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UDK: 336.71
DOI: 10.2478/jcbtp-2021-0016

Journal of Central Banking Theory and Practice, 2021, 2, pp. 109-131
Received: 15 December 2019; accepted: 28 April 2020

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How Do Bank Capital and Capital Buffer Affect Risk: Empirical Evidence from Large US Commercial Banks

Abstract: This research aims to investigate the influence of bank capital, risk-based capital and bank capital buffers on the behaviour of bank risk-taking by applying GMM on the data of US commercial banks ranges from 2002 to 2018. The findings show that bank capital has a positive influence on total risk. However, risk-based capital and capital buffer have a negative impact on total risk. In addition, the results showed that the relationship between bank asset risk and bank capital, risk-based capital and a capital buffer is negative in pre, amid and post-crisis periods. The findings also reveal that the result of bank capital, risk-based capital and a capital buffer is not similar in case of well, adequately, under, significantly under, and critically undercapitalized banks. Our conclusions have numerous implications for policymakers and regulators in the banking sector.

Keywords: Bank capital, Total Risk-Based Bank capital, Capital Buffers, Total Risk and Asset Risk.

JEL Classification: G21, G28, G32

1. Introduction

Bank capital and bank riskiness have been controversial topics recently for several reasons. Firstly, large banks always remain vital in crises. Secondly, banks are interrelated globally. Thirdly, large banks are required to maintain a high amount of capital to absorb losses. Based on Basel-II

developed in 2004, the Basel-III regulations were issued to focus more on assets risk to mitigate the bank-risk taking. In Basel-III, regulators suggest the higher amount of bank capital and put a great emphasis on tier-one equity capital to improve the loss-absorption capacity of banks in present conditions.

Theoretically, bank capital and bank risk can influence each other either positively or negatively. The mean-variance hypothesis framework suggests that a rise in capital indicates a fall in returns for banks. Therefore, banks take risky projects to increase their profits. In this sense, regulators suggest that banks must raise their ratio of capital in reaction to a rise in risk, which is known as a regulatory hypothesis. On the one hand, the progressive relation between bank risk-taking and capital is supported empirically by many studies (Aggarwal and Jacques (2001); Rochet (1992); Shrieves and Dahl (1992); Kim and Santomero (1988); Kufo (2015); Rime (2001); Teply and Matejašák (2007). On the other hand, a negative relationship between risk and bank capital does occur. According to the moral hazard hypothesis, banks take more risk owing to the deposit insurance plan. The agency theory may justify the high-risk taking; managers take a higher risk to get higher compensation. Several studies support the inverse relationship between bank capital and risk-taking (Jacques and Nigro (1997); Mongid, Tahir, and Haron (2012); Zhang, Jun, and Liu (2008); Raj Aggarwal and Kevin Jacques (1998); Altunbas, Carbo, Gardener, and Molyneux (2007); Lee and Hsieh (2013). Capital buffers mean to conserve an amount of capital higher than the minimum required capital of regulators. Besides, banks retain more capital than needed to show their soundness and to obtain a good rating from agencies (Jackson et al. (1999). Also, capital buffers are required to absorb losses that occur because of assets quality ((Allen & Saunders, 2002); Curry, Fissel, and Hanweck (2008). However, research investigating the impact of capital buffers and bank risk-taking are scarce (Jokipii and Milne (2008, 2011); (Guidara, Soumaré, & Tchana, 2013).

This research study attempts to investigate the effect of bank capital, risk-based capital, and capital buffers on the behaviour of banks risk-taking in the USA in pre, pro and post-crisis periods. The following questions are under discussion in the research. How do bank capital ratios influence bank risk? Is the impact of the bank capital different from risk-based capital and capital buffer? Is there any variation in the behaviour of risk-taking in pre, pro and post-crisis periods? Is the relationship between different capital definitions and risk-taking similar for well, adequately, under, significantly under and critically undercapitalized commercial banks?

The study is distinct from the previous reviews for the following reasons: First, the focus of the earlier studies is on inspecting the use of regulations and the role

of a fixed premium of insurance paid by banks and excessive risk-taking (Mayne (1972); Peltzman (1970); Kahane (1977); Koehn and Santomero (1980); Dahl and Shrieves (1990). This study also covers the current risk-taking behaviour of banks under the newly developed regulations of insurance and capital. Second, previous studies have included limited samples, limited periods, specific risk measures and common bank capital ratio (Angbazo (1997); Molyneux and Thornton (1992); Shrieves and Dahl (1992); R AGGARWAL and K Jacques (1998); Jackson et al. (1999); Aggarwal and Jacques (2001). The data used in this study cover an extended period between 2002 and 2018 to reach conclusions in a comparative context regarding risk and bank capital in the banking industry. Two proxies of risk are used, one for total risk and others for asset risk. The study provides the latest insights about the impact of bank capital on bank risk-taking in the USA under the new bank regulations.

