Does prudential capital reduce bank risktaking? Empirical evidence from the Indonesian banks industry

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Article Type: Research Paper

Does prudential capital reduce bank risk-taking? Empirical evidence from the Indonesian banks industry

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THIS ARTICLE IS AVALILABLE IN:
http://journal.umy.ac.id/index.php/esp

DOI: 10.18196/jesp.v24i1.17696

CITATION:
Salim, A., & Suripto, S. (2023). Does prudential capital reduce bank risk-taking? Empirical evidence from the Indonesian banks industry. *Jurnal Ekonomi & Studi Pembangunan, 24*(1), 182-197.

ARTICLE HISTORY
Received:
23 Jan 2023
Revised:
23 May 2023
Accepted:
29 May 2023

Abstract: The implementation of macroprudential supervision, significantly tighter capital regulation in developing economies, has recently been debated, which focuses on reducing bank risk-taking and promoting financial stability in the banking sector. Our study investigates the impact of prudential capital on commercial bank risk-taking in Indonesia. We employed a GMM system approach to analyze bank and macro level data from 2004 to 2019. Our result confirms that appropriate capital regulations for reducing bank risk-taking are heterogeneous. Traditional capital ratios decrease bank risk-taking. However, the risk-based capital ratio shows an unexpected affirmative effect. Implementing macroprudential policy instruments of capital buffer effectively manages bank risk, and so does the regulatory capital pressure variable. The results are intimate for guiding commercial banks' risk management and capital effectiveness.

Keywords: Macroprudential Policy; Financial Stability; Bank Risk-Taking; Prudential Capital Buffer; Regulatory Capital Pressure
JEL Classification: E58; G21; G28

Introduction

Capitalization has been essential in mitigating bank risk since the commencement of a universal model, the 1988 Basel I, 2004 Basel II, and 2010 Basel III accords. Implementing Basel III required regulators to maintain the capitalizations of their commercial banks (Abbas, Ali, et al., 2021; Jiang & Zhang, 2017). Generally, Basel III has three kinds of capital regulation: capital adequacy ratio, the risky asset of tier-one capital ratio, and tier-one standard equity ratio. It promotes that the most analyzed capitalization topics are around these three ratios. Das & Rout (2020) found an affirmative correlation involving bank risk activity and adequacy of capital. Anginer et al. (2021), Illueca et al. (2022), Mateev et al. (2021), Le et al. (2022), and Son et al. (2022) show a positive correlation between equity ratio on the financial stability of commercial banks or adversely affects bank risk-taking. However, they generally utilized risk-based and non-risk-based capital requirements to examine how market capitalization affected bank risk-taking. They do not include macroprudential capital instruments in mitigating financial risk and promoting recently implemented stability.

Nowadays, macroprudential policy has an important position in the financial aspects of many countries (Davis et al., 2022; De Schryder & Opitz, 2021; Gaganis et al., 2020; Igan et al., 2022). Implementing macroprudential policy instruments is not a new regulation in the financial system. However, the adjustment of macroprudential policy instruments is intensive, notably in the light of the worldwide downturn of 2007–2008 (Maatoug et al., 2019; Noman et al., 2017; Ovi et al., 2020; Tongurai & Vithessonthi, 2020; Zhang et al., 2018). The period of the most implemented prudential policy is also the beginning year for the implementation of macroprudential policy in developing countries to mitigate and prevent future bank risk-taking, promoting financial stability.

Issues regarding implementing the macroprudential policy have emerged among the studies of scholars and policymakers (Gaganis et al., 2020; Igan et al., 2022). The majority of previous investigations emphasized the variability impact of time-varying policy and the implementation of macroprudential instruments (Ćehajić & Košak, 2022; Davis et al., 2022; De Schryder & Opitz, 2021; Ekananda, 2022; Fabiani et al., 2022; Gaganis et al., 2020; Igan et al., 2022). In particular, Ćehajić & Košak (2022), Fabiani et al. (2022), and De Schryder & Opitz (2021) show an inverse effect of prudential capital requirements on the credit supply of commercial banks.

The impact analysis by Ćehajić & Košak (2022) studied on how macroprudential policy affects the accessibility of small and medium enterprises (SMEs) to banks' financial intermediation. They use monthly panel data of firms' levels from January 2009 to February 2011. The results revealed a negative correlation between capital requirement tightening and the financial flow to the SMEs. Specifically, more tightening capital and macroprudential requirements, a decline of private sectors could access bank financing. With stricter access to financial intermediation, they conclude that tighter saving requirements produce more credit to small and medium enterprises (SMEs) in European countries. However, the loosening of capital rules shows an inverse effect. Furthermore, they also analyzed the effect of liquidity tightening and loosening on financial intermediation. They reveal a negatively significant impact of liquidity loosening but an insignificant effect of liquidity tightening due to some activities for searching a huger yield by choosing a riskier investment.

Study on prudential capital requirements with a higher sample by Gaganis et al. (2020). They investigated the variability effect of ten macroprudential instruments on bank-risk taking for 356 banks from 50 selected countries. The result shows an inverse relationship between macroprudential policy and bank risk-taking. It confirms that a tighter policy would lower the risk taken by commercial banks operations. Overall, they conclude that implementing macroprudential instruments reduces bank risk-taking, boosting financial stability. However, both impactful studies by Ćehajić & Košak (2022) and Gaganis et al. (2020) employed aggregate macroprudential policy indicators and did not provide different effects of each instrument implemented.

In the disaggregate macroprudential instrument, the impact of capital control on smoothing credit booms was analyzed by Fabiani et al. (2022). They employ quarterly panel data from the second quarter of 2005 to the second quarter of 2008 to analyze a source of bank loans over the implementation of macroprudential policy in Colombia. They found that an increase in the reserve requirements worsens credit supply, especially for non-profitable firms. Furthermore, De Schryder & Opitz (2021) examine the effect of typical macroprudential on bank lending in 13 European countries using panel data from 1999 to 2018. They found that decreased reserve requirement loss reduces consumer credit to GDP and bank credit to GDP ratio in selected EU economies. Igan et al. (2022) support De Schryder & Opitz (2021) study that tighter reserve requirements and regulations weaken bank risk-taking across 52 economies. These studies conclude that the policy regarding reserve requirements reduces bank risk-taking by eliminating non-profitable financing.

Other disaggregate macroprudential indicators were applied by Davis et al. (2022), who analyzed the effect of macroprudential policy on bank earnings. The result shows a inverse impact of macroprudential instruments on profitability for over 7250 global banks for over 57 emerging and 35 advanced economies. However, they focused on bank's profitability rather than risk-taking indicators. The implementation of the countercyclical capital buffer (CCB) instrument has insignificantly negative for developing economies but significantly favorable effects on bank profitability in developed countries. It means that a sharp tightening of CCB reduces banks' profit in emerging economies, but improves richer countries' bank profitability. They also applied loan-to-value, and the results remained the same for both groups of economies.

Most of the previous studies implement the aggregate macroprudential policy indicators (Ćehajić & Košak, 2022; Gaganis et al., 2020). Other studies use the central bank reserve requirement to represent prudential capital requirements affecting bank financial intermediations (De Schryder & Opitz, 2021; Fabiani et al., 2022; Igan et al., 2022; Johari et al., 2022). Another complete implementation of disaggregate macroprudential indicators focused on implementing each instrument on banks profit earnings (Davis et al., 2022). Moreover, they employed a group of countries that may reveal different characteristics of each economy. Other, so far as we are concerned, research on the evaluation of macroprudential policy instruments focused on capitalization, such as prudential buffer and regulatory capital pressure across several types with a single country to reduce bias caused by different scales of economies and to employ specific prudential capital instrument, are scarce. Thus, our study tries to fill the gap by examining capitalization's effect, which focuses on the effectiveness of prudential capital buffer as one of the macroprudential policy instruments and regulatory capital pressure on bank risk-taking in strengthening financial stability. Employing a single country observation, Indonesia, that has different groups of banks and possible indices of domestic-systematically important banks (D-SIB) appears, our study provides a discussion with completed real data for each sample bank from their report to financial service authority of Indonesia.

