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Article

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BANKING & FINANCE | RESEARCH ARTICLE

Nexus between bank capital and risk-taking behaviour: Empirical evidence from US commercial banks

Faisal Abbas¹, Shoaib Ali^{2*}, Syed Moudud-Ul-Huq³ and Muhammad Naveed⁴

Abstract: The study aims to investigate the effect of conventional capital ratio, risk-based capital ratio, and capital buffer ratio on commercial bank risk-taking over the period from 2002 to 2019 using a two-step GMM method. The finding reveals that there is a positive relationship between traditional capital ratio and risk-taking for the full sample results, which is supported by the regulatory hypothesis. The results are same across various categories based on capitalization and liquidity. Whereas the relationship is negative when capital is measured through risk-based capital ratio and capital buffer, the results are in line with the moral hazard hypothesis. The outcomes are consistent for all subcategories other than for well-capitalized and low liquid banks. The full sample findings are consistent when risk is proxied through loan loss provision. The impact of capital ratios on risk-taking in the pre-, pro- and post-crisis eras is heterogeneous and significant. The findings have significant insights for regulators to observe the differences among pre-, pro- and post-crisis periods for the well, adequately, under, significantly under-capitalized, high and low liquid insured commercial banks of the USA.

Subjects: Finance; Business, Management and Accounting; Risk Management

Keywords: Traditional Capital Ratio; Risk-based Capital Ratio; Capital Buffer Ratio
JEL classification: G21; G28; G32

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PUBLIC INTEREST STATEMENT

This study aims to examine how capital affects the banks' risk-taking by using the annual data of US commercial banks. The finding suggests that traditional capital increase the banks' ability to take more risk whereas risk-based capital ratio and capital buffer negatively affect banks' risk-taking. Furthermore, the results are consistent across the various categories, including well, adequately, under-capitalized, high and low liquid banks. This study may be valued for the decision-makers. They may seek guidance from this study for formulating policies in this area in the future. This study may also open a new horizon for researchers.

1. Introduction

Globalization and technological transformation have encouraged financial institutions to develop innovative financial products to fulfil concerned stakeholders' requirements. These developments are accompanied by some risks in the banking sector. The regulators have been trying to provide a universal model to manage the bank capital and risk-taking since Basel-I presented in 1988. Then, it is followed by Basel-II that introduced in 2004. In a similar context, in Basel Accord-III¹ 2010, BCBS² provides three bank capital ratios. The capital adequacy ratio, which requires 8% of the risky assets. Tier-one capital ratio, which needs 6% ratio against risky assets of banks. Tier one common equity ratio of at least 4.5% of risky assets. Surprisingly, an increase in capital level always remains the primary focus for regulators to reduce the probability of failure, as witnessed in the earlier literature by Jacques and Nigro (1997) and Aggarwal and Jacques (1998). Following the recommendation of Molyneux (2018) for future research and the recent studies of (Bitar et al., 2018; Ding & Sickles, 2018, 2019; Jiang et al., 2019), we are interested in answering the following critical questions regarding the association of different capital ratios and bank risk-taking. First, how does a change in traditional capital ratio, risk-based capital ratio and capital buffer ratio affect a bank's risk-taking during the post-crisis period in comparison with pre-crisis and pro-crisis period? In a specific manner, how do capital ratios of the well-capitalized banks influence risk differently from adequately and under-capitalized commercial banks? How do capital ratios of the high-liquid banks affect risk-taking differently than low-liquid banks?

Theoretically, there have been various hypotheses reported in the banking literature about the relationship between risk-taking and adjustment of bank capital ratios. For instance, the mean-variance hypothesis suggests a positive correlation between capital and risk Kim and Santomero (1988), and Rochet (1992); whereas, the option pricing theory concluded an inverse association between capital and risk Keeley and Furlong (1990). The moral hazard hypothesis supports the negative association between risk-taking and capital ratios Lee and Hsieh (2013) and Zhang et al. (2008). According to the moral hazard theory, bank managers usually exploit the depositor's rights that they primarily favour their interest in managerial compensation and secondly support the benefit of shareholders for their wealth maximization. The regulatory hypothesis theory favours the positive relationship between capital and risk, as evidenced in the literature by Shrieves and Dahl (1992) and Altunbas et al. (2007). According to the regulatory theory, banks required to increase their capital level with an increase in risk-taking. Regulators suggest the positive connection between risk and capital to reduce the problem of bankruptcy owing to higher risk and lower capital.