The present research enriches the literature on bank capital and risk as follows. It investigates the influence of bank capital, capital buffers, and risk-based capital on bank risk using total risk and asset risk, which is limited to the post-crisis period in the USA banking industry. This research also covers the regulatory transition period ranging from 2002 to 2018. Besides, this study investigates the influence of capital buffers on bank asset risk and total risk for well, adequately, under, significantly under, and critically undercapitalized banks in the USA in the pre, during, and post-crisis periods. Moreover, this study provides a comparative analysis of bank capital buffers, risk-based capital, and bank capital by using the assets risk and total risk of banks in the USA. It also reviews the theoretical literature while focusing on the latest empirical results. This study provides empirical evidence for currently working in large commercial banks in the USA. It explores the importance of capital buffers in influencing the risk-taking of large commercial banks in pre-crisis, during-crisis and post-crisis periods in the USA banking industry.

The remainder of the study comprises of the following parts: the second Section corroborates the related literature. The third Segment contains data collection and econometric model requirements. Forth Chapter introduces the findings and the study. The final Section concludes the whole research.

2. Literature Review

Banking literature can be categorized into three types: primary literature on banking, banking literature on equity and debt-funded under Basel-I/II/III regulations on bank risk-based capital, and literature on bank leverage ratio and

bank liquidity requirements. This study is concerned with the third paradigm of banking literature.

2.1. The theoretical relationship between Bank Capital and Bank Risk

Several studies have found the relationship between bank capital and bank risk and risk-taking as positive. Iannotta, Nocera, and Sironi (2007) revealed that there is a direct relationship between credit risk and bank capital using a sample of European banks. Shrieves and Dahl (1992) explored the connection between bank risk and capital in their seminal paper. They were the first to use the risk-weighting concept in banking literature. In their study, they used banks' assets as risk factors based on their riskiness and their relation with bank capital. They also used bank capital as equity to total assets, and non-performing loans were used as assets quality. 3SLS methods were applied, and the study concluded a positive relationship between risk and capital. These findings support the theory of bankruptcy and risk aversion hypothesis. They also reveal the interdependence between risk and bank capital, and that they must be managed simultaneously. Altunbas et al. (2007) demonstrated in their research that the bank capital of large banks has a positive effect on bank risk-taking in Europe. They also found a positive impact of capital on saving banks in Europe. Rime (2001) investigated the relationship between risk-taking and adjustment of bank capital in the Swiss banking industry. The findings of their research support the suggestions of regulators about the increase in capital. However, the coefficient of capital was insignificant to influence bank risk. Awdeh, El-Moussawi, and Machrouh (2011) conducted a study using panel data of commercial banks for the period between 1996 and 2008. They used a Z-score for risk and equity to bank capital and used equity to risk-weighted assets ratio. Ghosh (2014) opined in his study that banks increase their capital with the upsurge of their risk as suggested by regulators. Thus, those banks adjust capital more rapidly, which leads to a risky portfolio as compared to others.

Regulatory hypothesis-1: bank capital and Risk-Based Bank capitals have a positive relationship with bank risk-taking

Several studies have found the relationship between bank capital and bank risk and risk-taking as negative. Jacques and Nigro (1997) used risk-based capital and risk-weighted assets as a risk variable in their study. They applied a 3SLS approach and found an inverse relationship between risk and capital. They contended that banks that have lower capital and higher risk raise their capital, and those which have higher capital and lower risk increase their risk or decrease their capital. Ag-

garwal and Jacques (2001) showed that the commercial banks in the US banking industry push their capital up in reaction to an increase in their risk as a prompt corrective action. They also used data for the period between 1993 and 1997. Lee and Hsieh (2013) inspected the relationship between risk, profitability, and capital in Asian banking, covering the period between 1994 and 2008. They found an inverse correlation between bank risk and capital. They argued that banks in Asia follow the moral hazard hypothesis. Zhang et al. (2008) inspected the impact of bank capital on bank risk in China's commercial banks covering the period between 2004 and 2006 and concluded that bank capital and risk have an inverse relationship. They concluded that changes in the capital have a negative impact on bank risk. Mongid et al. (2012) investigated the relationship between capital, inefficiency and bank risk in commercial banks of ASEAN countries covering the period ranging from 2003 to 2008. They use the 3SLS technique to test the relationship between risk and capital. They found that capital has a negative influence on bank risk, whereas the risk has no impact on bank capital. Altunbas et al. (2007) inspected the influence of capital on bank risk-taking in Europe using the data covering the period between 1992 and 2000. They concluded that there is a negative relationship between bank capital and bank risk in European cooperative banks. Agoraki, Delis, and Pasiouras (2011) concluded that requirements of capital, as suggested by regulators, decrease the risk of banks. They use data from Central Europe for the period between 1998 and 2005. Anginer, Demirguc-Kunt, and Zhu (2014) revealed a negative relationship between different bank capitals and bank risk while using the data of China and other economies.