This study comprises the implementation impact of prudential and non-prudential capital on bank risk-taking of Indonesian commercial banks. Furthermore, We operate the system of generalized method of moments (GMM-SYS) found by Arellano & Bond (1991) and Blundell & Bond (1998) in accordance to limit the potential endogeneity issues. In various ways, our manuscript contributes to the body of knowledge on the capitalization of bank risk-taking. First, this study covers the period before 2007 and after 2009, using six different groups of commercial banks data for deeper analysis. To the best of our knowledge, we clearly ensure that our study is the first comprising different group of banks in the case of risk-taking analysis in Indonesia. Second, other studies use a non-risk-adjusted capitalization ratio such as Anginer et al. (2021), Das & Rout (2020), Illueca et al. (2022), Mateev et al. (2021), Le et al. (2022), and Son et al. (2022), while we employ both risk-adjusted capitalization ratios and prudential capital buffers to cover the implementation of macroprudential policy instruments. Third, we also contribute to extending the capital buffer ratio by adding regulatory capital pressure to provide a deeper capitalization analysis for specific domestic-systemically important banks (D-SIB) regulations. In the case of Indonesia, with different bank types and systemically commercial banks, this study first implements the regulatory capital pressure as an additional macroprudential instrument to capture the D-SIB phenomenon. Finally, the results are essential for policymakers to observe the variability effect of different capitalizations and provide a new guideline for banking stability.

The complete procedure of this study is divided into different sections: Part two is devoted to methodology, the third chapter informs the analysis and discussion of the research result, and the last section concludes the overall manuscript.

Research Method

Data

This study used yearly panel data containing two types of data sets, bank scope level, and macroeconomic level, from 2004 to 2019. The original dataset was mainly extracted from the official site of the Central Bank of Indonesia (BI), the Financial Service Authority (FSA) of Indonesia, and the Indonesian Central Bureau of Statistics. This study analyzed the risk-taking of 18 conventional commercial banks in Indonesia. Generally, Indonesia categorizes banks into six groups. We used the top three sizes of banks in each group. The size of banks used in this study is size data in 2019 as the last period of the reported bank to the FSA.

Table 1 Indicators of Variable Measurement

Variable Name	Measurement	Source
Bank risk-taking	Z-score	Compiled from Financial Service Authority
Bank specific control		
1. Bank size (BAS)	The logarithm of total asset	Compiled from Financial Service Authority
2. Asset composition (ASC)	Loan-to-asset ratio	Compiled from Financial Service Authority
3. Operational efficiency (OPE)	Income to asset ratio	Compiled from Financial Service Authority

Table 1 Indicators of Variable Measurement (cont')

Variable Name	Measurement	Source
Capitalization		
1. Traditional capital ratio (TCR)	Total equity/Total asset	Compiled from Financial Service Authority
2. Risk-based capital ratio (RCR)	Capital adequacy ratio	Compiled from Financial Service Authority
3. Capital buffer ratio (CBR)	The differential between RCR and minimum regulatory requirement	Compiled from Financial Service Authority and Bank Indonesia
4. Regulatory capital pressure (RCP)	The differential between RCR and standard deviation of CAR and minimum regulatory requirement	Compiled from Financial Service Authority and Bank Indonesia
Macroeconomic control		
1. Real GDP	Natural log of real GDP	Indonesian Central Bureau of Statistics
2. Inflation rate	Consumer price index	Indonesian Central Bureau of Statistics
3. Interest rate	Bank Indonesia rate	Bank Indonesia

Model Specification

We built an empirical model with a few associated variables to experimentally investigate capitalization's impact on risk-taking. The dependent variable is bank risk-taking, which uses the Z-score as a proxy. We divide the independent variables into three groups. First, bank-specific operational factors include bank size, amenities and infrastructure, and operational performance. Second, capitalization is the primary variable estimate of this study, which focuses on four types of capitalization, such as traditional capital ratio (TCR), risk-based capital ratio (RCR), and capital buffer ratio (CBR). We add the extended variable, the regulatory capital pressure (RCP), to provide a more specific analysis. The third is macroeconomic control variables, which include inflation rate and real GDP growth. Thus, we employ a general regression model as follows:

$$Z_{it} = \alpha + \beta BSC_{it} + \vartheta CAP_{it} + \emptyset MAC_{it} + \varepsilon_{it} \quad (1)$$

Where i = 1 to N and t = 1 to T, N is the figure of individual banks, T is time, and α, β, ϑ, $\emptyset$ are approximated parameters. Z_{it} refers to the risk-taking for bank i at time t, which Z-score as a proxy. BSC_{it} represents bank characteristics for bank i at time t. CAP_{it} indicates the effect of types of capitalization. MAC_{it} shows the effect of macroeconomic conditions, and ε_{it} represents the error term.

Variable Measurement

Bank Risk-Taking

We employ bank risk-taking as an explained variable by calculating Z-score as a primary ratio. The essential idea of using Z-score measurement is the capitalization and returns variability of the bank. It reveals efficiency with minimum insolvency of a bank (Adu, 2022; Gaganis et al., 2020). We determine Z-score as follows (Illueca et al., 2022; Moudud-Ul-Huq, 2019; Son et al., 2022; Toh & Zhang, 2022):

$$Z_{it}=\frac{ROA_{it}+E_{it}/TA_{it}}{\delta\ ROA_{it}}$$

Where Z_{it} represents the risk score of bank i at time t. ROA_{it} represents the bank i's asset returns at time t. We calculate ROA as follows:

$$ROA_{it}=\frac{\text{Earning Before Tax}_{it}}{\text{Total Asset}_{it}}x100\%$$

The E_{dit}/TA_{it} measures the equity to total assets ratio of bank i at time t. $\delta\ ROA_{it}$ measures the standard deviation of ROA_{it} . A higher Z-score increases the probability and capitalization level, decreasing bank risk-taking. To represent a higher Z-score as a more advanced bank risk-taking, we multiply the Z-score by -1.

Bank Specific Control

We calculate bank-specific supervision using bank size (BAS), asset composition (ASC), and operational efficiency (OPE) as independent variables. The bank size variable represents that bigger bank could be willing to take on more risk due to their more significant market clout. Furthermore, this study uses total assets to represent the bank size variable. To show the effect of asset composition, we substitute by using the loan-to-asset ratio. The use of the loan-to-asset ratio that it controls asset composition as a metric of bank lending behavior. Finally, we employ the cost-to-income proportion as one of the characteristics peculiar to a certain bank to measure the bank's operational efficiency. Operational costs and operating income are divided to determine the cost-to-income ratio. Since we employed an inverse of Z-score as dependent variable, we expect that BAS, ASC, and OPE negatively affect the bank Z-score. It means that, an increase in the size of banks, asset composition, and operational efficiency would decrease the risk taken by banks.

Capitalization

Capitalization strengthens the financial system while preventing systemic risk buildup by restricting financial institutions' excessive risk-taking (Abbas, Ali, et al., 2021; Adu, 2022; Agénor & Silva, 2021; Malovaná & Ehrenbergerová, 2022). We examine four kinds of capitalization to provide a different effect of capitalization on bank risk-taking. First, the traditional capital ratio (TCR) is measured by total equity by total assets as follows:

$$TCR_{it}=\frac{\text{Total Asset}_{it}}{\text{Total Equity}_{it}}x100\%$$

Second, risk-based capital ratio (RCR) as a weight of banks and minimum regulatory requirements is an essential strategy in bank risk-taking (Broll et al., 2018; Das & Rout, 2020). We calculated RCR as follows:

$$RCR_{it} = \frac{\text{Tier 1 Capital}_{it} + \text{Tier 2 Capital}_{it}}{\text{Risk-Weighted Asset}_{it}} \times 100\%$$

Whereas i denotes the bank and t denotes the amount of time, Equity capital comprises Tier 1 capital, commonly referred to as required reserves, shares outstanding, intellectual properties, and verified earnings reserves. Reserves retained earnings, and overall liability reserves that have not been audited make up Tier 2 capital.

Third, the capital buffer ratio (CBR) indicates changes in banks' capitalization levels due to capital regulations (Illueca et al., 2022; Jiang et al., 2020; Jiang & Yuan, 2022; Quyen et al., 2021). By influencing borrowers, we anticipate that a more excellent BCB ratio will decrease bank risk-taking and boost financial stability. According to this analysis, more stringent capital regulations, such as underwriting standards, sectoral capital buffers, and countercyclical availability of capital, will raise funding costs or restrain credit expansion (Auer et al., 2022; Bagntasarian & Mamatzakis, 2019). This circumstance could lead to stricter credit requirements supported by borrowers and could lower loan demand. The capital buffer can also help banks' financial standing and reduce their risk-taking distribution by obtaining loans from customers who adhere to stricter restrictions.

