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The Impact of Bank Size, Capital, and Funding Structure to Systemic Risk: Evidence from ASEAN-5 Countries

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ABSTRACT

This paper aims to analyze the role of bank size, capital, and funding structure to the systemic risk in ASEAN-5 countries during period 2004-2014. The systemic risk is measured by Marginal Expected Shortfall (MES) and SRISK. Using panel regression, we find that systemic risk measured by MES has a positive relationship with bank size, but it has inverse relationship with capital using both MES and SRISK. However, the funding structure has a small effect on systemic risk compare to size and capital. Our findings provide a justification of Basel III's proposition that bank capital requirement tightening would reduce systemic risk.

Keywords: Systemic risk, bank fragility, financial crisis, bank performance, Southeast Asia

JEL Classification: G01, G15, G21

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INTRODUCTION

The recent financial crisis has led researchers and market participants to increase their understanding of risks inflicted by financial institutions, particularly concerning systemic risks. There are some reasons for this increase in understanding. First, large financial institutions are considered the main drivers of the recent financial crisis. For example, the recent financial crisis in 2008 affected large financial institutions such as the AIG Group and Lehman Brothers. The effect is contiguous and has affected other financial institutions' assets, such as Bank of America, Citigroup, Merrill Lynch, and other banks in the United States, along with other financial systems. Boyd and Gertler (1993) discovered behavioral differences between large and small banks in the United States: large banks tend to grant loans to developing countries rather than for domestic consumption and mortgage loans, which are, on average, more secure than other loans. Major banks in the United States are also involved in off-balance-sheet activities such as derivatives trading, which has lower interest margins than smaller banks. Second, large banks prefer to have lower capital ratios, less stable funding, and more exposure to risky market-based activities.

In Southeast Asia, the attention toward systemic risk significantly increased when the Asian banking crisis first hit Thailand in 1997 and then spread to Malaysia, Indonesia, and other Asian countries. In Indonesia, the debate about systemic risk occurred when the government decided to bail out Bank JTrust in 2008 (formerly known as Bank Century) because failure of the bank would have caused a serious systemic impact. After this financial crisis, there has been a significant development of the banking industry in Southeast Asia in the last decades, based on asset growth. The ASEAN Economic Community (AEC) was formed in 2015. Part of the plan is to integrate the financial institutions between member countries in 2020 (see Asian Development Bank, 2013). One of the goals is to facilitate the flows of capital flows between financial institutions from different countries. The integration surely would have several consequences, as banks in Southeast Asia will become more interconnected. For example, some difficulties faced by financial institutions in one country may affect the financial institutions of other countries within the ASEAN financial system as well, creating what is commonly known as the "contagion effect." Regardless of the sources of the shock, potential economic disruptions due to systemic risk would not merely trigger the bankruptcy of several financial institutions, it also would incur a great amount of social costs in order to recover economic conditions of a larger scale of the region.

Figure 1 provides stock prices of four major banks in four ASEAN countries, respectively. During the 2008 subprime crisis that hit the United States, banks suffered a significant decrease in their stock values. This offers insight into the knowledge that risk is contagious and is caused by the presence of interconnectedness between financial institutions in different regions.

This paper aims to examine systemic risk in Southeast Asia by using marginal expected shortfall, as proposed by Brownlees and Engle (2016) and Acharya *et al*. (2012), and SRISK proposed by De Jonghe *et al*. (2015). The two systemic risk measures are selected because they use market information to estimate risk exposure between banks and the market. Our study is different compared with that of Laeven *et al*. (2015), where we focus only on the ASEAN-5 countries, while Laeven *et al*. (2015) only included Malaysia and Singapore. Commercial banks