Moral Hazard Hypothesis-2: bank capital and risk-based bank capital have a negative relationship with bank risk-taking

Bitar, Pukthuanthong, and Walker (2018) demonstrated in their study that risk-based bank capitals are ineffective in mitigating risk in banks. They used the banks' sample of the Organization for Economic Cooperation and Development (OECD) economies and collected data between 1999 and 2013. They concluded that risk-based bank capital is not appropriate for decreasing bank risk. Cathcart, El-Jahel, and Jabbour (2015) conducted a study to test the effectiveness of risk-based regulated capital and concluded that risk-based bank capitals are not enough to control the risk-taking in the banking industry. They indicated that there is a need to propose a new bank capital besides the risk-based bank capitals. Haldane (2012) found that risk-based bank capitals, as suggested by regulators, are not conclusive to decrease the risk of banks run. Dermine (2015) explained that regulatory capital does not reflect the actual loss absorption capacity, and there is a need to develop a non-risk based bank capital, which provides additional support to the regulatory ratios.

Hypothesis-3: bank capital and risk-based bank capital have no relationship with bank risk-taking

2.2. The theoretical and empirical relationship between Capital Buffer and Bank Risk

Different researchers have examined the relationship between capital buffers and bank risk. Jokipii and Milne (2008) concluded in their study conducted in Europe that banks usually create a higher amount of buffer due to the higher cost of capital adjustment. They found an inverse movement between the economic cycle and capital buffers for large commercial and for saving banks. They also revealed that small banks incline to increase their capital buffer during economic booms. Jokipii and Milne (2011) found that bank capital and risk have a positive and causal relationship in the US banking sector. They indicated that banks normally use capital buffers amount to adjust capital and risk. This relationship signifies that banks increase their capitalization with the increase in their risk. Guidara et al. (2013) explored the relationship between bank risk and bank capital buffers using the data of commercial banks of Canada, and they found that higher capitalized banks follow the market discipline. Anginer et al. (2014) showed that higher capital provides greater power to resist earning shocks. They demonstrated that higher capital buffers offer more confidence to stockholders to make full investments choices. Examples of other studies conducted to explore the bank buffers are Ayuso, Pérez, and Saurina (2004), Bitar et al. (2018), Fonseca and González (2010), and Valencia and Bolaños (2018).

Regulatory Hypothesis-4: Bank Capital Buffers has a positive relationship with bank risk-taking

3. Data and Methodology

3.1. Data Description

The data used in this research study were obtained for the US commercial banks for the period between 2002 and 2018. The banks were classified into the following two categories: Firstly, nationally charter banks, which are member banks of Federal Reserve Banks of the United States. Secondly, State charter banks, which were further categorized into state charter member banks and state charter non-member banks. The banks were selected based on their consolidated assets as reported in Federal Deposit Insurance Corporation (FDIC) and Federal Reserve

Banks (FRB) on 31 December 2018. The FDIC and FRB published a list of insured large commercial banks of the USA on 31 December 2018, including 1806 large commercial banks, out of which only 923 banks were selected for analysis. The bank selection criteria are quite simple: banks should have greater than three hundred million dollars assets on 31 December 2018 and active status as per the Federal Deposit Insurance Corporation. The data contain annual observations that started on 31 December 2002 and ended in 2018. Sufficient information was available about the bank capital from 2002 to date due to the implementation of regulations of the bank capital in the US. The data for this period is available about tier-one and tier-two risk-based capital and total equity capital, which is required to calculate the bank capital buffers, one of the key variables in this study.

3.2. Measurement of Variables

3.2.1. Risk, Definition, and Measurement

Risk is used as a key-dependent variable in this study. Following the previous studies, non-performing loans to gross loans are used as risk proxy for loan quality of banks (Berger and DeYoung (1997); Chaibi and Ftiti (2015); Ahmad and Ariff (2007); Bitar, Saad, and Benlemlih (2016); Valencia and Bolaños (2018); Ayuso et al. (2004)). Risk-weighted assets to total assets proxy were considered as total risks measure (Shrieves and Dahl (1992); Van Roy (2008); Rime (2001) and (Pfeifer & Pikhart, 2019).

3.2.2. Explanatory Variables Definitions and Measurement

Bank capital is used as an independent variable and is defined by using the instructions of regulators and previous literature. The simple non-risk based bank capital represents total equity capital to total assets (Altunbas et al. (2007); Lee and Hsieh (2013); Bitar et al. (2016); Guidara et al. (2013); (Kola, Gjipali, & Sula, 2019); Shrieves and Dahl (1992) and (Abbas, Iqbal, & Aziz, 2019). The element of risk called Risk-based bank capital include tier-I plus tier-II capital to risk-weighted assets (Jacques and Nigro (1997); Guidara et al. (2013); Bitar et al. (2016). The final definition of bank capital included in this study is capital buffers. This definition is based on the above both meanings, which means that capital buffers are the difference between the actual capital and required capital of banks (Jokipii and Milne (2008); Fonseca and González (2010); Valencia and Bolaños (2018); Guidara et al. (2013); Shim (2013) and (Abbas, Butt, Masood, & Javaria, 2019). Bank size is also used as an explanatory variable and measured as the natural

log of total assets (Rime (2001); Valencia and Bolaños (2018); Jacques and Nigro (1997); (Mashamba & Magweva, 2019). Revenue diversification proxy is also used (Shim (2013); and Stiroh (2004). The other variables include loans growth, liquidity (Hughes, Lang, Mester, and Moon (1995); Stiroh (2004), funding diversification Stiroh (2004), and operating efficiency (Jacques and Nigro (1997) which are held constant to explain the impact of different bank capitals on different proxies of risk in pre-crisis, during-crisis and post-crisis period. Table 1 summarizes the variables used in this study and related definitions.