We add an extended variable, the regulatory capital pressure (RCP). Because we use several commercial banks with varied capital structures as a sample, we include numerous institutions in the list of domestic-systemically important banks (D-SIB). We introduce regulatory capital pressure (RCP) as an independent variable to match the bank macroprudential policy instrument. We determine RCP as the difference between the minimum regulatory norm for commercial banks, including D-SIB and other banks, and the capital adequacy ratio (CAR) and standard deviation of CAR. RCP is calculated as follows for bank i at time t (Zhang et al., 2018):

$RCP_{it} = CAR_{it} - \delta CAR_i - 8\%$ For other banks;
$RCP_{it} = CAR_{it} - \delta CAR_i - (9\% \text{ to } 10.5\%)$ For D-SIB.

Furthermore, there is a shortage of research on the connection between capitalization (capital buffer ratio and regulatory capital pressure) and bank risk-taking. According to the operational information of each capitalization variable, we expect that TCR, RCR, CBR, and RCP negatively affect Z-score. It presents that tightening capital requirements such as traditional capital ratio, risk-based capital ratio, capital buffer ratio, and regulatory capital pressure would reduce bank risk-taking.

Macroeconomic Control

This analysis uses the pace of Indonesian GDP growth and the rate of inflation macroeconomic control variables. GDP denotes a variation in economic activity during the business cycle, which most likely influences the performance of a country's financial institutions (Abbas, Ali, et al., 2021; Abbas, Masood, et al., 2021; Anginer et al., 2021; Banai et al., 2022; Conti et al., 2022; Ginting & Widyawati, 2022; Zhang et al., 2018). The consumer price index will be utilized as a stand-in for the inflation rate in this study. The actual economy and financial stability of a nation are both impacted by inflation since it has an inverse relationship with both (Auer et al., 2022; Mateev et al., 2022; Ongena et al., 2022). Finally, we also put interest rate by employing the Bank Indonesia rate to analyze the effect of the rate of return. We expect a tighter interest rate would reduce bank risk-taking (Adão et al., 2022; Bongiovanni et al., 2021). GDP growth, consumer pricing information, and interest rate are taken from the official website of the Indonesian Central Bureau of Statistics and Bank Indonesia. We generally expect a positive effect of inflation and a negative effect of GDP and interest rates. It confirms that an increase in the scale of the economy and interest rate and a decrease in the inflation rate would reduce bank risk-taking.

Estimation Strategy

We use a panel data simulation to study the impact of capitalization on bank risk-taking because it incorporates the nature of bank risk-taking and the potential endogeneity issue across variable estimates. Moudud-Ul-Huq (2019) demonstrates that the static model based on the random and fixed effect model has a significant econometric imbalance and contradictory conclusions since there is an association between lag changes in the dependent variable. Therefore, in a dynamic situation, we employ a generalized method of moments (GMM) that regulates the endogeneity of the lag-dependent variable. GMM lowers omitted bias concerns, regulates unaccounted heterogeneity issues, and manages panel measurement error problems (Abbas, Masood, et al., 2021; Moudud-Ul-Huq, 2019; Son et al., 2022).

Notably, our research uses a System-GMM estimator propounded by Arellano and Bond (1991) and Blundell and Bond (1998) to develop accurate estimators. When there is a lack of time sequence (t) and a large cross-section (N), the System-GMM is the best estimator, according to Noman et al. (2017). Additionally, System-GMM has improved estimation capabilities to estimate the explanatory variable coefficients. The transformed econometric model by the System-GMM in the following equation:

$$Z_{it} = \alpha + \beta BSC_{it} + \vartheta CAP_{it} + \emptyset MAC_{it} + \gamma_t + \gamma_i + \varepsilon_{it} \quad (2)$$

Where γ_t reflects the time effect, which has i = 1 to T and γ_i is the bank effect, which has t = 1 to N, and α, β, ϑ, $\emptyset$ are estimated parameters. Finally, ε_{it} is an error term of model estimates.

Result and Discussion

Issues on the connection between bank capitalization and risk-taking emerge every period, primarily when the business cycle occurs remarkably. Most studies estimate the determinants of bank risk-taking, which focus on asset measurements such as the total or size and the adequacy effect (Andries et al., 2020; Broll et al., 2018; Das & Rout, 2020; Kosenko & Michelson, 2022; Le et al., 2022; Mateev et al., 2021; Noman et al., 2017). It merely shows that the studies focused on the effect of prudential capital are scarce. Thus, we dedicate our study to applying bank capital buffer and regulatory capital pressure to capture new prudential regulations implemented recently.

Table 2 Data Summary Statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
Z	288	-12.3043	22.09202	-293.845	-0.08965
BAS	288	17.93833	1.471917	13.05979	21.01823
ASC	288	0.557846	0.123323	0.270976	0.818855
OPE	288	3.151325	2.769243	0.21924	19.20034
TCR	288	0.116744	0.046779	-0.00073	0.31769
RCR	288	0.405991	0.933963	0.091624	10.89108
CBR	288	0.325991	0.933963	0.011624	10.81108
RCP	288	0.036556	0.820682	-3.2733	7.526148
GDP	288	5.525	0.572429	4.63	6.49
INF	288	6.135625	3.719024	2.72	17.11
INT	288	7.1675	2.067774	4.25	12.75

Table 3 Matrix Correlation

	Z	BAS	ASC	OPE	TCR	RCR	CBR	RCP	GDP	INF	INT
Z	1										
BAS	-0.2409	1									
ASC	-0.0436	-0.1475	1								
OPE	-0.0047	-0.239	0.0917	1							
TCR	-0.4177	-0.0231	0.2466	0.0232	1						
RCR	0.2295	-0.1454	-0.0028	-0.1572	0.0471	1					
CBR	0.1878	-0.1502	-0.0001	-0.1392	0.1229	0.9872	1				
RCP	-0.1285	0.0533	0.0746	0.0595	0.2134	0.4696	0.4533	1			
GDP	0.0945	-0.1345	0.1818	0.0592	-0.1244	-0.0228	-0.025	-0.07	1		
INF	0.1442	-0.3031	0.1571	0.1524	-0.053	-0.1143	-0.113	-0.1386	0.3288	1	
INT	0.1808	-0.3739	0.1284	0.1557	-0.0412	-0.1122	-0.1064	-0.1518	0.2327	0.8737	1

We begin our discussion based on the result of the statistic description in Table 2. We apply 288 observations based on 18 banks as cross-sections and 16 years of each bank. Over the sample period, Bank size varies from the bank with higher and lower assets. Banks with maximum size are primarily categorized as state-owned commercial banks. Averagely, the capital buffer ratio of commercial banks is 33 percent, implying that the proportion of capital buffer was at a well-managed level. The minimum point is 1.16

percent, mainly at the beginning of the sample in 2004, and it increased to the maximum in 2019. The regulatory capital pressure is 3.7 percent, indicating that most banks are included in domestic-systemically important banks (D-SIB).

We also examine the correlation coefficient of each variable estimate. The coefficient correlation analysis is presented in Table 3. The result above the critical value (α=0.01, 0.05, and 0.1) confirms the presence of correlation (Abbas, Ali, et al., 2021; Abbas, Masood, et al., 2021; Anginer et al., 2021; Zhang et al., 2018). Our analysis was confirmed through the number of correlation coefficients above the critical value. The result reveals that traditional capital and risk-based capital ratio are statistically significant. We confirm the result of Abbas, Ali, et al. (2021) and Defung & Yudaruddin (2022). The capital prudential buffer variables, such as capital buffer and regulatory capital pressure, correlate similarly with bank risk-taking (Abbas, Ali, et al., 2021).