The research is not similar to previous studies due to the following aspects. This study used the sample of insured commercial banks from the USA with consolidated assets of 300 USD million or above covering the period between 2002 and 2019. However, the previous studies remain limited to investigate a limited period and sample. For example, the study conducted by Aggarwal and Jacques (1998) used 2552 insured commercial banks having assets of 100 USD million or above as reported between 1990 and 1993. Shrieves and Dahl (1992) used the sample of USA banks covering the period between 1984 and 1986. Jacques and Nigro (1997) used a sample of 2570 insured banks of the USA, including the period ranging between 1990 and 1991. Jahankhani and Lynge (1979) conducted a study by using the data of 95 commercial banks from the USA over the period between 1972 and 1976. Pettway (1976) used a sample of US banks and covered the period between 1971 and 1974. Shim (2010) used US companies to study the relationship between risk and capital covering the period between 1993 and 2004. The study uses the two-step system GMM approach, which incorporates the issues of endogeneity and simultaneity. However, most of the previous studies that are cited above have used simple panel OLS, 2SLS and 3SLS³ while ignoring the issue of endogeneity.

The study contributes to the literature on bank capital and risk in many ways: first, to the best of the researchers' knowledge, this is the first study in the post-crisis era, covering the Basel-II, Basel-III, and crisis period of 2007–2009. Second, this is the first study in the post-crisis period, which

provides a more in-depth analysis of risk-taking and capital ratios by dividing the banks according to their capitalization and liquidity in the US. Third, other studies remain limited to using traditional capital ratio measured as equity to total assets while studying the relationship between risks as measured risk-weighted assets to total assets. Finally, the study provides new insights into the influence of risk-based capital ratio and capital buffer ratio for the post-crisis period as compared to pre- and pro-crisis periods.

The findings are critical for regulators to observe the differences among pre-, pro- and post-crisis periods for the well, adequately, under, significantly under-capitalized, high liquid and low liquid insured commercial banks of the USA. The results give valuable information to formulate new guidelines for the stability of the financial system. The findings are significant because of covering the period of technological transformation and global integration of the world.

The rest of the study is structured as follows: The second part contains the theoretical and empirical literature review, the third section provides data and methodology, fourth part consists of results and discussion, and the fifth part is about the conclusion.

2. Theoretical and empirical literature on bank capital and risk-taking

The theorem of Modigliani and Miller states that the market is fully efficient and perfect in the sense that depositors are fully informed about the actual risk of their financial institutions. This situation depicts that equity holders cannot exploit the depositors. If the depositors claim higher rates against the banks' true riskiness, this means that equity holders cannot use their vigilant position to increase their interest in the cost of depositors. Under this condition, the value of the bank will remain independent of the debt and equity mix. Sealey (1983) claims that the MM theory is not useful in banking capital structure. He demonstrates that depositors are not fully informed about the riskiness of bank assets. Therefore, they cannot monitor their banks. This situation provides an edge to bank managers to take higher risks, known as a moral hazard in banking. Jensen and Meckling (1976) argue that if depositors cannot sign a perfect agreement with bank managers, shareholders have an edge of investing in more risky assets. Numerous theoretical and empirical studies have investigated the association between bank risk-taking and capital. For example, by applying the mean-variance hypothesis, Koehn and Santomero (1980) and Kahane (1977) concluded that risk-based capital boosts risk-taking. Shrieves and Dahl (1992) and Jokipii and Milne (2011) confirm the positive relationship between capital and risk changes while studying the USA banking data. Blum (1999) advocates that capital adequacy requirements increase the riskiness of banks. Borio and Zhu (2012) claim that there is a need to explore the conceptual and theoretical framework of capital and risk relationship in banking. Furthermore, following studies (Athanasoglou, 2011; Teply & Matejašák, 2007;) favor a positive correlation between risk-taking and capital ratio. Ugwuanyi (2015) examined the relationship between risk and capital in the post-crisis setting and concluded a positive association.

In contrast, Jacques and Nigro (1997) and Aggarwal and Jacques (1998) applied a similar methodology and concluded an inverse relationship between risk and capital. Lee and Hsieh (2013) examined the effect of capital ratio on risk-taking of Asian commercial banks covering 1994 and 2008. They document an inverse relationship between risk and capital ratio. They argue that the moral hazard hypothesis supports the negative association between risk and capital. Godlewski (2005) highlighted the negative correlation between risk and capital. Tan and Floros (2013) found an inverse relationship between capital and risk. Similar results are provided by Hua (2011) and Maji and Hazarika (2016) in their studies. Recently conducted studies also favour the negative relationship between risk-taking and bank capital (Ding & Sickles, 2018, 2019; Jiang et al., 2019).

Therefore, based on the conflicting results in the literature, this study has developed the following hypothesis:

Hypothesis 1: Traditional, Risk-based capital ratio and capital buffer ratios have a significant relationship with banks risk-taking.

The studies on the nexus between bank capital and risk show that the relationship varies with capitalization and adequacy. For instance, Abbas and Ali (2020) find that the relationship between capital and risk varies with the level of capitalization and liquidity. While studying the Lebanese banking sector, El-Khoury (2020) finds that under-capitalized banks increase their capital faster than well-capitalized banks, and their behaviour is driven by regulatory pressure. Memmel and Raupach (2010) conclude that large banks create less liquidity in the market but they do not react to credit loss. Abbas and Masood (2020a, 2020b) find that banks performance and capital adjustment vary on the basis of their liquidity position. The findings indicate that low-liquid banks require higher time than high-liquid banks to restore their equilibrium capital ratios. In addition, studies about the relationship between capital and risk are scarce. These observations lead us to develop the following hypotheses:

Hypothesis 2: The relationship between banks capital ratios and risk-taking varies with bank capitalization.