Table 1

Variables Names	Definitions	References
Dependent Variables		
Total Risk	Risk-Weighted Assets to total assets	(Abbas, Masood, Ali, &, Rizwan, 2021)
Asset Risk	Non-performing loans to gross loans	(Ali, Shah, &, Chughtai, 2019)
Independent Variables		
Capital	Total equity to total assets	(Abbas, Ali, & Rubbaniy, 2021)
Risk-Based capital	Tier-I + Tier-II/Risk-Weighted Assets	(Abbas, Ali, Yousaf & Rizwan, 2021)
Capital Buffer	Actual Risk-based Capital less 8%	(Abbas, Yousaf, Ali, & Wong, 2021)
Liquidity ratio	The ratio of liquid assets to total assets	(Yousaf, Ali & Hassan, 2019a)
Loan growth	Yearly change in loans	(Abbas and Masood, 2020b)
Operating Efficiency	Operating expenses to total asset	(Abbas and Masood, 2020b
Income Diversification	1-(net income-operating income)/ operating income	(Stiroh, 2004)
Funding Diversification	$1-((equity/total)^2+(subordinate\ debt/\ total)^2+ (deposits/total)^2 + (short\ term\ fund/total)^2)$	(Abbas, Rubbaniy, &, Ali, 2021)
Size	Natural Log of total assets	(Yousaf, Ali and Hassan, 2019b)

3.3. Econometric Model

The primary purpose of this study is to investigate the effect of different proxies of capital buffer on bank risk. This relationship can be written in the static form in the following equation:

$$
\begin{aligned}
&Bankr\ Risk_{i,t} = \\
&\alpha + \beta_1 Bank\ Capital_{i,t-1} + \beta_2 \text{Liquidity Ratio}_{i,t} + \beta_3 Loans\ Ratio_{i,t} + \\
&\quad \beta_4 Operating\ Efficiencey + \beta_5 Income\ Diversification_{i,t} + \\
&\quad \beta_6 Funding\ Diversification_{i,t} + \beta_7 Bank\ Size_{i,t} + \varepsilon
\end{aligned} \tag{1}
$$

The static model cannot incorporate the problem of endogeneity, heteroscedasticity and serial correlation owing to this, the coefficient remains biased.

The estimation technique, which addresses the endogeneity, heteroscedasticity and serial correlation problem among variables in econometrics is GMM estimators introduced by Arellano and Bond (1991). The reasons to use a GMM instead of least square (OLS) and least-squares dummy variables (LSDV) are that these methods cannot incorporate the problem of endogeneity in panel data. OLS and LSDV provide inconsistent estimators with the availability of endogeneity in panel data sets. The availability of lagged series of dependent variables among explanatory variables makes GMM the best choice. To control the misspecification of GMM estimators, the significance of AR (1), the significance of AR (2) and Wald statistics as well were investigated. Arellano and Bond (1991) claimed in their dynamic panel setting that their method is better as compared to the conventional estimators due to the following reasons: Firstly, this method corrects the problems of heteroscedasticity, autocorrelation, and endogeneity in panel data sets. Secondly, the technique uses lagged numbers for dependent variables and solves the problem of instruments. Thirdly, this method provides an estimator which captures correlations among explanatory variables. The standard form of this model contains the lagged value of the dependent variable, which can be written as follows:

$$
\begin{aligned}
&Bankr\ Risk_{i,t} = \\
&\beta_1 Bankr\ Risk_{i,t-1} + \beta_2 Bank\ Capital_{i,t-1} + \beta_3 \text{Liquidity Ratio}_{i,t} + \\
&\beta_4 Loans\ Ratio_{i,t} + \beta_5 Operating\ Efficiencey + \beta_6 Income\ Diversification_{i,t} + \\
&\beta_7 Funding\ Diversification_{i,t} + \beta_8 Bank\ Size_{i,t} + \varepsilon
\end{aligned} \tag{2}
$$

Here *i* represents a cross-section, *t* represents time, *Bank Risk* represents a dependent variable (Total Risk and Asset Risk) $Bank\ Risk_{i,t-1}$ represents lagged variables for the dependent variable. Bank Capital, is independent variables (replaced by risk-based capital and capital buffer) represents explanatory variables, $Control_{i,t}$ represents control variables. The β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8 represent the coefficient and ε is error term in the above equation. This model is used to check the effect of bank capital, risk-based capital and capital buffer on the total as well as on assets risk. Moreover, the model is extended to get the insights of relationship in pre-, amid and post-crisis by using dummy variables and the model can be expressed in mathematics.

