the relationship between risk and profitability. We first investigate the effect of covid-19 on the relationship between credit risk and profitability, and Table 11 and Table 12 display the estimation results for models (3) and (4). In both models (3) and (4), the regression coefficients of NPL are negative, and the regression coefficients of the interaction term NPLCOVID are also negative, indicating that the moderating variable COVID strengthens the negative impact of the explanatory variable NPL on ROA and ROE, respectively, i.e., credit risk hurts commercial banks' profitability more severely under the epidemic, which is consistent with our proposed hypothesis H3. Furthermore, the epidemic had the same

Table 11. Regression results for model (3)

	(1)	(2)	(3)	(4)
VARIABLES	All banks ROA	SOCB ROA	JSCB ROA	CITY ROA
NPLCOVID	-0.418*** (0.0578)	-0.204 (0.433)	-0.268*** (0.0905)	-0.427*** (0.0836)
NPL	-0.129*** (0.0117)	-0.249*** (0.0749)	-0.379*** (0.0479)	-0.126*** (0.0157)
COVID	-0.0319 (0.0217)	-0.0483 (0.0992)	-0.173*** (0.0415)	-0.0261 (0.0323)
CR	-0.00200*** (0.000746)	-0.00177 (0.00181)	-0.000524 (0.00120)	-0.00183* (0.00109)
CIR	-0.0106*** (0.00221)	-0.0132* (0.00784)	-0.00746** (0.00285)	-0.0112*** (0.00384)
SIZE	-0.171*** (0.0204)	-0.284*** (0.0928)	0.0636 (0.0453)	-0.190*** (0.0269)
GGDP	-0.00188 (0.00476)	-0.00787 (0.0118)	-0.0133* (0.00796)	-0.000409 (0.00716)
INFLATION	0.0300*** (0.00488)	0.00153 (0.00879)	0.00812 (0.00926)	0.0283*** (0.00763)
Constant	6.165*** (0.612)	10.30*** (2.970)	-0.573 (1.349)	6.445*** (0.788)
Observations	379	65	123	191
R-squared	0.596	0.793	0.656	0.619
Number of code	32	5	10	17

Standard errors in parentheses

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

Source: Author computation from computer output.

Table 12. Regression results for model (4)

	(1)	(2)	(3)	(4)
	All banks	SOCB	JSCB	CITY
VARIABLES	ROE	ROE	ROE	ROE
NPLCOVID	-5.751*** (1.230)	-2.642 (6.976)	-1.948 (1.898)	-6.069*** (1.689)
NPL	-1.934*** (0.249)	-2.979** (1.205)	-7.450*** (1.004)	-1.780*** (0.318)
COVID	-1.107** (0.461)	0.546 (1.596)	-4.098*** (0.871)	-1.145* (0.652)
CR	-0.0836*** (0.0159)	-0.0230 (0.0291)	-0.0509** (0.0252)	-0.0721*** (0.0221)
CIR	-0.00619 (0.0470)	0.123 (0.126)	-0.208*** (0.0598)	0.0957 (0.0776)
SIZE	-2.206*** (0.434)	-7.902*** (1.493)	-0.595 (0.950)	-1.589*** (0.544)
GGDP	0.226** (0.101)	0.0168 (0.189)	0.0412 (0.167)	0.0528 (0.145)
INFLATION	0.399*** (0.104)	0.365** (0.141)	-0.368* (0.194)	0.433*** (0.154)
Constant	79.96*** (13.02)	252.9*** (47.80)	42.59 (28.30)	58.14*** (15.92)
Observations	379	65	123	191
R-squared	0.622	0.921	0.772	0.572
Number of code	32	5	10	17

Standard errors in parentheses

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

Source: Author computation from computer output.

impact on all three types of banks. However, covid-19 has no moderating effect on the ROA of SOCBs in the model (3), and it has no moderating effect on the ROE of both SOCBs and JSCBs in the model (4). (4). This implies that the relationship between credit risk and profitability (ROA and ROE) of SOCBs are unaffected by covid-19, whereas the effect of credit risk on ROE of JSCBs is not significantly affected by covid-19. Additionally, the regression coefficient of the interaction term of CITY in the model (3) is smaller than that of JSCBs, indicating that the relationship between credit risk and ROA of CITY is more strongly influenced by covid-19 than that of JSCBs.

Following that, we ran regression analyses on models (5) and (6) to see if the impact of liquidity risk on profitability changed as a result of covid-19, and the results of the regression are shown in Table 13 and Table 14. In models (5) and (6), the regression

coefficients of the current ratio (CR) are -0.00234 and -0.0919, both negative, and the regression coefficients of the interaction term CRCOVID are 0.00432 and 0.1, both positive, implying that covid-19 weakens the negative effect of liquidity ratio on profitability. In other words, because liquidity risk and profitability both decrease during the epidemic, the positive relationship between liquidity risk and profitability becomes stronger in the presence of the epidemic, which is consistent with H4.