Hypothesis 3: The relationship between capital ratios and risk-taking varies with banks liquidity.

3. Data and methodology

3.1. Data

The Federal Deposit Insurance Corporation (FDIC)⁴ is used to collect data for commercial banks. The FDIC listed banks required to submit their prescribed financial statements information quarterly. The data used in this study is based on yearly information for financial institutions and covers a long period ranging from 2002 to 2019. The sample of the study is balanced panel data containing insured commercial banks of the US, as described by FDIC. Further, the assets are also based on a consolidated theme. There were many banks, nearly 1806, in the mentioned list on 31 December 2019⁵. However, for appropriate and reliable data analysis, the inclusion of the study sample units was based on the following criteria: the listed banks should have been active on the reported date. There must not be any missing observations for any specific study variables of at least two years in the studied period. The total assets of banks must be higher than 300 USD million on the 31st December 2019. After filtration of properly used criteria, there were 902 banks selected for the study sample size.⁶ The data for the inflation rate are retrieved from the WDI database,⁷ and data for trade freedom index are collected from Heritage Foundation 2019⁸. The detail of proxies enlisted in Table 1.

3.2. Econometric model

The study uses the dynamic model due to several reasons. Significantly, GMM controls the endogeneity of the lagged reliant variable in a dynamic setting. GMM controls the measurement error problem, reduces omitted bias issues, and controls the unobserved heterogeneity problem in panels. Arellano and Bond (1991) provide a method called the generalized method of moments as the solution to make the estimators consistent. Later, Blundell and Bond (1998) worked on it further. Various studies use the said methodology in the field of banking (Abbas, Batool et al., 2020; Abbas & Masood, 2020a, 2020b; Fiordelisi et al., 2011; Lee & Hsieh, 2013; Tan, 2016; Tran et al., 2016). Significantly, we use the two-step system GMM in this study. The two-step system GMM is more efficient than the one-step system GMM, and two-step system GMM can capture the maximum values to calculate the estimators. The basic model of the system GMM approach is the following form:

$$\ln \text{Bankrisk}_{i,t} = \phi \text{bankrisk}_{i,t-1} + \beta \text{capitalratio}'_{i,t} + (\eta_i + \varepsilon_{i,t}) \quad (1)$$

Table 1. Descriptive statistics and measurement of variables

Variable Name	Measurement	Mean	Std.Dev.
Bank Risk (RWATA)	Risk Weighted Assets/ Total Assets (Abbas et al., 2021a)	0.723	0.110
Bank Risk (LLRTA)	Loan loss reserves/Total Assets (Shrieves & Dahl, 1992)	0.0003	0.0002
Traditional Capital Ratio (TCAPR)	Total Equity/Total Assets (Abbas et al., 2021b)	0.102	0.018
Risk-Based Capital Ratio (TRBCR)	Tier I Plus Tier II/Risk-Weighted Assets (Abbas et al., 2021c)	0.141	0.027
Capital Buffer (BTRBC)	Actual Risk-Based Capital Ratio less 8% (Abbas et al., 2021d)	0.059	0.021
Profitability (ROA)	Net Income/Total Assets (Ali et al., 2020)	0.010	0.005
Liquidity Ratio (LIQ)	Liquid Assets/Total Assets (Yousaf et al., 2019a)	0.048	0.027
Loan Ratio (LR)	Total Loans/Total Assets (Ali et al., 2019)	0.666	0.113
Bank Size	Natural Log of Total Assets (Yousaf et al., 2019b)	13.554	0.950
Market Power (MP)	Total Bank Deposit/Total Industry Deposit (Mizaei, 2011)	0.139	0.271
Bank Efficiency (BE)	Cost/Revenue (Dalla Palma et al., 1999)	3.048	1.756
Income Diversification (INDIV)	Non-Interest Income/ Total Assets (Bitar et al., 2018)	0.463	0.098
Trade Freedom Index	An index is taken from the heritage foundation	84.959	2.811
Inflation Rate (CPI)	Consumer Price Index (CPI)	1.920	0.665
During-Crisis Dummy (DC)	1 for 2007 to 2009 otherwise 0		
Before-Crisis Dummy (BC)	1 for 2002 to 2006 otherwise 0		
After-Crisis Dummy (AC)	1 for 2010 to 2018 otherwise 0		

This table reports measurement and summary statistics of our variables of study over the period from 2002 to 2019. Mean, and standard deviation refers to the cross-sectional average and standard deviation of the firms' time-series averages.