$$Bankr\ Risk_{i,t} = \beta_1 Bankr\ Risk_{i,t-1} + \beta_2 Bank\ Capital_{i,t-1} + \beta_3 \text{Liquidity Ratio}_{i,t} + \beta_4 Loans\ Ratio_{i,t} + \beta_5 Operating\ Efficiencey + \beta_6 Income\ Diversification_{i,t} + \beta_7 Funding\ Diversification_{i,t} + \beta_8 Bank\ Size_{i,t} + \beta_{10} During\ Crisis\ dummy_{i,t} + \beta_{11} Before\ Crisis\ dummy_{i,t} + \varepsilon$$

To enhance the scope of the study model, it is extended to investigate the depth of the relationship between risk and capital by categorized the sample into five groups named well, adequately, under, significantly under and critically under-capitalized banks by using dummy variables which can be expressed in the following way.

4. Results and Discussion

Table 2 contains the information of proxies used in this study. The descriptive statistics include the mean values, maximum values, minimum values, standard deviation values, and a number of observations for each variable. There are two proxies used as an indicator of risk: total risk, which has 11,410 annual observations with an average value of 0.724; the standard deviation is 0.116, where the minimum and maximum values are 1.072 and 0.385, respectively. The ratio of capital, risk-based capital and capital mean values are 0.106, 0.141, and 0.063, respectively.

Table 2: Descriptive Statistics

Variable	Obs	Mean	S.D	Min	Max
Total Risk	11,410	.724	.116	.385	1.072
Assets Risk	11,410	.200	.006	-.017	.025
Bank capital	11,410	.106	.031	.067	.518
Risk-based capital ratio	11,410	.141	.045	0.01	.339
Capital Buffer	11,410	.063	.039	-.006	.257
Liquidity Ratio	11,410	.054	.044	.010	.267
Loans Growth	11,410	.716	.146	.353	1.065
Operating Efficiency	11,410	.029	.013	.010	.169
Income Diversification	11,410	.451	.162	-.887	.659
Funding Diversification	11,410	.555	.014	.492	.626
Size	11,410	13.613	1.329	10.08	18.749

Source: Author's Calculations by using Stata

Table 3 contains correlations and results indicate that variables have quite a suitable correlation with each other and there is no problem of multicollinearity. The signs of the correlation matrix are as per the economic theory and reported in results. The results show that the bank capital buffer and risk-based capital are correlated negatively with each other in case of the total as well as with asset risk. According to the coefficient signs, bank capital and total risk are found to correlate positively and bank capital and asset risk are negatively correlated.

Table 3: Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Total Risk	1										
Asset Risk	0.06	1									
Bank Capital	0.01	-0.05	1								
Risk-based capital	-0.48	-0.07	0.48	1							
Capital Buffer	-0.51	-0.08	0.53	0.05	1						
Liquidity	-0.14	-0.04	0.05	0.20	0.20	1					
Loan Growth	0.68	0.10	-0.11	-0.43	-0.46	-0.14	1				
Efficiency	0.02	-0.01	0.02	0.01	0.01	0.09	-0.02	1			
Income Diversification	0.01	-0.10	0.04	0.04	0.05	-0	-0.04	0.05	1		
Funding Diversification	0.03	-0.02	0.08	0.41	0.45	-0.01	-0.10	0.05	0.05	1	
Size	0.12	-0.02	0.13	-0.11	-0.12	-0.05	-0.03	-0.04	0.24	0.27	1

Source: Author's Calculations by using Stata

4.1. Full Sample Results for Risk-taking and Capital ratios

Table 4 Panel-A contains the results of bank total risk dependency on bank capital, risk-based capital and bank capital buffer of large commercial banks. The coefficient of lagged risk is positive and statistically significant, which means that the bank lagged total risk is contributing to the current total risk. The impact of bank capital is positive and significant at 1% significance level on risk, which means a one-unit increase in bank capital leads to an increase of 0.835 units in bank total risk, which is similar to the findings of Jacques and Nigro (1997), Rime (2001) and Shrieves and Dahl (1992). The effect of risk-based capital on bank risk is negative and significant, which means a one-unit increase in risk-based capital leads to a decrease of 0.872 units in risk at a 1% level of significance, which is similar to Jokipii and Milne (2011). The findings show that Bank capital buffer and total bank risk have an inverse relationship, which means a one-unit increase in bank capital buffer leads to a decrease of 1.180 bank risk at a one percent level of significance, which is similar to Jokipii and Milne (2011) findings. The effect

of the control variable, i.e., loan growth, operating efficiency, and income diversification, is positive on bank risk-taking. The liquidity ratio and funding diversification have a negative connection with bank risk in the short run. It means the availability of liquid assets and more than one option to get funds to cause a decrease in bank risk.

Table 4 contains the results of a two-step GMM method and robust standard errors in parentheses. The dependent variables: Total Risk and Assets Risk independent variables: Bank capitals, Risk-Based capital, and Capital Buffer.