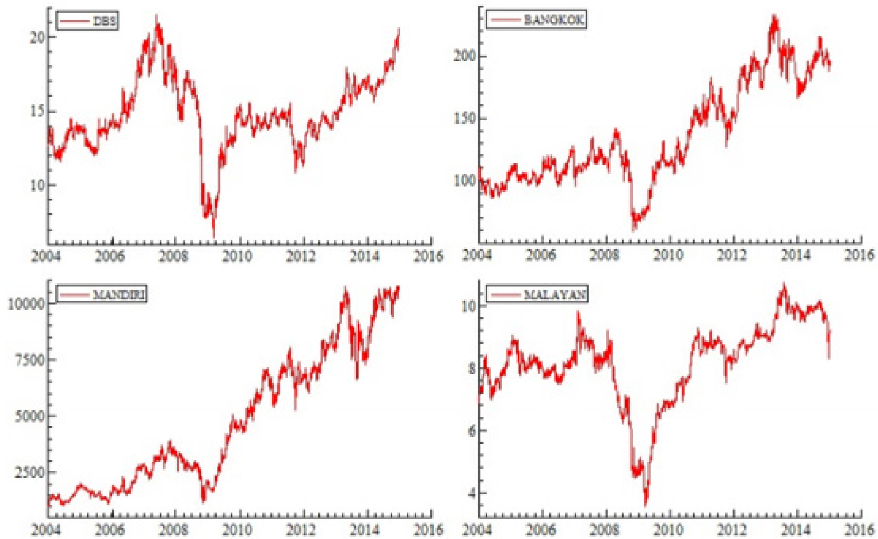

Fig 1. Stock prices of four major ASEAN banks, 2004-2016. Source: Datastream.

are considered as the most important financial institutions in ASEAN where they comprise of more than 82% of total financial assets in the region in 2009 (see ADB, 2013). This study will take a closer analysis how these banks relate to financial system. The rest of this paper is organized as follows. Section 2 provides related literature to this study. Section 3 elaborates upon the data and methodology used to examine the systemic risk. Section 4 provides the empirical results and discusses its findings. The last section is the conclusion.

RELATED LITERATURE

A financial system is defined as a set market for financial instruments, individuals, and institutions that are involved in trading activities, along with regulators who act as controllers of the system (see Howells & Bain, 2007). Mishkin (2013) defined a financial system as a complex entity that consists of a combination of financial institutions such as banks, insurance companies, financing companies, investment banks, and mutual funds, where all the activities are controlled and heavily regulated by the government and other financial regulators. Due to its importance to the economy, a sustainable financial system is regarded as one of the leading keys to economic growth. However, due to its complexity, any mishaps in the financial system also could be highly troublesome to the economy.

Systemic risk within financial systems has become a major concern in recent years, yet they have not been able to reach a consensus regarding the concept of financial stability or even systemic risk itself. The manifestation of systemic risk, particularly the one caused by the subprime crisis in the United States in 2008, has made it more than just an individual risk that affects the performance of financial institutions within a single system. de Bandt and Hartmann (2000) defined systemic risk as a risk that causes failure to one or more financial institutions as a result of systemic events. Systemic events are typically formed by a shock that affects certain financial institutions, which would then simultaneously spread to other financial institutions. Acharya (2009) strengthened the concept of systemic risk by defining this risk as an event in which banks are failing together, and the risk generated by the collapse of one financial institution will cause the collapse of other financial institutions. Tarullo (2009) argued that a financial institution can be classified as systemically important financial institution(s) (SIFI) if the default experienced by that financial institution affects other financial institutions, the financial system, and the economy as a whole. Therefore, those events inspire debate about the determinants of systemic risk.

With respect to systemic risk, two important hypotheses are widely discussed in the recent literature. The first hypothesis is the "too big to fail" hypothesis (TBTF). Labonte (2015) argues that financial institutions can be categorized as too big to fail when policymakers evaluate if the failure of those financial institutions could cause damage to the financial system as a whole. The expectations that the government would not let these institutions fail would induce moral hazard. If this occurs, then financial institutions have no incentives to strengthen their control of risk. The second hypothesis is the "too interconnected to fail" hypothesis (TITF). Allen *et al*. (2012) argued that banking systems are connected to each other via assets and liabilities on their balance sheet accounts. This connection is typically referred to as "banking networks." The banking networks approach is highly relevant as a method to assess systemic risk. de Bandt *et al*. (2009) proposed the "financial fragility" hypothesis, where systemic risk and contagion effects are a financial system's major concerns. The authors argue that three characteristics form the basis of this hypothesis. First, there exists a complex interrelationship between banks associated with exposure to systemic risk. Second, the activities carried out by banks, particularly related to the activity of maturity transformation, make the balance sheet structure become problematic because the assets tend to be more illiquid than the liabilities. Third, the monitoring cost increases the risk of uncertainty and liquidity.