It is assumed that the above specification is a random walk equation, and the dependent variable is persistent. Accordingly, the results of difference GMM produce an inefficient and biased parameter, particularly in finite samples. It means the period remains limited, and cross-sections contain large numbers. The empirical literature explains that the above bias and poor performance of difference GMM are due to weak instruments (Blundell & Bond, 1998). For the solution of the above problem, the system GMM is used. The system GMM uses one equation in levels form with the first differences as instruments, whereas the second equation is used in the first differences form with level as instruments. The system GMM approach implicates a higher number of instruments. Still, Monte Carlo evidence recommends that where the period is limited, and the dependent variable is found to be persistent, the use of system GMM reduces the bias of a small sample. There is another feature of system GMM; if there are autocorrelation and heteroscedasticity in the data, a two-step system GMM should be applied by developing a weighting matrix using residuals

from the first step. It is also argued that in limited samples, the standard errors found to be downward biased. In this situation, researchers recommend applying the robust standard error approach developed by Windmeijer (2005), which corrects the sample bias. The following model is used in this study under the condition elaborated above:

$$\text{Bankrisk}_{i,t} = \alpha + \text{Bankrisk}_{i,t-1} + \beta_1 \text{Capital}_{i,t} + \beta_2 \text{control}_{i,t} + \varepsilon_{i,t} \quad (2)$$

Here the *Bankrisk* is a dependent variable, which is risk-taking (risk-weighted assets to total assets (RWATA), loan loss reserves to total assets (LLRTA) in this study i , represents banks and t shows time, $t - 1$ is lagged value of risk. β Unknown parameters, where the capital is the independent variable, which may be traditional capital ratio (total equity to total assets), risk-based capital ratio (tier-I plus tier-II to risk-weighted assets) and capital buffer ratio (risk-based capital ratio less 8%) based on the simulation under observation. Control variables include profitability, liquidity, loan ratio, bank size, market power, bank efficiency, income diversification, trade freedom, and inflation rate and ε is an error term. The following model is also used by adding time dummies to find out the results of the pre, during, and a post-crisis period where needed. The standard form of equations when time dummies are added is as follows:

$$\text{Bankrisk}_{i,t} = \alpha + \beta_1 \text{Bankrisk}_{i,t-1} + \beta_2 \text{Capital}_{i,t} + \beta_3 \text{controlvariables}_{i,t} + \beta_4 \text{PeriodDummies} + \varepsilon_{i,t} \quad (3)$$

In the above model period, dummies include pre, during, and post-crisis periods. This equation provides the results of the variations of concern variables by comparing the different periods.

4. Results and discussion

4.1. Overall sample results for large insured commercial banks

The descriptive analysis and correlations matrix are provided in the appendices in [Tables 1 and 2](#). The values reported in the descriptive analysis and correlations matrix are statistically reasonable to test. [Table 3](#), columns 1 to 3 represent the results of the overall sample. However, when the risk is measured as risk-weighted assets to total assets, the impact of a traditional capital ratio is statistically significant and positive on risk-taking in the short run, other factors held constant. The first theoretical justification for the positive relationship is due to the stringent regulations imposed by regulators. The second explanation for positive correlation is to avoid the bankruptcy cost. The third argument for a positive relationship between risk-taking and bank capital is managerial risk aversion. These results are consistent with the previous studies of (Aggarwal & Jacques, 1998; Altunbas et al., 2007; Jokipii & Milne, 2011; Shrieves & Dahl, 1992). The coefficient on the lagged risk in the model ranges about 0.394. It is positive, which indicates that one of the reasons for the increase in the current risk is the previously prevailing risk, as found by Aggarwal and Jacques (1998). However, the positive sign of the lagged risk is contradicting the findings of Shrieves and Dahl (1992). The findings show that the relationship between risk-based capital, capital buffer ratio, and risk-taking is significant and negative, as evidenced by risk-weighted assets. The negative relationship is supported by the moral hazard hypothesis as corroborated by (Jacques & Nigro, 1997; Jokipii & Milne, 2011; Lee & Hsieh, 2013; Mongid et al., 2012; Zhang et al., 2008). The countercyclical relationship between risk-weighted asset and risk-based capital suggests that banks required managing their lending concerning risk-based capital and capital buffer ratio. The impact of profitability is positive with risk, as concluded by Aggarwal and Jacques (1998). This observation appears to favor the hypothesis that insured commercial banks with a greater proportion of risk-based capital would have lesser chances of default. Therefore, by maintaining a higher proportion of risk-based capital against risky assets, commercial banks can keep the probability of default lower. The findings are in-line with Shim (2013). The coefficient of liquidity ratio is negative, which means that an increase in the liquidity of banks reduces the risk in the short run, other things held similarly. The positive and statistically significant coefficient of loan ratio means that the excessive lending of banks increases risk-taking.