Similarly, we conduct regression analysis on each of the three types of banks. We find that epidemics have a strengthening effect on the positive relationship between liquidity risk and profitability, but this effect is only significant for JSCBs when ROA is used as a measure of profitability. This could be because liquidity risk or covid-19 have higher significance and magnitude, which means they have a direct effect on profitability and thus the moderating effect is insignificant. Furthermore, the absolute

Table 13. Regression results for model (5)

	(1)	(2)	(3)	(4)
VARIABLES	All banks ROA	SOCB ROA	JSCB ROA	CITY ROA
CRCOVID	0.00432*** (0.00148)	0.00393 (0.00298)	0.00571* (0.00303)	0.00274 (0.00228)
CR	-0.00234*** (0.000801)	-0.00214 (0.00165)	-4.76e-05 (0.00122)	-0.00258** (0.00118)
COVID	-0.117*** (0.0280)	-0.111*** (0.0343)	-0.259*** (0.0404)	-0.0668 (0.0517)
NPL	-0.0643*** (0.00848)	-0.217*** (0.0387)	-0.357*** (0.0504)	-0.0596*** (0.00973)
CIR	-0.00808*** (0.00232)	-0.0130* (0.00771)	-0.00597** (0.00288)	-0.00828** (0.00409)
SIZE	-0.140*** (0.0212)	-0.249*** (0.0754)	0.0920** (0.0449)	-0.160*** (0.0284)
GGDP	0.000678 (0.00509)	-0.00349 (0.00758)	-0.0151* (0.00817)	0.00364 (0.00779)
INFLATION	0.0304*** (0.00519)	0.000464 (0.00822)	0.00708 (0.00951)	0.0275*** (0.00818)
Constant	5.160*** (0.645)	9.362*** (2.465)	-1.014 (1.309)	5.495*** (0.839)
Observations	379	65	123	191
R-squared	0.546	0.799	0.640	0.563
Number of code	32	5	10	17

Standard errors in parentheses

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

Source: Author computation from computer output.

Table 14. Regression results for model (6)

	(1)	(2)	(3)	(4)
VARIABLES	All banks ROE	SOCB ROE	JSCB ROE	CITY ROE
CRCOVID	0.100*** (0.0300)	0.0597 (0.0480)	0.0316 (0.0623)	0.0577 (0.0445)
CR	-0.0919*** (0.0163)	-0.0278 (0.0267)	-0.0473* (0.0250)	-0.0844*** (0.0231)
COVID	-2.733*** (0.569)	-0.304 (0.552)	-4.671*** (0.831)	-2.041** (1.008)
NPL	-1.028*** (0.173)	-2.555*** (0.624)	-7.333*** (1.037)	-0.837*** (0.190)
CIR	0.0304 (0.0471)	0.125 (0.124)	-0.197*** (0.0592)	0.140* (0.0796)
SIZE	-1.757*** (0.432)	-7.423*** (1.214)	-0.378 (0.924)	-1.139** (0.553)
GGDP	0.232** (0.104)	0.0739 (0.122)	0.0307 (0.168)	0.0949 (0.152)
INFLATION	0.411*** (0.106)	0.352** (0.132)	-0.381* (0.196)	0.425*** (0.159)
Constant	62.90*** (13.14)	239.8*** (39.71)	42.73 (26.93)	41.75** (16.36)
Observations	379	65	123	191
R-squared	0.610	0.923	0.770	0.544
Number of code	32	5	10	17

Standard errors in parentheses

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

Source: Author computation from computer output.

values of the regression coefficients of CRCOVID are smaller than those of NPLCOVID, indicating that the effect of covid-19 on the relationship between liquidity risk and profitability is smaller than that on the relationship between credit risk and profitability.

5. Discussion and conclusion

5.1. Discussion

When we compare the regression coefficients of NPL and CR in the model (1) and model (2), we find that the negative impact of credit risk indicator NPL and liquidity indicator CR on ROE is greater than that of ROA. This finding suggests that the negative impact of credit risk and liquidity on profitability is primarily achieved by

reducing the investment return on capital, while the damage to the return on assets formed by liabilities is smaller, which results in relatively little impairment. As a result, we believe that financial institutions ought to give careful consideration to the management of returns on capital investments. This is something that can be accomplished by elevating the proportion of capital to total assets, which can also improve the ability of commercial banks to withstand risks. Moreover, the effect of GDP growth on ROA is insignificant, which indicates that commercial banks' assets are not sensitive to GNP growth. This may be because commercial banks also anticipate changes in the speed of macroeconomic activity and take appropriate countermeasures.