The next question is how to measure systemic risk with respect to these two hypotheses. Chan-Lau (2010) utilized value at-risk (VaR) with a quantile bivariate regression estimation to measure systemic risk with respect to the too-big-to-fail hypothesis. The data used in the measurements demonstrate the difference of buy-and-sell price of credit default swaps (CDS), and the input used is the probability of failed-to-pay credit default swaps. His proposal to some extent can relate to the micro-aspects of financial institutions to banking and macroeconomic systems. Adrian and Brunnermeier (2016) proposed another method to measure systemic risk: the conditional variance-at risk (CoVaR). This measurement method is a refinement of the method developed earlier. CoVaR is defined as the difference between the conditional risk of financial institutions and the system when financial distress occurs compared with the median state. In other words, CoVaR provides a measurement of the contribution of a bank to systemic risk in a financial system. Anginer *et al*. (2014) used Merton's distance-to-default approach to measure the bankruptcy risk of commercial banks. Using equity valuation, the probability of default is measured by the difference between the value of assets and book value of its debt.

Brownlees and Engle (2016) and Acharya *et al*. (2012) proposed the SRISK method to measure systemic risk. SRISK is defined as additional capital needed by financial institutions when crisis occurs. SRISK estimation uses bivariate daily return of financial institutions and its market. In this method, volatility is modeled using the threshold ARCH, and correlation is estimated by the dynamic conditional correlation approach (see Engle, 2002). Laeven *et al*. (2015) found that large banks enjoy too-big-to-fail subsidies. Large banks have tendencies to lessen the control of the risks because they expect that the government will help them if financial difficulties occur.

DATA AND METHODOLOGY

We follow the approach of Laeven *et al*. (2015) to estimate systemic risk in Southeast Asian countries. Our focus is the measurement of systemic risk in Southeast Asian countries, while Laeven *et al*. (2015) only included Malaysia and Singapore in their samples. Our study employs information from 45 publicly traded banks in ASEAN-5 countries from January 1, 2004, until December 31, 2014. We exclude banks that are not publicly traded because our measures of systemic risk are based on equity returns. For the most part, we exclude non-bank financial institutions and focus on deposit-taking institutions (i.e., commercial banks and bank holding companies).

We employ SRISK, as proposed by Brownlees and Engle (2016) and Acharya *et al*. (2012), as a measurement for systemic risk. Let r_{it} and r_{mt} be the log return of each financial institution and market. Then, the bivariate equation for each log return can be expressed as follows (Brownless & Engle, 2012):

$$r_{mt} = \sigma_{mt}\, \epsilon_{mt}$$

$$r_{it} = \sigma_{it}\, \rho_{it}\, \epsilon_{mt} + \sigma_{it} \sqrt{1-\rho^2_{it}\, \xi_{it}}$$

$$(\epsilon_{mt}, \xi_{it}) \sim F,$$

where σ_{mt} is the conditional standard deviation of market returns, σ_{it} is the conditional standard deviation of financial institution returns *i*, ρ_{it} is the conditional correlation of financial institution and market, and $(\epsilon_{mt}, \xi_{it})$ are the shocks that affect the system. Shocks are independent and identically distributed over time and have zero mean, unit variance, and zero covariance (i.i.d).

We use the threshold ARCH model for volatility and dynamic conditional correlation specification between financial institutions and market. The threshold ARCH can be written as follows:

$$\sigma 2_{mt} = \omega_m\, G+\alpha_m\, Gr^2_{mt-1} + \gamma_m\, Gr^2_{mt-1}\, I^-_{mt-1}+\beta_m\, G\sigma^2_{mt-1}$$

$$\sigma^2_{it} = \omega_i\, G+ \alpha_i\, Gr^2_{it-1}+ \gamma_i\, Gr^2_{it-1}\, I^-_{it-1}+ \beta_i\, G\sigma^2_{it-1}$$

with $I^-_{it} = r_{it} < 0$ and $I^-_{mt} = r_{mt} < 0$. The purpose of this specification is to capture the leverage effect. This effect emerges when the propensity of volatility is higher with negative news rather than positive. The dynamic conditional correlation (DCC) can be written as follows:

$$Var_{t-1}\begin{pmatrix} r_{it} \\ r_{mt} \end{pmatrix} = D_t P_t D_t$$

$$Var_{t-1}\begin{pmatrix} r_{it} \\ r_{mt} \end{pmatrix} = \begin{bmatrix} \sigma_{it} & 0 \\ 0 & \sigma_{mt} \end{bmatrix} \begin{bmatrix} 1 & \rho_t \\ \rho_t & 1 \end{bmatrix} \begin{bmatrix} \sigma_{it} & 0 \\ 0 & \sigma_{mt} \end{bmatrix}.$$

The SRISK measures the expected capital shortage faced by a bank during periods of financial system distress when the market substantially declines. The SRISK can be written as

$$SRISK_{i,t} = kD_{i,t} - (1-k)\ W_{i,t}\ (1-LRMES_{i,t+h|t}\ (C_{t+h|t})),$$

where k is the minimum fraction of capital as a ratio of total assets that each firm needs to hold (we set k equal to the prudential capital ratio of 8 percent), and $D_{i,t}$ and $W_{i,t}$ are the book value of its debt (total liabilities) and the market value of equity, respectively.