Table 2. Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
RWATA	1												
TCAPR	0.024	1											
TRBCR	-0.516	0.505	1										
BTRBCR	-0.507	0.488	0.983	1									
ROA	0.053	0.086	0.081	0.074	1								
LIQ	-0.147	0.048	0.185	0.189	-0.090	1							
LR	0.761	-0.076	-0.447	-0.442	0.015	-0.178	1						
SIZE	0.101	0.120	-0.105	-0.103	-0.011	-0.056	-0.026	1					
MP	0.020	0.010	-0.023	-0.022	0.031	0.030	-0.079	0.102	1				
BE	-0.044	-0.061	-0.008	0.001	-0.486	0.100	-0.017	-0.034	-0.024	1			
INDIV	-0.001	0.113	0.090	0.094	0.585	0.034	-0.113	0.312	0.112	-0.219	1		
TFINDX	0.054	0.190	0.132	0.141	-0.203	0.170	0.034	0.266	0.008	0.095	0.036	1	
CPI	0.029	-0.108	-0.113	-0.121	0.168	-0.204	0.038	-0.142	-0.006	-0.106	-0.029	-0.561	1

Table 2 reports the pair-wise correlations between our variables of study over the period from 2002 to 2019. * represents the significance at 5%.

Table 3. Full sample results of the relationship between banks capital and risk

	Bank Risk	Bank Risk	Bank Risk
Lagged dep.	0.394*** (0.058)	0.371*** (0.057)	-0.509 (0.440)
Traditional Capital ratio	0.925** (0.418)		
Risk-based capital ratio		-0.536* (0.324)	
Capital buffer ratio			-6.013** (2.934)
Profitability	0.869* (0.495)	0.724 (0.574)	-13.57** (6.715)
Liquidity	-0.499*** (0.061)	-0.533*** (0.065)	-0.216 (0.206)
Loan ratio	0.662*** (0.020)	0.713*** (0.027)	0.401*** (0.134)
Bank Size	-0.006 (0.005)	-0.002 (0.006)	-0.073** (0.034)
Market power	-0.001 (0.043)	-0.015 (0.046)	0.029 (0.087)
Bank efficiency	0.001 (0)	0.004 (0)	-0.006* (0.003)
Income diversification	0.006 (0.037)	-0.010 (0.050)	0.503** (0.240)
Trade freedom	0.004 (0)	0.003 (0)	0.010** (0.005)
Inflation rate	-0.004*** (0)	-0.003*** (0)	0.013* (0.007)
Observations	13,483	13,498	13,498
Number of id	900	901	901
AR(2)	0.171	0.166	0.051
Hansen Test Statistics	0.078	0.064	0.837

Table 3 presents two-step system GMM of the effect of capital on banks risk. The dependent variable is bank risk (ratio of risk weighted assets to total assets) traditional capital ratio. Robust standard errors are reported in parentheses. ***, **, * represent statistical significance at 1%, 5% and 10% respectively.

4.2. During-, before-, and post-crisis period

Table 4 columns 1 to 3 show the results of during-crisis, before-crisis and post-crisis periods. The lagged coefficient of bank risk is found to be positive and statistically significant to influence the current risk. The positive sign indicates that the previous risk has a positive impact on current risk-taking. The positive sign of the lagged risk is contradicting with Shrieves and Dahl (1992) and Aggarwal and Jacques (1998). The results show that the influence of bank capital ratios is not similar in before-crisis, during-crisis and post-crisis period. The relationship between the traditional capital ratio and the risk-taking ratio is statistically significant and positive. The results show that the intensity of banks' risk-taking due to the increase in the traditional capital ratio was higher in before-crisis as compared with during and post-crisis periods. The proportionate change in risk-taking against traditional capital ratio is lower during and in the after-crisis period, which may refer to the effect of regulators' recommendations.

Table 4. Impact of banks capital on risk in pre, amid and post crisis period

	Bank Risk	Bank Risk	Bank Risk
Lagged dep.	0.275*** (0.050)	0.188*** (0.047)	0.218*** (0.033)
Traditional Capital ratio	0.517*** (0.130)		
Traditional Capital ratio*DC	-0.240** (0.102)		
Traditional Capital ratio*AC	-0.272** (0.121)		
Risk-based capital ratio		-0.437*** (0.099)	
Risk-based capital ratio*DC		-0.234*** (0.071)	
Risk-based capital ratio*AC		-0.246*** (0.083)	
Capital buffer ratio			-0.383*** (0.140)
Capital buffer ratio*DC			-0.306*** (0.106)
Capital buffer ratio*AC			-0.276** (0.124)
Observations	13,483	13,498	13,498
Number of id	900	901	901
AR(2)	0.117	0.074	0.128
Hansen Test Statistics	0.056	0.091	0.003

Table 4 presents two-step system GMM of the effect of capital on banks risk during pre, amid and post crisis period. The dependent variable is bank risk (ratio of risk weighted assets to total assets) traditional capital ratio. Robust standard errors are reported in parentheses. ***, **, * represent statistical significance at 1%,5% and 10% respectively.