According to the results of the regression on models (3) and model (4), we can see that the negative impact of credit risk on the profitability of commercial banks is exacerbated by the epidemic. We believe that the reason for this situation is that commercial banks are unable to credit screen and manage the loans that were issued at the time of the epidemic, and the epidemic causes companies to face production, sales, and transportation difficulties as well as liquidity difficulties, so solvency is reduced, and individuals' expected income is reduced due to workplace blockades or the operational difficulties of the companies that they work for, which results in individuals' solvency is also retracted. As shown in Figure 1, a declining trend can be seen in the nonperforming loan rate of commercial banks in 2021. This is evidenced by the fact that banks can improve their review standards for loans issued after the outbreak, which is one way to reduce the NPL rate. In addition, covid-19 exacerbates the negative impact of CITY's credit risk on profitability (ROA and ROE), which indicates that CITY is less tolerant of unexpected risks than SOCBs and JSCBs.

By observing the regression results of model (5) and model (6), we conclude that the epidemic strengthens the positive relationship between liquidity risk and commercial banks' profitability. This could be because, in the early stages of the epidemic, commercial banks had already generated expectations of future risks and increased liquidity to deal with future uncertainties. Commercial banks typically maintain liquidity by converting existing assets into more liquid assets or borrowing, with the former reducing profits and the latter increasing costs, resulting in decreased profitability for commercial banks. This fits with the contradictory relationship between profitability and liquidity.

We also compare the regression coefficients of the interaction terms in models (3) and (4) to models (5) and (6) and discover that the effect of covid-19 on the relationship between liquidity risk and profitability is smaller than the effect on the relationship between credit risk and profitability, suggesting that commercial banks should strengthen credit risk management during the epidemic to avoid downward fluctuations in profitability.

5.2. Limitations

The sample size and time period of this study are limited by the fact that there are a large number of missing values, even for listed commercial banks, due to the Chinese

banking industry's continued lack of a relatively well-developed information disclosure system, limiting the choice of control variables and potentially leading to less accurate results. Furthermore, Imbierowicz and Rauch (2014) found that the interaction of credit and liquidity risk affects the level of the default probability of banks: for banks with a default probability of 10% to 30%, the interaction of credit and liquidity risk increases their default probability, whereas, for banks with a default probability of 70% to 90%, this interaction decreases the probability of default. To ensure the exclusivity of the research problem, this paper does not consider the relationship between credit risk and liquidity risk and their joint impact on commercial bank profitability. Future research could look into the role of covid-19 in this issue. Finally, because the epidemic is only two years old and we do not know when it will end, there is less data for the epidemic period, and future studies could use more adequate data to validate the findings of this study.

5.3. Conclusion

This study investigates the impact of credit risk and liquidity risk on banks' profitability using the annual financial data and financial indicators of 32 listed commercial banks in China from 2009-2021. These banks include 5 state-controlled large commercial banks, 10 joint-stock commercial banks, and 17 urban commercial banks. The study also explores the impact of covid-19 on their relationship based on this impact. There have been a great number of studies in the past that have investigated the impact that risk has on the profitability of commercial banks; however, there has been no study on the impact that the epidemic has had on their relationship since the outbreak. As a result, the contribution of this paper is twofold: first, it provides an update on the findings of previous studies, and second, it offers evidence on the impact that the new crown epidemic has had on commercial banks.

As per our research findings, Chinese commercial banks' credit risk has a significant negative impact on profitability (ROA and ROE). This is due to the fact that an increase in the NPL ratio results in an increase in asset impairment losses, which in turn reduces profits; liquidity risk can improve the profitability of commercial banks, and poor liquidity indicates that commercial banks have low current assets or high current liabilities, while the financing cost of current liabilities is low, so corporate financing low costs and high returns. This is consistent with the findings of Guo (2017) and Yong Tan et al. (2017) . Furthermore, covid-19 strengthens the negative impact of credit risk on commercial banks' profitability, which is mainly due to the fact that lenders' solvency is impaired by the epidemic, and banks, therefore, have difficulty in recovering principal and interest. This effect, however, is only significant for ROA of JSCBs and ROA and ROE of CITY, but not for SOCBs, which we attribute to SOCBs' higher risk tolerance than the other two types of commercial banks with state support; the positive relationship between liquidity risk and commercial banks' profitability is strengthened by covid-19, which we argue that this is because commercial banks' activities to maintain liquidity reduce returns and increase costs and that increased liquidity itself sacrifices profits. Nevertheless, this

effect only reflects a significant impact on the ROA of JSCBs, which may be due to the direct impact of liquidity risk or covid-19 on profitability.

In an era of financial product diversification, China must also improve commercial banks' risk management supervision standards in order to increase their risk tolerance. The information disclosure system also needs to be improved because it not only provides commercial bank supervision but also more complete data for future studies to ensure the accuracy of the findings.

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