The LRMES is defined as long-run marginal expected shortfall (MES) as follows:

$$LRMES_{i,t+180|t)}\ C_{t+180|t} = 1 - exp\ (-18 * MES_{i,t+1|t}\ (C_{t+1|t})\ ).$$

We specify that h in $C_{t+h|t}$ equals to 180 days and $C_{t+180|t}$ equals to -40 percent; we use the following approximation to compute long-run MES based on one-day MES. One-day MES is defined as the tail expectation of a firm's equity return conditional on a market decline: $MES_{i,t+1|t}$ $(C_{t+1|t)} = -E_t\ (R_{i,t+1|t} \mid R_{m,t+1|t} < C)$, where $R_{i,t+1|t}$ and $R_{m,t+1|t}$ denote the one-day stock return for the firm and the market, respectively, and C is the threshold of the decline in market index (–2 percent in this case). In this study, we also include marginal expected shortfall (MES) as a measurement of systemic risk. MES captures the increase of risks of the system, induced by marginal increase in the weight of bank i in the system. The higher the bank's MES (in absolute value), the higher the contribution of bank i to the risk of the banking system.

Following Laeven *et al*. (2015), we employ three variables: bank size, capital, and funding structure. Size is measured by the natural logarithm of bank assets (in US$ million), capital is measured by a Tier 1 ratio, and funding structure is measured by the ratio of total deposits to total assets. We also use the ratio of total loans to total assets to control the bank-specific variables, except for models in which we include funding structure as one of our main variables. To control the heterogeneity within the region, we use GDP per capita that serves as a proxy of the government's ability to support the financial system during distress. The specification can be written as

Model 1

$$SRISK_{i,t} = \alpha + \beta_1\ Size_{i,t-1} + \beta_2\ Capital_{\ i,t-1} + \beta_3\ Size*Capital_{i,t-1} + \beta_4\ DTA_{i,t-1} + \beta_5\ LTA_{i,t-1} + \beta_6\ Control_{i,t-1} + \varepsilon_{it}$$

Model 2

$$MES_{i,t} = \alpha + \beta_1\ Size_{i,t-1} + \beta_2 Capital_{i,t-1} + \beta_3\ Size*Capital_{i,t-1} + \beta_4\ DTA_{i,t-1} + \beta_5 LTA_{i,t-1} + \beta_6\ Control_{i,t-1} + \varepsilon_{it}$$

where SRISK and MES are measures of systemic risk of bank i computed from 2004–2014. Size is outlined by the logarithm of total assets (in US$ million), capital is outlined by Tier 1 ratio, and bank's funding structure is outlined by deposits/assets (DTA) and loans/assets (LTA). To control this model, we use interaction of the logarithm of GDP per capita and the logarithm of total assets.

EMPIRICAL FINDINGS AND DISCUSSION

Table 1 reports the statistics summary of our two measures of systemic risk, along with other variables. We find that SRISK ranges from a low of US$ –15.451 million to a high of US$ 18.162,00 million, and MES ranges from a low of zero to a high of 6 percent. The difference in number of observations between these two measures of systemic risk is due to the lack of information on statements of financial position for some banks. Acharya *et al*. (2012) limited SRISK from below zero because they wanted to estimate capital shortage that, by definition, cannot take negative values. Our study, however, uses negative values of SRISK because they provide information on their contribution of the institution to systemic risk. The marginal expected shortfall as a measure of systemic risk is in absolute values.

Table 1 Summary statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max
SRISK	488	-929.79	2985.89	-15451.00	18162
MES	495	0.012	0.01	0.00	0.06
Log Assets	488	9.27	1.63	4.35	12.71
Tier 1 ratio (%)	434	0.13	0.04	0.05	0.44
Deposits/assets	488	0.77	0.09	0.24	0.92
Loans/assets	488	0.62	0.12	0.13	0.89
Log GDP per capita	495	3.60	0.38	4.75	3.03

Notes: This table reports the descriptive statistics of the 45 publicly listed banks in ASEAN-5 countries used as samples in this study. SRISK is computed annually between 2004 and 2014 and is expressed in millions of US dollars. Log assets is the natural logarithm of total assets (in millions of US dollars). Tier 1 ratio is the ratio of Tier 1 capital to risk-weighted assets. Deposits/assets is the ratio of bank deposits to total assets. Loans/assets is the ratio of bank loans to total assets. Log GDP per capita is the natural logarithm of GDP per capita. Source: authors' calculations.