The positive relationship is supported by the regulatory theory (Aggarwal & Jacques, 1998; Altunbas et al., 2007; Jokipii & Milne, 2011; Shrieves & Dahl, 1992). The findings reveal that the banks usually adjust their risk-based capital ratios with risk-taking, as evidenced by risk-weighted assets. The results are favoring the regulators' suggestion for a higher amount of capital to decrease risk in the short run. The coefficients of the risk-based capital ratio show that the influence is more pronounced in the post-crisis period as compared with the before-crisis period. However, the impact remains more significant during the crisis than the before-crisis period. The findings reveal that the connection between the capital buffer ratio and risk-taking is negative and significant. The negative relationship is supported by the moral hazard theory (Jacques & Nigro, 1997; Lee & Hsieh, 2013; Zhang et al., 2008). The role of profitability, liquidity, income diversification, loan ratio and trade freedom has an economic significance for readers. The profitability and liquidity remain key determinants to decrease the risk of large insured commercial banks during-crisis period, which is supporting the holding of higher liquidity. The results show that the loan ratio is a cause to increase risk. It is observed that more diversified banks take higher risk during-crisis period. The impact of trade freedom also encourages bank managers to take a higher risk.

Table 5. Impact of banks capital on banks risk varies across level of capitalization

VARIABLES	Well-capitalized			Adequately capitalized			Under-Capitalized			High liquid			Low liquid		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bank risk	0.653**	0.513**	0.501***	0.387***	0.201	0.176	0.180***	0.226***	0.232**	0.188**	0.201***	0.204***	0.454***	0.450***	0.469***
Lagged risk	(0.284)	(0.217)	(0.190)	(0.136)	(0.131)	(0.135)	(0.096)	(0.131)	(0.116)	(0.088)	(0.071)	(0.069)	(0.076)	(0.079)	(0.091)
Traditional Capital ratio	1.942			0.313			0.352***			-0.681			0.769**		
	(1.474)			(0.937)			(0.425)			(0.558)			(0.373)		
Risk-based capital ratio		0.742			-0.949*			-0.482**			-0.574*			0.487**	
		(0.827)			(0.532)			(0.563)			(0.322)			(0.320)	
Capital buffer ratio			0.891			-1.157*									
			-0.575*			0.520**									
			(0.881)			(0.606)			(0.456)			(0.308)			(0.355)
Observations	2,110	2,125	2,125	1,525	1,525	1,525	3,611	3,611	3,611	6,718	6,733	6,733	6,765	6,765	6,765
Number of id	143	142	142	102	102	102	241	241	241	449	450	450	451	451	451
AR(2)	0.051	0.171	0.133	0.931	0.876	0.922	0.181	0.335	0.343	0.261	0.298	0.302	0.282	0.251	0.294
Hansen Statistics	0.827	0.262	0.293	0.398	0.19	0.222	0.549	0.497	0.477	0.488	0.644	0.636	0.108	0.137	0.112

Table 5 presents two-step system GMM of the effect of capital on banks risk of well, adequately, under-capitalized, high and low liquid banks. The dependent variable is bank risk (ratio of risk weighted assets to total assets) traditional capital ratio. If the overall risk-based capital ratio (Tier 1 + II/Total Risk-weighted assets ratio) of banks is 10 percent or above is well-capitalized, if the ratio is less than or equal to 8 percent is considered undercapitalized, otherwise adequately capitalized banks. Based on their median value, commercial banks are classified as highly liquid or low liquid banks, banks with a higher ratio of liquid assets to deposits and short term funding than median are treated as highly liquid banks, and low liquid banks otherwise. Robust standard errors are reported in parentheses. ***, **, * represent statistical significance at 1%,5% and 10% respectively.

4.3. Well, adequately, and under-capitalized banks results

Table 5 columns 1 to 3 shows the results of well-capitalized banks. The results show that the traditional capital ratio, risk-based capital ratio, and capital buffer ratios of the well-capitalized banks have no influence on risk-taking, which is consistent with Shrieves and Dahl (1992). These results indicate that well-capitalized banks are not bound to build their capital with an increase in their risk in the short run because of lower restrictions and relax monitoring. The results are more valued for regulators to assess the behavior of well-capitalized banks to manage their capital and risk while observing the real story of risk-taking and the capital ratio simultaneously. **Table 5** columns 4 to 6 provide the results of adequately capitalized banks regarding the relationship between risk-taking and capital ratios. The findings reveal that the traditional capital ratio of adequately capitalized banks has no impact on bank risk-taking in the short run; other things remain similar, which is consistent with Shrieves and Dahl (1992). The results indicate that the relationship of risk-based capital ratio, capital buffer ratio and risk-taking are negatively related. The findings demonstrate that an increase in risk-based capital ratio and capital buffer ratio leads to a decrease in the risk of adequately capitalized banks. The findings are in line with (Jacques & Nigro, 1997; Lee & Hsieh, 2013; Zhang et al., 2008).