Table 4 Estimation Result of System Generalized Method of Moment (SYS-GMM)

	Model 1	Model 2	Model 3	Model 4	Model (5)
c	1.4800	-1.5418	-1.4047*	-0.7943	-0.5342
	(2.4795)	(2.4027)	(2.4760)	(3.5208)	(2.2133)
Bank Specific Control					
BAS	-0.1882*	-0.1700*	-0.2183*	-0.2877**	-0.1280
	(0.0992)	(0.1027)	(0.1056)	(0.1393)	(0.9159)
ASC	0.1729	-1.9391	-1.2590	-2.4051	0.0070
	(1.0216)	(1.2635)	(0.9290)	(1.7168)	(0.8776)
OPE	-0.0742	-0.0076	-0.0277	-0.1454	0. 0861*
	(0.05697)	(0.0823)	(0.1060)	(0.1522)	(0. 0444)
Capitalization					
TCR	-16.4624***				-8.5645 ***
	(2.4748)				(2.4822)
RCR		0.7318***			3.1864*
		(0.2768)			(2.3745)
CBR			-0.6743***		-1.9982***
			(0.1435)		(1.8450)
RCP				-0.4294***	-0.3487**
				(0.1122)	(0.0388)
Macroeconomic Control					
GDP	0.0560	1.3398**	0.9427*	1.1699*	0.1690
	(0.7312)	(0.6375)	(0.6458)	(0.7784)	(0.7091)
INF	-0.0610**	-0.0216	-0.0188	-0.0512**	-0.0617***
	(0.0253)	(0.0370)	(0.0395)	(0.0258)	(0.0220)
INT	0.0763*	0.1302**	0.0808*	0.1233**	0.0881*
	(0.0577)	(0.0548)	(0.0530)	(0.0588)	(0.0558)
Obs.	234	234	234	234	234
Hansen J	0.457	0.595	0.573	0.630	0.415
AR(2)	0.097**	0.014*	0.076**	0.033*	0.171***

The standard deviation is shown in brackets (), and the significance levels at 1%, 5%, and 10% are indicated by *, **, and ***, respectfully (Source: Author's Computation).

The importance of the Hansen J-test for the correctness of the overidentifying restriction and endogeneity problem is provided by using the GMM system estimate. Table 4, column models 1 through 5 show that the Hansen J-test outcome is not statistically significant. The test's lack of significance guarantees that the incorporation of instrumental variables for managing the endogeneity problem is legitimate with the overidentifying constraint in place. We conclude that there is no link between the instruments and the standard errors, and we address the endogeneity issue within those findings from our approach.

Table 4 shows the causality investigation result of bank risk-taking determinants. We provide five models due to the cross variability of capitalization effects. In the separated below side, we provide the number of observations, the result of the Hansen test for overidentification restriction, and the Arellano-Bond test for AR(2) in the first differences. The probability values of the Hansen test of all models are high, which means that our used instruments are valid. The overall model (model 5) has no autocorrelation issue since we cannot reject our null hypothesis of no serial correlation at 1 percent, while other models cannot reject 5 and 10 percent.

Since we divide the models according to the different effects of a single capitalization, we also provide three variable groups for each model. The first group is banking-specific control variables. We employ three variables of bank-specific control such as banks size, asset composition, and operational efficiency. The result shows that bank size has a significant and inverse effect in models 1 to 4. It indicates that the bigger asset of banks can effectively decrease bank risk-taking. Our finding supports the study of Abbas, Masood, et al. (2021), who mentioned that the size of banks could decrease non-potential credit of banks, decreasing risk-taking. However, other bank-specific control variables such as asset composition and operational efficiency are supposed to have an insignificant effect on ban risk-taking. It merely shows that the composition of assets and cost of operation do not directly impact on the risk of a bank. However, it would be following some channels to support bank financial stability.

Model 1 shows the traditional capital ratio's negative and empirically significant effect on bank risk-taking. Equity-to-total asset ratio indicates the use of the company's capital in financing the company's assets. It means that an increase in the capital in the total equity would decrease the risk banks have taken while the total asset and other factors remain constant (Abbas, Masood, et al., 2021; Conti et al., 2022; Le et al., 2022). We refuse the previous result of Abbas, Masood, et al. (2021). However, Our findings agree with the results of Das & Rout (2020), who suggest that an increase in equity would improve the mean cost of capital. However, a rise in the lending rate simultaneously would decrease bank risk-taking. Besides, Le et al. (2022) explain that increasing the bank's portfolio would decrease bank risk-taking. The coefficient estimates of the traditional capital ratio of model 1 were confirmed by model 5, with overall capitalization variables analyzed.

The risk-based return rate on capital has a favorable and statistically significant effect. Interestingly, most previous studies suggested that increased capital adequacy would decrease bank risk-taking. However, our estimates indicate that increasing the risk-based capital requirement would enhance banks' risk. This result is different explains with the previous research by Son et al. (2022). They explain that with an increase in the bank capital requirements for the risk-weighted asset, the bank would be more stable due to the moral hazard hypothesis, decreasing bank risk-taking. However, we support the finding of Das & Rout (2020), who suggested the reason behind the affirmative correlation between the risk-weighted capital ratio and bank risk-taking due to the "too big to fail attitude" and other errors in screening and monitoring. Furthermore, following the intuition of Agénor & Silva (2021), a tighter risk-weighted capital ratio passed through its optimal point (whose marginal effect is zero), and the return weakens as the number of loans decreases.

The capital buffer ratio (CBR) shows tighter regulation, additional capital requirements for commercial banks, and reduced bank risk-taking (Abbas, Ali, et al., 2021; Moudud-Ul-Huq, 2019). Model 3 in Table 4 reveals a single capitalization variable effect on bank risk-taking. The calculated correlation of CBR is contrary and quantitatively relevant at a 1 percent confidence ratio. The coefficient of 0.6743means a-1% rise in the required capital buffer by the central bank, and the risk-taking by commercial banks would decrease by around 67.43 percent. This result corroborates the earlier research of Zhang et al. (2018), Abbas, Masood, et al. (2021), Illueca et al. (2022) in the case of the pre-adoption period of Spanish private banks, Jiang & Zhang (2017) in the case of upper tail risk for Chinese banks. Following the transmission from Auer et al. (2022), banks are more likely to charge higher interest rates in response to a rise in the capital buffer proportion. It would decrease the lending rate, especially the non-performing intermediation. Therefore, the decrease in non-performing intermediation reduces bank risk-taking.

Model 4 presents a single capitalization effect of regulatory capital pressure on bank risk-taking. The coefficient of regulatory capital pressure is also negative (0.4294) and statistically significant at a one percent confidence level. An increase in regulatory capital pressure weakens bank risk-taking. The impact of RCP of simultaneous capitalization effect in model 5 confirms it. Zhang et al. (2018) reveal the transmission of capital pressure affecting the bank's risk-taking through the central bank reserve requirement channel. They explain that a higher regulatory capital pressure is due to higher reserve requirements, decreasing bank risk-taking.

Finally, macroeconomic control variables show various effects on bank risk-taking. GDP provides a positive and significant effect in Model 2, model 3, and Model 4. We present this unexpected effect due to the procyclicality of financial institutions. Banks tend to lend more when paying attention to a positive signal and abide by the precautionary principle. Therefore, the booms of credit would increase the risk in financial institutions. The inflation rate negatively affects bank risk-taking, especially in Model 1, model, 4, and Model 5. Our result supports the study of Son et al. (2022). The last macroeconomic control is the interest rate. The result presents an affirmative and significant effect of interest rates on bank risk-taking. Overall, the variability of macroeconomic variables affects bank risk-taking in Indonesia.

Conclusion

Governments all across the globe are being compelled to improve their financial soundness as a consequence of the worldwide turmoil. The banking industry needs more stringent capital regulations to protect the financial system from disasters. Therefore, capitalization-based tools are a part of macroprudential policy and are used to raise the emergency preparedness signal. We present an analysis of capitalization's impact on bank risk-taking in the case of Indonesian commercial banks.

Our finding shows that single and overall cross-capitalization variables are consistent. The variable of the traditional capital ratio effectively weakens bank risk-taking. However, the risk-based capital ratio is inverse to our expected sign, which is an improvement in the risk-based capital ratio that improves bank risk-taking. The macroprudential instruments for the capitalization aspect, the capital buffer ratio for commercial banks, reduces the risk probability. Furthermore, our extended prudential capital buffer and regulatory capital pressure for domestic-systemically important banks (D-SIB) confirm the decrease in bank risk-taking. Therefore, we suggest maintaining the performance of macroprudential capital instruments for further analysis and policy decision-making.

This study is restricted to a review of the impact of prudential and non-prudential capital buffers on the Indonesian banking sector's financial stability. Our study is indeed confined to the bank industry in measuring the financial stability variable. It does not yet employ a number of materials to demonstrate overall financial stability across Indonesia's numerous financial institutions. Additionally, the cross-sectional data set consists of 18 commercial banks, each representing a different Indonesian bank group, and the time series data utilized is restricted to pre-pandemic datasets. Therefore, future studies may create a more thorough measure of financial stability that takes into account financial stability overall, the fluctuations of financial stability throughout an outbreak, and the number of institutions that would be more suitable to reflect a representative of all Indonesian commercial banks.