VARIABLES	Panel-A			Panel-B		
	Total Risk	Total Risk	Total Risk	Asset Risk	Asset Risk	Asset Risk
Lagged .Total Risk	0.662***	0.530***	0.488***	-0.0381**	-0.0254	-0.0306
	(0.0287)	(0.0313)	(0.0324)	(0.0190)	(0.0191)	(0.0187)
Bank capital	0.835***			-0.104***		
	(0.216)			(0.0277)		
Liquidity Ratio	-0.734***	-0.610***	-0.573***	-0.00393	-0.00169	-0.000328
	(0.0300)	(0.0333)	(0.0345)	(0.00381)	(0.00405)	(0.00402)
Loans Growth	0.0719***	0.0381***	0.0259**	0.0102***	0.00990***	0.00885***
	(0.0125)	(0.0127)	(0.0125)	(0.00139)	(0.00153)	(0.00150)
Operating Efficiency	0.345***	0.296***	0.288***	0.00565	0.00138	0.00196
	(0.112)	(0.109)	(0.109)	(0.0129)	(0.0125)	(0.0131)
Income Diversification	0.0227***	0.0353***	0.0367***	-0.0106***	-0.00984***	-0.00857***
	(0.00674)	(0.00639)	(0.00646)	(0.00186)	(0.00174)	(0.00173)
Funding Diversification	-0.773**	2.044***	2.559***	0.193***	0.0309	0.0455**
	(0.388)	(0.364)	(0.400)	(0.0534)	(0.0205)	(0.0208)
Size	-0.00222	0.00605	0.00880**	0.00340***	0.00262***	0.00290***
	(0.00392)	(0.00376)	(0.00394)	(0.000497)	(0.000476)	(0.000493)
Risk-Based Capital		-0.872***			-0.0177**	
		(0.151)			(0.00751)	
Capital Buffer			-1.180***			-0.0236***
			(0.166)			(0.00822)
Constant	0.589***	-0.764***	-1.099***	-0.145***	-0.0525***	-0.0656***
	(0.210)	(0.182)	(0.213)	(0.0280)	(0.0113)	(0.0116)
Observations	11,410	11,410	11,410	11,410	11,410	11,410
Number of ids	923	923	923	923	923	923
No. of Instruments	128	128	128	113	113	113
AR-2	0.3800	0.2172	0.3188	0.1919	0.2339	0.2486

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

Table 4 Panel-B shows the banks' assets risk dependency on bank capital, risk-based capital and a capital buffer of large commercial banks in the US banking industry. The coefficient of lagged assets risk is significant in the case of bank capital and insignificant in the case of risk-based capital and capital buffer. It means assets lagged risk contributes to current assets risk when the bank capital is used as an explanatory variable. The effect of bank capital, risk-based capital and capital buffer on asset risk of banks is statistically significant and negative similar to Jokipii and Milne (2011). The results show that the influence of bank capital is not similar to the influence of total risk and assets risk, which means bank capital decreases the risk of assets and increases the total risk of large commercial banks. The effect of the control variables i.e. loans growth and funding diversification is positive on bank assets risk, whereas the effect of income diversification is negative at a one percent level of significance in the short run; other things remain constant.

4.2. Results for Pre, During and Post Crisis period

In Table 5 Panel-A, dummies are used to differentiate the effect of bank capitals on total risk for three groups in a crisis. The first is before-crisis dummy, the second is a during-crisis dummy, and without the dummy, the results will be considered as after crisis period. The results show that the impact of bank capital was different during the three periods. The findings indicate that the after crisis group coefficient was significant and positive, which is similar to (Shrieves & Dahl, 1992), and (Rime, 2001). It means a one-unit increase in bank capital will lead to an increase of .853 units in total risk. Before the crisis slope dummy is significant and negative as provided by Jokipii and Milne (2011), so net coefficient for the before crisis period will be reduced by 0.0787, and net value will be positive as found by Jokipii and Milne (2011). The third dummy during the crisis was also negative and significant, which reduced the coefficient by 0.021, and the net relation remains positive. The coefficient of during-crisis dummy and before-crisis dummy is negative and significant, which means that the impact of risk-based capital and capital buffer remains the same during-crisis, before-crisis, and after-crisis. The negative coefficient of during and before a crisis indicates that risk-based capital and capital buffer reduce the total risk of banks with greater intensity than after-crisis. However, the findings reflect that the effect of a capital buffer is greater than risk-based capital to reduce total risk during-crisis, before-crisis, and after-crisis, other things remaining constant. The results are supporting the recommendations of regulators.

In Table 5 Panel-B, dummies are used to differentiate between the effects of bank capitals on bank asset risk for three periods, including before-crisis, during-crisis, and after-crisis. The results show that the effect of bank capitals was not similar during three periods. The after crisis coefficient was significant and negative, which is similar to the results reached by Jokipii and Milne (2011). The coefficients for pro and pre-crisis were significant and positive, which is similar to the findings of (Jokipii & Milne, 2011) in the short run. The findings reveal that in before crisis, the net effect of capital remains negative with assets risk. However, the risk-reducing intensity goes down from 0.0459 to 0.0284 pre-crisis. The impact of bank capital during-crisis remains negative to influence assets risk. However, the intensity to reduce risk drops down from 0.0459 to 0.0075 during-crisis.