The results of **Table 5** Columns 7 to 9 show the findings of under-capitalized banks. The results reveal a positive and statistically significant connection between risk-taking and the traditional capital ratio of under-capitalized banks. The relationship between risk-based capital, capital buffer ratio and risk-taking is statistically significant and negative. **Table 5** columns 7 to 9 show the results of significantly under-capitalized banks. The results reveal that the relationship between traditional capital ratio and risk-taking is positive and significant. The positive correlation between capital and risk is supported by (Aggarwal & Jacques, 1998; Altunbas et al., 2007; Jokipii & Milne, 2011; Shrieves & Dahl, 1992). The findings indicate that risk-based capital, capital buffer ratio and bank risk-taking are negatively associated. The findings are consistent with the results of (Jacques & Nigro, 1997; Lee & Hsieh, 2013; Zhang et al., 2008). It means the under-capitalized banks required to build a buffer to reduce their risk in the short-run other things remain equal.

4.4. Highly liquid and low-liquid banks results

Table 5, column 10 to 12, shows the findings of the highly liquid commercial banks. The results show that the traditional capital ratio is not significant to influence the risk-taking of highly liquid banks. The results reveal that the relationship between risk-based capital ratio, capital buffer ratio, and bank risk-taking is negative and significant at 10% level of confidence. The negative correlation is consistent with (Jacques & Nigro, 1997; Lee & Hsieh, 2013; Zhang et al., 2008). The inverse relationship means the increase in risk-based capital and capital buffer ratio leads to a decrease in the riskiness of banks. **Table 5**, column 13 to 15, shows the results of low-liquid insured commercial banks. The results show that there is a positive and significant relationship between traditional capital ratio, risk-based capital ratio, capital buffer ratio and risk-taking of low liquid banks. The positive connection between risk-taking and capital ratios are supported by the regulatory hypothesis, as concluded by 1998; Jokipii & Milne, (2011); Shrieves & Dahl, (1992). The results are not similar to the highly liquid insured commercial banks because the low-liquid banks rely on the traditional capital ratio to boost their performance and highly liquid banks use risk-based capital ratios to manage their regulatory requirements.

4.5. Robustness

For robustness, the measure of risk-weighted assets is replaced with loan loss reserves. Each set of bank categories retested by using the loan loss reserves and find the results consistent with base outcomes expect the results of undercapitalized banks. The results also favor the increase in capital level with the increase in risk measured either in terms of risk-weighted assets or in terms of loan loss reserves. **Table 6** columns 1 to 3 contain overall sample results and columns 4 to 6 represents well-capitalized banks' findings. **Table 6** columns 7 to 9 presents adequately capitalized banks' results and columns 10 to 12 contains under-

Table 6. Robustness results- the impact of banks capital on risk

VARIABLES	Full Sample			Well capitalized			Adequately-capitalized			Under-capitalized banks		
	1	2	3	4	5	6	7	8	9	10	11	12
	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk
Logged risk	0.924*** (0.019)	0.938*** (0.018)	0.937*** (0.018)	0.795*** (0.102)	0.817*** (0.071)	0.819*** (0.068)	0.953*** (0.041)	0.947*** (0.041)	0.949*** (0.041)	1*** (0.090)	0.993*** (0.068)	0.993*** (0.069)
Traditional Capital ratio	0.0106*** (0.029)			0.0369 (0.024)			0.0247* (0.011)			0.161*** (0.047)		
Risk-based capital ratio		-0.036*** (0.004)			0.018* (0.009)			-0.009* (0.007)			0.038** (0.016)	
Capital buffer ratio			-0.032*** (0.004)			0.031* (0.014)			-0.011 (0.008)			0.049*** (0.018)
Observations	14,401	14,401	14,401	2,188	2,188	2,188	1,644	1,644	1,644	3,867	3,867	3,867
Number of id	903	903	903	138	138	138	104	104	104	242	242	242
AR(2)	0.551	0.271	0.103	0.731	0.576	0.622	0.151	0.572	0.313	0.631	0.571	0.622
Hansen Statistics	0.727	0.326	0.493	0.298	0.49	0.322	0.427	0.362	0.393	0.598	0.49	0.422

Table 6 presents the results of two-step system GMM method of the effect of capital on banks risk for full sample, well, adequately and under-capitalized banks. The dependent variable is bank risk (ratio of loan loss reserves to total assets). If the overall risk-based capital ratio (Tier I + II/Total Risk-weighted assets ratio) of banks is 10 percent or above is well-capitalized, if the ratio is less than or equal to 8 percent is considered undercapitalized, otherwise adequately capitalized banks. Robust standard errors are reported in parentheses. ***, **, * represent statistical significance at 1%, 5% and 10% respectively.