Table 2 reports the correlations between variables used in our analysis where it indicates that bank size is negatively correlated with SRISK and positively correlated with MES. Moreover, a Tier 1 ratio is positively correlated with SRISK and negatively correlated with MES. Both measures of systemic risk are negatively correlated with deposits/assets and positively correlated with loans/assets.

Table 2 Correlation matrix.

	SRISK	MES	Log Assets	Tier 1 ratio	DTA	LTA
SRISK	1.000					
MES	0.251	1.000				
Log Assets	-0.200	0.270	1.000			
Tier 1 ratio	0.056	-0.143	-0.199	1.000		
DTA	-0.061	-0.076	-0.207	-0.154	1.000	
LTA	0.003	0.190	-0.010	-0.302	0.044	1.000

Notes: This table reports the correlation matrix of the main regression variables for the 45 publicly listed bank sample in ASEAN-5 countries. Source: authors' calculations.

Table 3 provides a summary for banks that have the largest contribution to systemic risk during the period of 2004 to 2014 for both SRISK and MES, respectively. In panel A, we can interpret that DBS Group Holdings Ltd., which is based in Singapore, has the largest contribution to systemic risk measured by SRISK. The DBS Group Holdings Ltd.'s SRISK index in 2008 reaches US$ 18.162 million or US$ 18,162 billion. On average, banks based in Malaysia and Singapore have higher asset compare to other banks. The SRISK estimates for these banks are on average relatively higher than other banks. This may explain the reason why the top banks based on SRISK estimates.

Based on panel B, Bank Negara Indonesia (Persero) Tbk., based in Jakarta, Indonesia, has the largest contribution to systemic risk measured by MES. Bank Negara Indonesia (Persero) Tbk MES value reaches 6% in 2007. In general, banks in Singapore and Malaysia have high SRISK indexes compared with banks in Thailand, Indonesia, and Philippines. This is because their market value of equity is also quite large. When a shock occurs and affects their stock price directly, it also will affect their market value of equity.

Table 3 Top ten ASEAN-5 banks with the largest contribution to systemic risk, 2004-2014

Panel A: top 10 bank by SRISK			Panel B: top 10 bank by MES		
1	DBS Group Holdings Ltd	Singapore	1	Bank Negara Indonesia Tbk	Indonesia
2	United Overseas Bank Ltd	Singapore	2	Bank of Ayudhya PCL	Thailand
3	Oversea-Chinese Banking Corp Ltd	Singapore	3	Siam Commercial Bank PCL	Thailand
4	CIMB Group Holdings Berhad	Malaysia	4	Bank CIMB Niaga Tbk	Indonesia
5	Malayan Banking Berhad	Malaysia	5	DBS Group Holdings Ltd	Singapore
6	Krung Thai Bank PCL	Thailand	6	Krung Thai Bank PCL	Thailand
7	Siam Commercial Bank PCL	Thailand	7	Kasikornbank PCL	Thailand
8	BDO Unibank Inc	Philippine	8	United Overseas Bank	Singapore
9	Bangkok Bank PCL	Thailand	9	Bank Rakyat Indonesia Tbk	Indonesia
10	Bank Mandiri (Persero) Tbk	Indonesia	10	Bank Mayapada Internasional	Indonesia

Source: authors' calculations.

We use generalized least-squares (GLS) for our regressions due to heteroskedasticity problems in our models. The results of systemic risk regressions are shown in Table 4. We can see MES as a proxy for systemic risk has more explanation on the determinants of systemic risk in ASEAN-5 than SRISK. We find that assets are negatively significant for SRISK. We find that the assets are significantly positive for MES. This result is aligned with the view that large banks enjoy the support provided by the government as a result of their characteristics as banks that fall into the too-big-to-fail category. Laeven *et al*. (2015) also reached the same conclusion: that systemic risk is positively associated with bank size by using CoVaR measurement. The SRISK measures are able to capture the exposure to common shocks that affect financial systems and in shocks in general that occur during the period of subprime crisis in 2008. After that crisis, the market values of equity of the majority of banks in ASEAN show positive trends. As a result, the SRISK index of the majority of banks in ASEAN from 2004–2014 has a negative value.