Table 5 contains the results of a two-step GMM method and robust standard errors in parentheses. The dependent variables Total Risk and Assets Risk independent variables Bank capitals, Risk-Based capital, and Capital Buffer.

VARIABLES	Panel-A			Panel-B		
	Total Risk	Total Risk	Total Risk	Asset Risk	Asset Risk	Asset Risk
Lagged Risk	.660***	.556***	.521***	-.0460***	-.0351**	-.0413**
	(.0310)	(.0311)	(.0324)	(.0173)	(.0175)	(.0172)
Bank capital	.852***			-.0459**		
	(.225)			(.0209)		
Before Crisis dummy	-.0787**	-.113***	-.116***	.0175***	.0160***	.0181***
	(.0314)	(.0313)	(.0325)	(.00413)	(.00403)	(.00392)
During Crisis dummy	-.0210	-.0828***	-.0933***	.0384***	.0375***	.0371***
	(.0243)	(.0223)	(.0218)	(.00385)	(.00376)	(.00371)
Risk-Based Capital		-.881***			-.00542	
		(.157)			(.00511)	
Capital Buffer			-1.199***			-.00812
			(.177)			(.00618)
Constant	.728***	-.623***	-.989***	-.0930***	-.0474***	-.0576***
	(.225)	(.208)	(.246)	(.0206)	(.0106)	(.0106)
Observations	11,410	11,410	11,410	11,410	11,410	11,410
Number of ids	923	923	923	923	923	923
No. of Instruments	130	130	130	115	115	130
AR-2	.3222	.1961	.2955	.4685	.4960	.2955

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

4.3. Results for well, adequately, under, significantly under, and critically undercapitalized banks

In Table 6 Panel-A, the results indicate that dummies are used to differentiate the effect of bank capitals on total risk for well, adequately, under, significantly under, and critically undercapitalized banks. The coefficient of well-capitalized bank capital is positive and statistically significant, which means that the capital of well-capitalized banks increases the total risk of banks, similar to Rime (2001), Jacques and Nigro (1997) and Shrieves and Dahl (1992). The impact of risk-based capital remains important for well-capitalized, undercapitalized, and significantly undercapitalized banks for total risk. The results show that the risk-based capital decreases the total risk of well-capitalized banks, undercapitalized banks, and significantly undercapitalized banks. However, an increase in one unit of risk-based capital of well-capitalized banks decreases the 0.902 units of total risk. A one-unit increase in risk-based capital of undercapitalized banks decreases 0.697 units of total risk, and a one-unit increase in total risk-based capital of significantly undercapitalized banks decreases 0.754 unit of total risk, similar to Jokipii and Milne (2011). Similar results are found for bank capital buffer to influence the risk-taking of well-capitalized, undercapitalized, and significantly undercapitalized banks.

In Table 6 Panel-B, dummies are used to differentiate between the effects of bank capitals on assets risk for well, adequately, under, significantly under, and critically undercapitalized banks. The coefficients of dummies show that the effect of well, adequately, and significantly undercapitalized banks remain similar. In contrast, the effect of bank capitals on assets risk is different in the case of under, and critically undercapitalized banks in the short run, other things held constant. The impact of capital on bank asset risk is only significant in the case of bank capital. Total risk-based capital and capital buffer decrease the risk of the assets of undercapitalized banks in the short run, other things held constant. The results show that the sign of control variables loan growth and funding diversification is positive to influence the risk of the assets of banks. In contrast, income diversification is negatively related to asset risk.

Table 6 contains the results of a two-step GMM method and robust standard errors in parentheses. The dependent variables Total Risk and Assets Risk independent variables Bank capitals, Risk-Based capital, and Capital Buffer.

VARIABLES	Panel-A			Panel-B		
	Total Risk	Total Risk	Total Risk	Asset Risk	Asset Risk	Asset Risk
Lagged Risk	.663***	.540***	.499***	-.0392**	-.0273	-.0327*
	(.0286)	(.0309)	(.0317)	(.0189)	(.0190)	(.0187)
Bank capital	.879***			-.0644*		
	(.266)			(.0358)		
Adequately Capitalized dummy	-.252	.191	.264	-.0130	-.0218	-.0189
	(.515)	(.383)	(.381)	(.0329)	(.0257)	(.0262)
Undercapitalized dummy	-.0716	.205***	.243***	-.0347**	-.0232**	-.0212**
	(.135)	(.0738)	(.0770)	(.0166)	(.00966)	(.00941)
Significantly undercapitalized dummy	.0329	.148***	.151***	-.0169	-.0111	-.00756
	(.0921)	(.0424)	(.0434)	(.0103)	(.00710)	(.00633)
Critically Undercapitalized dummy	.0088	-.136	-.115	.0565***	.0219	.0189
	(.207)	(.187)	(.205)	(.0172)	(.0261)	(.0237)
Risk-Based Capital		-.902***			-.0143*	
		(.151)			(.0741)	
Capital Buffer			-1.215***			-.0199**
			(0.165)			(0.00804)
Constant	.587***	-.482***	-.785***	-.144***	-.0788***	-.0850***
	(.213)	(.175)	(0.201)	(0.0287)	(0.0166)	(0.0158)
Observations	11,410	11,410	11,410	11,410	11,410	11,410
Number of ids	923	923	923	923	923	923
No. of Instruments	132	132	132	117	117	117
AR-2	.3567	.3084	.2380	.1907	.2299	.3053

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

4.4. Robustness Check

In this section, we discuss the robustness of our baseline results. We include the economic growth in the original model to test the role of economic condition to influence the relationship of bank risk-taking and different capital ratios. The findings seem to be a consistent sign and significance with baseline results. To save space, we only reported the coefficients to study direction and significance.