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Does prudential capital reduce bank risk-taking? Empirical evidence from the Indonesian banks industry

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DOI: 10.18196/jesp.v24i1.17696

CITATION:
Salim, A., & Suripto, S. (2023). Does prudential capital reduce bank risk-taking? Empirical evidence from the Indonesian banks industry. *Jurnal Ekonomi & Studi Pembangunan, 24*(1), 182-197.

ARTICLE HISTORY
Received:
23 Jan 2023
Revised:
23 May 2023
Accepted:
29 May 2023

Abstract: The implementation of macroprudential supervision, significantly tighter capital regulation in developing economies, has recently been debated, which focuses on reducing bank risk-taking and promoting financial stability in the banking sector. Our study investigates the impact of prudential capital on commercial bank risk-taking in Indonesia. We employed a GMM system approach to analyze bank and macro level data from 2004 to 2019. Our result confirms that appropriate capital regulations for reducing bank risk-taking are heterogeneous. Traditional capital ratios decrease bank risk-taking. However, the risk-based capital ratio shows an unexpected affirmative effect. Implementing macroprudential policy instruments of capital buffer effectively manages bank risk, and so does the regulatory capital pressure variable. The results are intimate for guiding commercial banks' risk management and capital effectiveness.

Keywords: Macroprudential Policy; Financial Stability; Bank Risk-Taking; Prudential Capital Buffer; Regulatory Capital Pressure
JEL Classification: E58; G21; G28

Introduction

Capitalization has been essential in mitigating bank risk since the commencement of a universal model, the 1988 Basel I, 2004 Basel II, and 2010 Basel III accords. Implementing Basel III required regulators to maintain the capitalizations of their commercial banks (Abbas, Ali, et al., 2021; Jiang & Zhang, 2017). Generally, Basel III has three kinds of capital regulation: capital adequacy ratio, the risky asset of tier-one capital ratio, and tier-one standard equity ratio. It promotes that the most analyzed capitalization topics are around these three ratios. Das & Rout (2020) found an affirmative correlation involving bank risk activity and adequacy of capital. Anginer et al. (2021), Illueca et al. (2022), Mateev et al. (2021), Le et al. (2022), and Son et al. (2022) show a positive correlation between equity ratio on the financial stability of commercial banks or adversely affects bank risk-taking. However, they generally utilized risk-based and non-risk-based capital requirements to examine how market capitalization affected bank risk-taking. They do not include macroprudential capital instruments in mitigating financial risk and promoting recently implemented stability.

Nowadays, macroprudential policy has an important position in the financial aspects of many countries (Davis et al., 2022; De Schryder & Opitz, 2021; Gaganis et al., 2020; Igan et al., 2022). Implementing macroprudential policy instruments is not a new regulation in the financial system. However, the adjustment of macroprudential policy instruments is intensive, notably in the light of the worldwide downturn of 2007–2008 (Maatoug et al., 2019; Noman et al., 2017; Ovi et al., 2020; Tongurai & Vithessonthi, 2020; Zhang et al., 2018). The period of the most implemented prudential policy is also the beginning year for the implementation of macroprudential policy in developing countries to mitigate and prevent future bank risk-taking, promoting financial stability.

Issues regarding implementing the macroprudential policy have emerged among the studies of scholars and policymakers (Gaganis et al., 2020; Igan et al., 2022). The majority of previous investigations emphasized the variability impact of time-varying policy and the implementation of macroprudential instruments (Ćehajić & Košak, 2022; Davis et al., 2022; De Schryder & Opitz, 2021; Ekananda, 2022; Fabiani et al., 2022; Gaganis et al., 2020; Igan et al., 2022). In particular, Ćehajić & Košak (2022), Fabiani et al. (2022), and De Schryder & Opitz (2021) show an inverse effect of prudential capital requirements on the credit supply of commercial banks.

The impact analysis by Ćehajić & Košak (2022) studied on how macroprudential policy affects the accessibility of small and medium enterprises (SMEs) to banks' financial intermediation. They use monthly panel data of firms' levels from January 2009 to February 2011. The results revealed a negative correlation between capital requirement tightening and the financial flow to the SMEs. Specifically, more tightening capital and macroprudential requirements, a decline of private sectors could access bank financing. With stricter access to financial intermediation, they conclude that tighter saving requirements produce more credit to small and medium enterprises (SMEs) in European countries. However, the loosening of capital rules shows an inverse effect. Furthermore, they also analyzed the effect of liquidity tightening and loosening on financial intermediation. They reveal a negatively significant impact of liquidity loosening but an insignificant effect of liquidity tightening due to some activities for searching a huger yield by choosing a riskier investment.

Study on prudential capital requirements with a higher sample by Gaganis et al. (2020). They investigated the variability effect of ten macroprudential instruments on bank-risk taking for 356 banks from 50 selected countries. The result shows an inverse relationship between macroprudential policy and bank risk-taking. It confirms that a tighter policy would lower the risk taken by commercial banks operations. Overall, they conclude that implementing macroprudential instruments reduces bank risk-taking, boosting financial stability. However, both impactful studies by Ćehajić & Košak (2022) and Gaganis et al. (2020) employed aggregate macroprudential policy indicators and did not provide different effects of each instrument implemented.

In the disaggregate macroprudential instrument, the impact of capital control on smoothing credit booms was analyzed by Fabiani et al. (2022). They employ quarterly panel data from the second quarter of 2005 to the second quarter of 2008 to analyze a source of bank loans over the implementation of macroprudential policy in Colombia. They found that an increase in the reserve requirements worsens credit supply, especially for non-profitable firms. Furthermore, De Schryder & Opitz (2021) examine the effect of typical macroprudential on bank lending in 13 European countries using panel data from 1999 to 2018. They found that decreased reserve requirement loss reduces consumer credit to GDP and bank credit to GDP ratio in selected EU economies. Igan et al. (2022) support De Schryder & Opitz (2021) study that tighter reserve requirements and regulations weaken bank risk-taking across 52 economies. These studies conclude that the policy regarding reserve requirements reduces bank risk-taking by eliminating non-profitable financing.

Other disaggregate macroprudential indicators were applied by Davis et al. (2022), who analyzed the effect of macroprudential policy on bank earnings. The result shows a inverse impact of macroprudential instruments on profitability for over 7250 global banks for over 57 emerging and 35 advanced economies. However, they focused on bank's profitability rather than risk-taking indicators. The implementation of the countercyclical capital buffer (CCB) instrument has insignificantly negative for developing economies but significantly favorable effects on bank profitability in developed countries. It means that a sharp tightening of CCB reduces banks' profit in emerging economies, but improves richer countries' bank profitability. They also applied loan-to-value, and the results remained the same for both groups of economies.

Most of the previous studies implement the aggregate macroprudential policy indicators (Ćehajić & Košak, 2022; Gaganis et al., 2020). Other studies use the central bank reserve requirement to represent prudential capital requirements affecting bank financial intermediations (De Schryder & Opitz, 2021; Fabiani et al., 2022; Igan et al., 2022; Johari et al., 2022). Another complete implementation of disaggregate macroprudential indicators focused on implementing each instrument on banks profit earnings (Davis et al., 2022). Moreover, they employed a group of countries that may reveal different characteristics of each economy. Other, so far as we are concerned, research on the evaluation of macroprudential policy instruments focused on capitalization, such as prudential buffer and regulatory capital pressure across several types with a single country to reduce bias caused by different scales of economies and to employ specific prudential capital instrument, are scarce. Thus, our study tries to fill the gap by examining capitalization's effect, which focuses on the effectiveness of prudential capital buffer as one of the macroprudential policy instruments and regulatory capital pressure on bank risk-taking in strengthening financial stability. Employing a single country observation, Indonesia, that has different groups of banks and possible indices of domestic-systematically important banks (D-SIB) appears, our study provides a discussion with completed real data for each sample bank from their report to financial service authority of Indonesia.