The market values of equity generally continue to increase every year and only drop when the subprime crisis befalls the United States in 2008. When too-big-to-fail hypothesis applies, large and complex banks tend to take excessive risks due to moral hazards that rise from expectations of government bailouts (Farhi & Tirole, 2012). This result is consistent with the view that large banks enjoy too-big-to-fail classification, making them less careful with the risks they take, which create externalities for the system as a whole when they face financial distress.

Table 4 Estimation results using SRISK and MES

Variables	(1) SRISK	(2) MES
Log assets	-430.7***	0.00172**
	(122.1)	(0.0005)
Tier 1 ratio	-10559.8*	-0.0590*
	(5094,0)	(0.0262)
Tier 1 ratio*log assets	1389.3	0.00954**
	(732.3)	(0.0035)
Deposits/assets	-107.2	0.0011
	(678.8)	(0.0031)
Loans/assets	1432.3*	0.00304***
	(615.3)	(0,0021)
GDP per capita	90.20	-0.00319**
	(337.6)	(0.0011)
Observation	430	430
R-Squared	0.234	0.164
F-stat	7.029	4.523
P-value	0.000	0.000

Notes: This table provides estimation results of SRISK and MES on a set of bank characteristics and macroeconomic variables. The SRISK estimation is reported in column (1) and the MES estimation is reported in in column (2) respectively. The dependent variables are computed over the period of 2004 to 2014. Standard errors are reported between brackets, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Source: authors' calculations.

We find that a Tier 1 ratio is negatively correlated with systemic risk. This means the higher Tier 1 ratio, the lower a bank's systemic risk. We also find that a Tier 1 ratio will decrease the systemic risks on average by US$10,559 million. This can become a motivation to increase prudential regulations formulated by the Basel Committee on minimum capital requirements, which must be effectively implemented to reduce ASEAN-5 banks' systemic risk. This view is consistent with the theory that capital adequacy acts as a buffer to prevent macroeconomic shocks and other systemic events. The interaction between bank size and bank capital also is significant for MES. This shows us clear justification that traditional micro-prudential regulations would not be enough in order to lower capital in larger banks. The fact that sufficient capital is more significant to reduce systemic risk measured by SRISK and MES for banks in

ASEAN-5 countries, regulators could use the Basel approach through capital surcharges rather than activity restrictions in order to reduce systemic risk.

The bank funding structure has less significant influence against systemic risk. The deposits do not play a crucial role to systemic risk. The only variable that has influence on systemic risk is loans/assets. This could support the notion that, if the ASEAN financial integration exists, then the relationship between banks will increase through inter-bank lending. Systemic risk can arise when one of the banks fails to meet its obligations, then the banks in the system will feel the impact. Loans are positively associated with systemic risk caused by inter-bank lending, as indicated in their statement of financial position. Systemic risk arises when one bank in the system fails, and it will affect the system as a whole via inter-bank lending accounts. It can be inferred that the spread of systemic risk would interfere with the financial position of banks in the system as a whole when one bank fails.

CONCLUSIONS

Our findings show that bank size has a positive relationship with systemic risk measured by MES, which is the expectation of loss in equity value during financial distress. Therefore, it can be inferred that, during financial crisis, banks with larger equity values have higher potential loss. However, this result is contradictory with the systemic risk measured using the SRISK. It may be caused by the expectation that large-sized banks will receive government assistance when experiencing financial difficulties: their market value of the equity would not fall, as it should have during a financial crisis. These results imply that large banks bear excessive systemic risk, but it would be difficult to limit the size of the banks in practice. Using MES and SRISK as systemic risk indicators, a bank's capital has a significantly negative effect on a bank's systemic risk. These findings justify tightening bank requirements, as stated in Basel III. A Tier 1 ratio can be used to prevent a bank's systemic risk by increasing the capital buffer of a bank in anticipation of distressing financial events.

The funding structure of banks generally has less influence compared with bank size and bank capital against systemic risk. Bank lending has a positive influence on bank systemic risk posed by inter-bank lending in the balance. If a certain bank failure occurs in a mechanism of inter-bank lending, then other banks in the same inter-bank lending mechanism system also will be affected by the failure of that particular bank. In summary, our findings provide some motivations to regulate ASEAN banks toward better capital adequacy requirement to have better financial stability in the region.

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