In detail, Table 7 panel-A contains the results for overall sample columns 1 to 3 and 4 to 6 for total risk and assets risk, respectively. In Table 7 Panel-B, a similar pattern is used to report the results for well, adequately, under, significantly under, and critically undercapitalized commercial banks.

Table 7 contains the results of a two-step GMM method and robust standard errors in parentheses. The dependent variables Total Risk and Assets Risk independent variables Bank capitals, Risk-Based capital, and Capital Buffer.

Panel-A	1	2	3	4	5	6
VARIABLES	Total Risk	Total Risk	Total Risk	Asset Risk	Asset Risk	Asset Risk
Bank capital	0.785***			-0.124***		
	(0.126)			(0.0376)		
Risk-Based Capital		-0.785***			-0.0242**	
		(0.211)			(0.0521)	
Capital Buffer			-.980***			-0.0316***
			(0.236)			(0.0042)
Panel-B	Well, Adequately, Under, Significantly, Critically Under-capitalized banks					
Bank capital	.799***			-.0543*		
	(.366)			(.0258)		
Adequately Capitalized dummy	-.352	.292	.364	-.0230	-.0318	-.0109
	(.145)	(.430)	(.351)	(.0291)	(.0475)	(.0361)
Undercapitalized dummy	-.0176	.305***	.433***	-.0447**	-.0332**	-.0311**
	(.235)	(.0348)	(.0670)	(.0266)	(.00166)	(.00242)
Significantly undercapitalized dummy	.0293	.241***	.141***	-.0219	-.0100	-.00516
	(.1021)	(.0324)	(.0534)	(.0203)	(.00510)	(.00363)
Critically Undercapitalized dummy	.0118	-.116	-.125	.0515***	.0220	.0209
	(.217)	(.207)	(.215)	(.0212)	(.0361)	(.0327)
Risk-Based Capital		-1.102***			-.0243*	
		(.251)			(.0641)	
Capital Buffer			-1.115***			-.0219**
			(0.156)			(0.0104)

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

5. Conclusion

Using a balanced panel of the US large commercial banks data for the period between 2002 and 2018, the study explores the relationship between bank capital,

risk-based capital and capital buffer with total risk and asset risk of banks. The results show the adjustment of different bank capital ratios for total and asset risk in the short run, ceteris paribus. The findings support the suggestions and recommendations of regulators that total bank risk and asset risk are related to the level of bank capitalization. The effect of total bank capital on total risk of well, adequately, under, significantly under, and critically undercapitalized banks is positive. However, the impact of risk-based capital and a capital buffer is negative. The relationship between bank capital and total risk remains similar in all categories of banks. In contrast, the effects of risk-based capital and capital buffers on total risk are different in the case of under and significantly undercapitalized banks. The impact of bank capital, risk-based capital and a capital buffer on the total risk of commercial banks are not similar in pre,amid and post-crisis. The bank capital, risk-based capital and capital buffer influence asset risks negatively. However, the impact of risk-based capital and bank capital is not significant in the pre- and during-crisis period.

The results show that bank capital and total risk have an inverse relationship in pre and during-crisis. In contrast, the association is positive in post-crisis, which indicates and signifies the impact of banking regulations of 2010 on increasing the bank capital with a rise in risk. The findings show that bank risk-based capital and capital buffer remain important for under and significantly undercapitalized banks to mitigate their total risk in the short run. Risk-based bank capital and capital buffer reduce the risk of banks, but this is difficult to maintain for all the banks. The results indicate that impact of capital buffer and risk-based capital remain lower for undercapitalized and significantly undercapitalized banks. The study concludes that the effect of bank capital, risk-based capital, and the capital buffer is not similar in well, adequately, under, significantly under, and critically undercapitalized banks in the USA. The impact of bank capital on asset risk remains similar for adequately under, significantly under and well-capitalized banks. In contrast, the effect of bank capital on assets risk is different in undercapitalized and significantly undercapitalized banks. The influence of risk-based capital and capital buffer on the risk of the asset remains similar in the case of well, adequately, significantly under, and critically undercapitalized banks.

The results show that the effect of bank capital is not similar during the three periods. The results indicate that post-crisis group coefficients are significant and negative; however, the coefficients for pre and during crisis are significant and positive. The findings also reveal that bank capital buffer and risk-based capital are not useful tools for asset risk.

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