This study comprises the implementation impact of prudential and non-prudential capital on bank risk-taking of Indonesian commercial banks. Furthermore, We operate the system of generalized method of moments (GMM-SYS) found by Arellano & Bond (1991) and Blundell & Bond (1998) in accordance to limit the potential endogeneity issues. In various ways, our manuscript contributes to the body of knowledge on the capitalization of bank risk-taking. First, this study covers the period before 2007 and after 2009, using six different groups of commercial banks data for deeper analysis. To the best of our knowledge, we clearly ensure that our study is the first comprising different group of banks in the case of risk-taking analysis in Indonesia. Second, other studies use a non-risk-adjusted capitalization ratio such as Anginer et al. (2021), Das & Rout (2020), Illueca et al. (2022), Mateev et al. (2021), Le et al. (2022), and Son et al. (2022), while we employ both risk-adjusted capitalization ratios and prudential capital buffers to cover the implementation of macroprudential policy instruments. Third, we also contribute to extending the capital buffer ratio by adding regulatory capital pressure to provide a deeper capitalization analysis for specific domestic-systemically important banks (D-SIB) regulations. In the case of Indonesia, with different bank types and systemically commercial banks, this study first implements the regulatory capital pressure as an additional macroprudential instrument to capture the D-SIB phenomenon. Finally, the results are essential for policymakers to observe the variability effect of different capitalizations and provide a new guideline for banking stability.

The complete procedure of this study is divided into different sections: Part two is devoted to methodology, the third chapter informs the analysis and discussion of the research result, and the last section concludes the overall manuscript.

Research Method

Data

This study used yearly panel data containing two types of data sets, bank scope level, and macroeconomic level, from 2004 to 2019. The original dataset was mainly extracted from the official site of the Central Bank of Indonesia (BI), the Financial Service Authority (FSA) of Indonesia, and the Indonesian Central Bureau of Statistics. This study analyzed the risk-taking of 18 conventional commercial banks in Indonesia. Generally, Indonesia categorizes banks into six groups. We used the top three sizes of banks in each group. The size of banks used in this study is size data in 2019 as the last period of the reported bank to the FSA.

Table 1 Indicators of Variable Measurement

Variable Name	Measurement	Source
Bank risk-taking	Z-score	Compiled from Financial Service Authority
Bank specific control		
1. Bank size (BAS)	The logarithm of total asset	Compiled from Financial Service Authority
2. Asset composition (ASC)	Loan-to-asset ratio	Compiled from Financial Service Authority
3. Operational efficiency (OPE)	Income to asset ratio	Compiled from Financial Service Authority

Table 1 Indicators of Variable Measurement (cont')

Variable Name	Measurement	Source
Capitalization		
1. Traditional capital ratio (TCR)	Total equity/Total asset	Compiled from Financial Service Authority
2. Risk-based capital ratio (RCR)	Capital adequacy ratio	Compiled from Financial Service Authority
3. Capital buffer ratio (CBR)	The differential between RCR and minimum regulatory requirement	Compiled from Financial Service Authority and Bank Indonesia
4. Regulatory capital pressure (RCP)	The differential between RCR and standard deviation of CAR and minimum regulatory requirement	Compiled from Financial Service Authority and Bank Indonesia
Macroeconomic control		
1. Real GDP	Natural log of real GDP	Indonesian Central Bureau of Statistics
2. Inflation rate	Consumer price index	Indonesian Central Bureau of Statistics
3. Interest rate	Bank Indonesia rate	Bank Indonesia

Model Specification

We built an empirical model with a few associated variables to experimentally investigate capitalization's impact on risk-taking. The dependent variable is bank risk-taking, which uses the Z-score as a proxy. We divide the independent variables into three groups. First, bank-specific operational factors include bank size, amenities and infrastructure, and operational performance. Second, capitalization is the primary variable estimate of this study, which focuses on four types of capitalization, such as traditional capital ratio (TCR), risk-based capital ratio (RCR), and capital buffer ratio (CBR). We add the extended variable, the regulatory capital pressure (RCP), to provide a more specific analysis. The third is macroeconomic control variables, which include inflation rate and real GDP growth. Thus, we employ a general regression model as follows:

$$Z_{it} = \alpha + \beta BSC_{it} + \vartheta CAP_{it} + \emptyset MAC_{it} + \varepsilon_{it} \quad (1)$$

Where i = 1 to N and t = 1 to T, N is the figure of individual banks, T is time, and α, β, ϑ, $\emptyset$ are approximated parameters. Z_{it} refers to the risk-taking for bank i at time t, which Z-score as a proxy. BSC_{it} represents bank characteristics for bank i at time t. CAP_{it} indicates the effect of types of capitalization. MAC_{it} shows the effect of macroeconomic conditions, and ε_{it} represents the error term.

Variable Measurement

Bank Risk-Taking

We employ bank risk-taking as an explained variable by calculating Z-score as a primary ratio. The essential idea of using Z-score measurement is the capitalization and returns variability of the bank. It reveals efficiency with minimum insolvency of a bank (Adu, 2022; Gaganis et al., 2020). We determine Z-score as follows (Illueca et al., 2022; Moudud-Ul-Huq, 2019; Son et al., 2022; Toh & Zhang, 2022):

$$Z_{it}=\frac{ROA_{it}+E_{it}/TA_{it}}{\delta\ ROA_{it}}$$

Where Z_{it} represents the risk score of bank i at time t. ROA_{it} represents the bank i's asset returns at time t. We calculate ROA as follows:

$$ROA_{it}=\frac{\text{Earning Before Tax}_{it}}{\text{Total Asset}_{it}}\text{x}100\%$$

The E_{dit}/TA_{it} measures the equity to total assets ratio of bank i at time t. $\delta\ ROA_{it}$ measures the standard deviation of ROA_{it} . A higher Z-score increases the probability and capitalization level, decreasing bank risk-taking. To represent a higher Z-score as a more advanced bank risk-taking, we multiply the Z-score by -1.

Bank Specific Control

We calculate bank-specific supervision using bank size (BAS), asset composition (ASC), and operational efficiency (OPE) as independent variables. The bank size variable represents that bigger bank could be willing to take on more risk due to their more significant market clout. Furthermore, this study uses total assets to represent the bank size variable. To show the effect of asset composition, we substitute by using the loan-to-asset ratio. The use of the loan-to-asset ratio that it controls asset composition as a metric of bank lending behavior. Finally, we employ the cost-to-income proportion as one of the characteristics peculiar to a certain bank to measure the bank's operational efficiency. Operational costs and operating income are divided to determine the cost-to-income ratio. Since we employed an inverse of Z-score as dependent variable, we expect that BAS, ASC, and OPE negatively affect the bank Z-score. It means that, an increase in the size of banks, asset composition, and operational efficiency would decrease the risk taken by banks.

Capitalization

Capitalization strengthens the financial system while preventing systemic risk buildup by restricting financial institutions' excessive risk-taking (Abbas, Ali, et al., 2021; Adu, 2022; Agénor & Silva, 2021; Malovaná & Ehrenbergerová, 2022). We examine four kinds of capitalization to provide a different effect of capitalization on bank risk-taking. First, the traditional capital ratio (TCR) is measured by total equity by total assets as follows:

$$TCR_{it}=\frac{\text{Total Asset}_{it}}{\text{Total Equity}_{it}}\text{x}100\%$$

Second, risk-based capital ratio (RCR) as a weight of banks and minimum regulatory requirements is an essential strategy in bank risk-taking (Broll et al., 2018; Das & Rout, 2020). We calculated RCR as follows:

$$RCR_{it}=\frac{\text{Tier 1 Capital}_{it}+\text{Tier 2 Capital}_{it}}{\text{Risk-Weighted Asset}_{it}}x100\%$$

Whereas i denotes the bank and t denotes the amount of time, Equity capital comprises Tier 1 capital, commonly referred to as required reserves, shares outstanding, intellectual properties, and verified earnings reserves. Reserves retained earnings, and overall liability reserves that have not been audited make up Tier 2 capital.

Third, the capital buffer ratio (CBR) indicates changes in banks' capitalization levels due to capital regulations (Illueca et al., 2022; Jiang et al., 2020; Jiang & Yuan, 2022; Quyen et al., 2021). By influencing borrowers, we anticipate that a more excellent BCB ratio will decrease bank risk-taking and boost financial stability. According to this analysis, more stringent capital regulations, such as underwriting standards, sectoral capital buffers, and countercyclical availability of capital, will raise funding costs or restrain credit expansion (Auer et al., 2022; Bagntasarian & Mamatzakis, 2019). This circumstance could lead to stricter credit requirements supported by borrowers and could lower loan demand. The capital buffer can also help banks' financial standing and reduce their risk-taking distribution by obtaining loans from customers who adhere to stricter restrictions.