Table 7. Robustness results- impact of banks capital on risk for high and low liquid banks

	High liquid			Low liquid		
	1	2	3	4	5	6
	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk	Bank Risk
Lagged dep.	0.860** (0.107)	0.874** (0.144)	0.856** (0.137)	0.977** (0.026)	0.972** (0.026)	0.972** (0.026)
Traditional Capital ratio	0.061 (0.043)			0.002** (0.004)		
Risk-based capital ratio		0.005 (0.038)			0.008** (0.004)	
Capital buffer ratio			0.032 (0.051)			0.009** (0.004)
Observations	7,170	7,170	7,170	7,231	7,231	7,231
Number of id	450	450	450	451	451	451
AR(2)	0.854	0.871	0.933	0.053	0.450	0.592
Hansen Statistics	0.227	0.118	0.863	0.398	0.290	0.258

Table 7 presents results of two-step system GMM of the effect of capital on banks risk for high and low liquid banks. The dependent variable is bank risk (ratio of loan loss reserves to total assets). Based on their median value, commercial banks are classified as highly liquid or low liquid banks, banks with a higher ratio of liquid assets to deposits and short term funding than median are treated as highly liquid banks, and low liquid banks otherwise. Robust standard errors are reported in parentheses. ***, **, * represent statistical significance at 1%,5% and 10% respectively.

capitalized banks' results. Table 7 columns 1 to 3 consists of high liquid bank findings and columns 4 to 6 represents low liquid bank results. Most of the outcomes are consistent with the baseline results of each equation concerning the sign and significance. However, the minor variation may be explained due to the measurement of two different proxies, which was expected.

5. Conclusion

The study aims to investigate the impact of traditional capital ratio, risk-based capital ratio and capital buffer ratio on the risk-taking of commercial banks over the period ranging from 2002 to 2019 by using a two-step system GMM estimation. The results are more significant for regulators to observe the behavior of risk-taking and adjustment of bank capital of large insured commercial banks in the post-crisis with a comparison of pre- and pro-crisis periods. The insights of well, adequately, under, significantly undercapitalized, high liquid and low liquid enrich the regulators for the formulation of appropriate guidelines accordingly. The simple justifications of results are due to stringent regulations for capital requirements, the pressure of bankruptcy problem and managerial risk aversion. The findings indicate that banks have increased their capital level during the post-crisis period than the pre-crisis and pro-crisis period in response to higher capital requirements regulation suggested in 2010. Besides, the study concludes that the regulations commanded to decrease in risk-taking, especially in the post-crisis period, as evidenced by risk-weighted assets and loan loss reserves. However, the findings do not confirm whether the increase in bank capital is enough for risk-taking in the turmoil time. The results show that the traditional capital ratio and risk-taking ratio move in the same direction as per the theory of regulatory hypothesis. The relationship between risk-based capital ratio, capital buffer ratio and risk-taking is negative.

This observation appears to favor the hypothesis that insured commercial banks with a higher proportion of risk-based capital would have lesser chances of default. Therefore, by maintaining a higher percentage of risk-based capital against risky assets, commercial banks can lower the probability of default. The influence of bank capital ratios is not similar in pre-, pro- and post-crisis periods. The results show that the intensity of banks' risk-taking due to the increase in traditional capital ratio was higher in the pre-crisis as compared with pro- and post-crisis periods. The proportionate change in risk-taking against the change in capital ratio is lower during and post-crisis period, which supports the regulators' recommendations. The coefficients of the risk-based capital ratio show that the influence is more pronounced in the post-crisis period as compared with the pre-crisis period. However, the impact remains more significant during the crisis than before-crisis period.

The adequately and well-capitalized banks are not bound to build their traditional capital ratio with an increase in their risk because of lower restrictions and relax monitoring. The results are more valued for regulators to assess the behavior of well-capitalized banks to increase their capital and risk while observing the real story of risk-taking and the capital ratios of well-capitalized banks. The increase in risk-based capital ratio and capital buffer ratio of adequately capitalized banks decreases the risk. The rise in capital leads to an increase in the risk-taking of under-capitalized and significantly undercapitalized banks, as evidenced by risk-weighted assets. However, the increase in risk-based capital ratio and capital buffer ratio provide margin to absorb losses. The highly liquid banks risk-based capital ratio and capital buffer ratio reduce risk, whereas the traditional capital ratio does not influence the risk-taking of highly liquid banks. The behavior of low-liquid banks is not similar to highly liquid banks. The low-liquid banks increase their traditional capital ratio with the increase of risk. There is a positive relationship between risk-based capital ratios and risk-taking of low liquid banks. The results have implications for regulators to formulate risk mitigation policies according to the requirement of banks. In this study, we investigate the large commercial banks; for a more in-depth understanding, one can study by including the saving, cooperative, investment banks in the future.

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Notes

1. For detail see (<http://www.bis.org/bcbs/basel3.htm>.)
2. Basel Committee on Banking and Supervision
3. OLS = ordinary least squares, 2SLS = Two-stage least squares and 3SLS = Three-stage least squares
4. <https://www7.fdic.gov/idasp/advSearchLanding.asp>
5. <https://www.federalreserve.gov/releases/lbr/current/>
6. The dataset may suffer from survivorship bias, since only those banks are included in the dataset that maintain their availability throughout the study period.
7. <https://data.worldbank.org/indicator>
8. <https://www.heritage.org/index/>

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