We add an extended variable, the regulatory capital pressure (RCP). Because we use several commercial banks with varied capital structures as a sample, we include numerous institutions in the list of domestic-systemically important banks (D-SIB). We introduce regulatory capital pressure (RCP) as an independent variable to match the bank macroprudential policy instrument. We determine RCP as the difference between the minimum regulatory norm for commercial banks, including D-SIB and other banks, and the capital adequacy ratio (CAR) and standard deviation of CAR. RCP is calculated as follows for bank i at time t (Zhang et al., 2018):

$RCP_{it}= CAR_{it} - \delta CAR_i - 8\%$ For other banks;
$RCP_{it}= CAR_{it} - \delta CAR_i - (9\% \text{ to } 10.5\%)$ For D-SIB.

Furthermore, there is a shortage of research on the connection between capitalization (capital buffer ratio and regulatory capital pressure) and bank risk-taking. According to the operational information of each capitalization variable, we expect that TCR, RCR, CBR, and RCP negatively affect Z-score. It presents that tightening capital requirements such as traditional capital ratio, risk-based capital ratio, capital buffer ratio, and regulatory capital pressure would reduce bank risk-taking.

Macroeconomic Control

This analysis uses the pace of Indonesian GDP growth and the rate of inflation macroeconomic control variables. GDP denotes a variation in economic activity during the business cycle, which most likely influences the performance of a country's financial institutions (Abbas, Ali, et al., 2021; Abbas, Masood, et al., 2021; Anginer et al., 2021; Banai et al., 2022; Conti et al., 2022; Ginting & Widyawati, 2022; Zhang et al., 2018). The consumer price index will be utilized as a stand-in for the inflation rate in this study. The actual economy and financial stability of a nation are both impacted by inflation since it has an inverse relationship with both (Auer et al., 2022; Mateev et al., 2022; Ongena et al., 2022). Finally, we also put interest rate by employing the Bank Indonesia rate to analyze the effect of the rate of return. We expect a tighter interest rate would reduce bank risk-taking (Adão et al., 2022; Bongiovanni et al., 2021). GDP growth, consumer pricing information, and interest rate are taken from the official website of the Indonesian Central Bureau of Statistics and Bank Indonesia. We generally expect a positive effect of inflation and a negative effect of GDP and interest rates. It confirms that an increase in the scale of the economy and interest rate and a decrease in the inflation rate would reduce bank risk-taking.

Estimation Strategy

We use a panel data simulation to study the impact of capitalization on bank risk-taking because it incorporates the nature of bank risk-taking and the potential endogeneity issue across variable estimates. Moudud-Ul-Huq (2019) demonstrates that the static model based on the random and fixed effect model has a significant econometric imbalance and contradictory conclusions since there is an association between lag changes in the dependent variable. Therefore, in a dynamic situation, we employ a generalized method of moments (GMM) that regulates the endogeneity of the lag-dependent variable. GMM lowers omitted bias concerns, regulates unaccounted heterogeneity issues, and manages panel measurement error problems (Abbas, Masood, et al., 2021; Moudud-Ul-Huq, 2019; Son et al., 2022).

Notably, our research uses a System-GMM estimator propounded by Arellano and Bond (1991) and Blundell and Bond (1998) to develop accurate estimators. When there is a lack of time sequence (t) and a large cross-section (N), the System-GMM is the best estimator, according to Noman et al. (2017). Additionally, System-GMM has improved estimation capabilities to estimate the explanatory variable coefficients. The transformed econometric model by the System-GMM in the following equation:

$$Z_{it} = \alpha + \beta BSC_{it} + \vartheta CAP_{it} + \emptyset MAC_{it} + \gamma_t + \gamma_i + \varepsilon_{it} \qquad (2)$$

Where γ_t reflects the time effect, which has i = 1 to T and γ_i is the bank effect, which has t = 1 to N, and α, β, ϑ, $\emptyset$ are estimated parameters. Finally, ε_{it} is an error term of model estimates.

Result and Discussion

Issues on the connection between bank capitalization and risk-taking emerge every period, primarily when the business cycle occurs remarkably. Most studies estimate the determinants of bank risk-taking, which focus on asset measurements such as the total or size and the adequacy effect (Andries et al., 2020; Broll et al., 2018; Das & Rout, 2020; Kosenko & Michelson, 2022; Le et al., 2022; Mateev et al., 2021; Noman et al., 2017). It merely shows that the studies focused on the effect of prudential capital are scarce. Thus, we dedicate our study to applying bank capital buffer and regulatory capital pressure to capture new prudential regulations implemented recently.

Table 2 Data Summary Statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
Z	288	-12.3043	22.09202	-293.845	-0.08965
BAS	288	17.93833	1.471917	13.05979	21.01823
ASC	288	0.557846	0.123323	0.270976	0.818855
OPE	288	3.151325	2.769243	0.21924	19.20034
TCR	288	0.116744	0.046779	-0.00073	0.31769
RCR	288	0.405991	0.933963	0.091624	10.89108
CBR	288	0.325991	0.933963	0.011624	10.81108
RCP	288	0.036556	0.820682	-3.2733	7.526148
GDP	288	5.525	0.572429	4.63	6.49
INF	288	6.135625	3.719024	2.72	17.11
INT	288	7.1675	2.067774	4.25	12.75

Table 3 Matrix Correlation

	Z	BAS	ASC	OPE	TCR	RCR	CBR	RCP	GDP	INF	INT
Z	1										
BAS	-0.2409	1									
ASC	-0.0436	-0.1475	1								
OPE	-0.0047	-0.239	0.0917	1							
TCR	-0.4177	-0.0231	0.2466	0.0232	1						
RCR	0.2295	-0.1454	-0.0028	-0.1572	0.0471	1					
CBR	0.1878	-0.1502	-0.0001	-0.1392	0.1229	0.9872	1				
RCP	-0.1285	0.0533	0.0746	0.0595	0.2134	0.4696	0.4533	1			
GDP	0.0945	-0.1345	0.1818	0.0592	-0.1244	-0.0228	-0.025	-0.07	1		
INF	0.1442	-0.3031	0.1571	0.1524	-0.053	-0.1143	-0.113	-0.1386	0.3288	1	
INT	0.1808	-0.3739	0.1284	0.1557	-0.0412	-0.1122	-0.1064	-0.1518	0.2327	0.8737	1

We begin our discussion based on the result of the statistic description in Table 2. We apply 288 observations based on 18 banks as cross-sections and 16 years of each bank. Over the sample period, Bank size varies from the bank with higher and lower assets. Banks with maximum size are primarily categorized as state-owned commercial banks. Averagely, the capital buffer ratio of commercial banks is 33 percent, implying that the proportion of capital buffer was at a well-managed level. The minimum point is 1.16

percent, mainly at the beginning of the sample in 2004, and it increased to the maximum in 2019. The regulatory capital pressure is 3.7 percent, indicating that most banks are included in domestic-systemically important banks (D-SIB).

We also examine the correlation coefficient of each variable estimate. The coefficient correlation analysis is presented in Table 3. The result above the critical value (α=0.01, 0.05, and 0.1) confirms the presence of correlation (Abbas, Ali, et al., 2021; Abbas, Masood, et al., 2021; Anginer et al., 2021; Zhang et al., 2018). Our analysis was confirmed through the number of correlation coefficients above the critical value. The result reveals that traditional capital and risk-based capital ratio are statistically significant. We confirm the result of Abbas, Ali, et al. (2021) and Defung & Yudaruddin (2022). The capital prudential buffer variables, such as capital buffer and regulatory capital pressure, correlate similarly with bank risk-taking (Abbas, Ali, et al., 2021).

Table 4 Estimation Result of System Generalized Method of Moment (SYS-GMM)

	Model 1	Model 2	Model 3	Model 4	Model (5)
c	1.4800	-1.5418	-1.4047*	-0.7943	-0.5342
	(2.4795)	(2.4027)	(2.4760)	(3.5208)	(2.2133)
Bank Specific Control					
BAS	-0.1882*	-0.1700*	-0.2183*	-0.2877**	-0.1280
	(0.0992)	(0.1027)	(0.1056)	(0.1393)	(0.9159)
ASC	0.1729	-1.9391	-1.2590	-2.4051	0.0070
	(1.0216)	(1.2635)	(0.9290)	(1.7168)	(0.8776)
OPE	-0.0742	-0.0076	-0.0277	-0.1454	0. 0861*
	(0.05697)	(0.0823)	(0.1060)	(0.1522)	(0. 0444)
Capitalization					
TCR	-16.4624***				-8.5645 ***
	(2.4748)				(2.4822)
RCR		0.7318***			3.1864*
		(0.2768)			(2.3745)
CBR			-0.6743***		-1.9982***
			(0.1435)		(1.8450)
RCP				-0.4294***	-0.3487**
				(0.1122)	(0.0388)
Macroeconomic Control					
GDP	0.0560	1.3398**	0.9427*	1.1699*	0.1690
	(0.7312)	(0.6375)	(0.6458)	(0.7784)	(0.7091)
INF	-0.0610**	-0.0216	-0.0188	-0.0512**	-0.0617***
	(0.0253)	(0.0370)	(0.0395)	(0.0258)	(0.0220)
INT	0.0763*	0.1302**	0.0808*	0.1233**	0.0881*
	(0.0577)	(0.0548)	(0.0530)	(0.0588)	(0.0558)
Obs.	234	234	234	234	234
Hansen J	0.457	0.595	0.573	0.630	0.415
AR(2)	0.097**	0.014*	0.076**	0.033*	0.171***

The standard deviation is shown in brackets (), and the significance levels at 1%, 5%, and 10% are indicated by *, **, and ***, respectfully (Source: Author's Computation).

The importance of the Hansen J-test for the correctness of the overidentifying restriction and endogeneity problem is provided by using the GMM system estimate. Table 4, column models 1 through 5 show that the Hansen J-test outcome is not statistically significant. The test's lack of significance guarantees that the incorporation of instrumental variables for managing the endogeneity problem is legitimate with the overidentifying constraint in place. We conclude that there is no link between the instruments and the standard errors, and we address the endogeneity issue within those findings from our approach.

Table 4 shows the causality investigation result of bank risk-taking determinants. We provide five models due to the cross variability of capitalization effects. In the separated below side, we provide the number of observations, the result of the Hansen test for overidentification restriction, and the Arellano-Bond test for AR(2) in the first differences. The probability values of the Hansen test of all models are high, which means that our used instruments are valid. The overall model (model 5) has no autocorrelation issue since we cannot reject our null hypothesis of no serial correlation at 1 percent, while other models cannot reject 5 and 10 percent.

Since we divide the models according to the different effects of a single capitalization, we also provide three variable groups for each model. The first group is banking-specific control variables. We employ three variables of bank-specific control such as banks size, asset composition, and operational efficiency. The result shows that bank size has a significant and inverse effect in models 1 to 4. It indicates that the bigger asset of banks can effectively decrease bank risk-taking. Our finding supports the study of Abbas, Masood, et al. (2021), who mentioned that the size of banks could decrease non-potential credit of banks, decreasing risk-taking. However, other bank-specific control variables such as asset composition and operational efficiency are supposed to have an insignificant effect on ban risk-taking. It merely shows that the composition of assets and cost of operation do not directly impact on the risk of a bank. However, it would be following some channels to support bank financial stability.

Model 1 shows the traditional capital ratio's negative and empirically significant effect on bank risk-taking. Equity-to-total asset ratio indicates the use of the company's capital in financing the company's assets. It means that an increase in the capital in the total equity would decrease the risk banks have taken while the total asset and other factors remain constant (Abbas, Masood, et al., 2021; Conti et al., 2022; Le et al., 2022). We refuse the previous result of Abbas, Masood, et al. (2021). However, Our findings agree with the results of Das & Rout (2020), who suggest that an increase in equity would improve the mean cost of capital. However, a rise in the lending rate simultaneously would decrease bank risk-taking. Besides, Le et al. (2022) explain that increasing the bank's portfolio would decrease bank risk-taking. The coefficient estimates of the traditional capital ratio of model 1 were confirmed by model 5, with overall capitalization variables analyzed.

The risk-based return rate on capital has a favorable and statistically significant effect. Interestingly, most previous studies suggested that increased capital adequacy would decrease bank risk-taking. However, our estimates indicate that increasing the risk-based capital requirement would enhance banks' risk. This result is different explains with the previous research by Son et al. (2022). They explain that with an increase in the bank capital requirements for the risk-weighted asset, the bank would be more stable due to the moral hazard hypothesis, decreasing bank risk-taking. However, we support the finding of Das & Rout (2020), who suggested the reason behind the affirmative correlation between the risk-weighted capital ratio and bank risk-taking due to the "too big to fail attitude" and other errors in screening and monitoring. Furthermore, following the intuition of Agénor & Silva (2021), a tighter risk-weighted capital ratio passed through its optimal point (whose marginal effect is zero), and the return weakens as the number of loans decreases.

The capital buffer ratio (CBR) shows tighter regulation, additional capital requirements for commercial banks, and reduced bank risk-taking (Abbas, Ali, et al., 2021; Moudud-Ul-Huq, 2019). Model 3 in Table 4 reveals a single capitalization variable effect on bank risk-taking. The calculated correlation of CBR is contrary and quantitatively relevant at a 1 percent confidence ratio. The coefficient of 0.6743means a-1% rise in the required capital buffer by the central bank, and the risk-taking by commercial banks would decrease by around 67.43 percent. This result corroborates the earlier research of Zhang et al. (2018), Abbas, Masood, et al. (2021), Illueca et al. (2022) in the case of the pre-adoption period of Spanish private banks, Jiang & Zhang (2017) in the case of upper tail risk for Chinese banks. Following the transmission from Auer et al. (2022), banks are more likely to charge higher interest rates in response to a rise in the capital buffer proportion. It would decrease the lending rate, especially the non-performing intermediation. Therefore, the decrease in non-performing intermediation reduces bank risk-taking.

Model 4 presents a single capitalization effect of regulatory capital pressure on bank risk-taking. The coefficient of regulatory capital pressure is also negative (0.4294) and statistically significant at a one percent confidence level. An increase in regulatory capital pressure weakens bank risk-taking. The impact of RCP of simultaneous capitalization effect in model 5 confirms it. Zhang et al. (2018) reveal the transmission of capital pressure affecting the bank's risk-taking through the central bank reserve requirement channel. They explain that a higher regulatory capital pressure is due to higher reserve requirements, decreasing bank risk-taking.

Finally, macroeconomic control variables show various effects on bank risk-taking. GDP provides a positive and significant effect in Model 2, model 3, and Model 4. We present this unexpected effect due to the procyclicality of financial institutions. Banks tend to lend more when paying attention to a positive signal and abide by the precautionary principle. Therefore, the booms of credit would increase the risk in financial institutions. The inflation rate negatively affects bank risk-taking, especially in Model 1, model, 4, and Model 5. Our result supports the study of Son et al. (2022). The last macroeconomic control is the interest rate. The result presents an affirmative and significant effect of interest rates on bank risk-taking. Overall, the variability of macroeconomic variables affects bank risk-taking in Indonesia.

Conclusion

Governments all across the globe are being compelled to improve their financial soundness as a consequence of the worldwide turmoil. The banking industry needs more stringent capital regulations to protect the financial system from disasters. Therefore, capitalization-based tools are a part of macroprudential policy and are used to raise the emergency preparedness signal. We present an analysis of capitalization's impact on bank risk-taking in the case of Indonesian commercial banks.

Our finding shows that single and overall cross-capitalization variables are consistent. The variable of the traditional capital ratio effectively weakens bank risk-taking. However, the risk-based capital ratio is inverse to our expected sign, which is an improvement in the risk-based capital ratio that improves bank risk-taking. The macroprudential instruments for the capitalization aspect, the capital buffer ratio for commercial banks, reduces the risk probability. Furthermore, our extended prudential capital buffer and regulatory capital pressure for domestic-systemically important banks (D-SIB) confirm the decrease in bank risk-taking. Therefore, we suggest maintaining the performance of macroprudential capital instruments for further analysis and policy decision-making.

This study is restricted to a review of the impact of prudential and non-prudential capital buffers on the Indonesian banking sector's financial stability. Our study is indeed confined to the bank industry in measuring the financial stability variable. It does not yet employ a number of materials to demonstrate overall financial stability across Indonesia's numerous financial institutions. Additionally, the cross-sectional data set consists of 18 commercial banks, each representing a different Indonesian bank group, and the time series data utilized is restricted to pre-pandemic datasets. Therefore, future studies may create a more thorough measure of financial stability that takes into account financial stability overall, the fluctuations of financial stability throughout an outbreak, and the number of institutions that would be more suitable to reflect a representative of all Indonesian commercial banks.

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