

## Systemic Risk Analysis Using Conditional Value at Risk (CoVaR) Model: Evidence in Indonesia

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### Abstract

This study aims to measure systemic risk in conventional commercial banks in Indonesia with the Conditional Value at Risk (CoVaR) model developed by Adrian and Brunnermeier (2009). The financial crises of 1998 and 2008 have become valuable lessons for Indonesian banks to always maintain financial system stability because the impact caused by systemic risks is very large. Systemic risk is the possibility of instability due to contagion in some or all of the financial system. This study uses a sample of 6 conventional commercial banks in Indonesia from January 2012 to December 2018. The results obtained from this study is the systemic risk is not related to the size of banks. Each bank has a negative externality so that it can cause a bank rush and systemic impact.

**Keywords:** *Systemic Risk; Conditional Value at Risk; Conventional Banking*

**JEL Classification:** D81, G21, G33

### INTRODUCTION

Banks have an important role in the economy, which is reflected in the growth of banks that are increasing and the ease of transactions that contribute to improving the domestic economy. Kasmir (2008) explains the definition of a bank that acts as a financial intermediary between parties who have funds and those who need funds, as well as institutions that function to facilitate payment traffic. The increase in the Indonesian banking intermediation function is shown in the following figure 1.

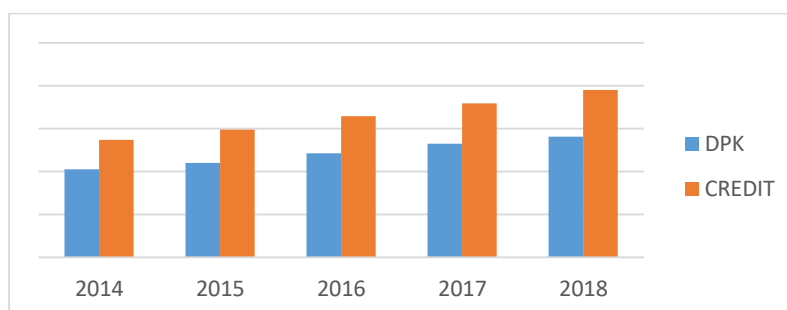


Figure 1. Development of Funds Deposits and Loans in Conventional Commercial Banks in Indonesia, 2014-2018

Sources: Banking Statistic of Indonesia, 2018

A stable and strong financial sector (banking and capital markets) can accelerate economic transactions to reduce transaction costs. Financial system stability is very important to protect the economy from shock when a crisis or shock occurs. For this reason, the financial sector, in this case, the banking sector needs to maintain its stability to anticipate and reduce the risks that arise.

The bank's business activities not only collect and channel funds but many other types of business activities with different complexity, so they are vulnerable to risk. One of them is the risk of failure (distress) that can disrupt other banks (systemic). Systemic risk is if an institution experiences financial difficulties (distress), it will increase the likelihood of other institutions in the banking industry participating in failing, so that bank runs can occur and the banking system is damaged (Adrian and Brunnermeier, 2009).

De Bant and Hartmann (2010), dividing systemic risk into two based on the nature of the shock, namely in terms of broad and narrow. Systemic risk in the broadest sense is defined as the simultaneous failure of several institutions or companies caused by the shock of macroeconomics. Meanwhile, systemic risk in the narrow sense is the risk that comes from the shock of microeconomics that occurs in a company and then spreads to other companies, this process is often referred to as a contagion effect.

The crisis of 1997/1998 and 2008 has become a valuable lesson for Indonesian banks to always be financial system stability. This is due to the large impact and cost of the crisis. Where the 1997/1998 crisis began with the exchange rate crisis in Thailand which then spread (contagion) to several Asian countries and had the most severe impact on the countries of Thailand, Indonesia, Philippines, and South Korea. In Indonesia, the 1997/1998 crisis caused a crisis of public confidence in national banks, especially after the business license of 16 banks was revoked on November 1, 2007, which eventually had a widespread impact on January 1998 (Bank Indonesia, 2000).

Meanwhile, the 2008 crisis stems from the financial crisis in the United States caused by the subprime mortgage. The crisis spread (contagion) and caused impacts in several countries. In Indonesia, this crisis created a polemic with Bank Century being declared a failed bank that had a systemic impact and government bailout. Reviewing the 1997/1998 and 2008 crises, research on systemic risk needs to be studied. This is to marginalize the occurrence of systemic risk because the impact is very large and costs a lot too. This main objective of this study is to measure and analyze systemic risk in Conventional Banks in Indonesia. Some other parts that will be studied include a) how are the individual risks of conventional banks in Indonesia, and b) how does the systemic risk contribution of each risks towards financial system stability in Indonesia.

Research on systemic risk has been carried out in several countries, such as in the member countries of Gulf Cooperation Council or GCC (Abedifar, 2017); Europe (Derbali & Hallara, 2015); United States (Cai, 2018, Drakos, 2015); Thailand (Roengpitya & Rungcharoenkitkul, 2010); Taiwan (Su & Kai Wen, 2010); China (Huang, 2016, Fang, 2018); and Indonesia (Zebua, 2011; Ayomi et al, 2013; Muharam & Erwin, 2017).

Research conducted by Huang et al (2016) in China shows that the biggest systemic risk is contributed by insurance companies, then commercial banks, and

other financial institutions. Meanwhile, the study of Abedifar et al (2017) comparing the systemic risk contributions from the Islamic banking sector and conventional banks in the member countries of Gulf Cooperation Council (GCC) finds the evidence that the CBw (conventional banks with Islamic windows) sector is the most systemically vulnerable, and has the highest systemic role.

Some research on systemic risk has also been studied in Indonesia. The research conducted by Ayomi and Hermanto (2013) found that banks with large assets contributed to a large systemic risk. It can be said, bank size has a direct relationship or is directly proportional to the contribution of systemic risk. Meanwhile, Erwin and Muharam's research (2017) found that total bank assets were not enough to explain the contribution of systemic risk. The bank with the eighth-largest total assets in Indonesia contributes the biggest systemic risk to its research.

There are several methods for measuring systemic risk. Ayomi & Hermanto (2013) and Erwin and Muharam (2017) use the Conditional Value at Risk (CoVaR) method referring to the research of Adrian and Brunnermeier (2009). Whereas, Derbali uses the Marginal Expected Shortfall (MES) method to measure risk based on the study of Acharya et al. (2010). Meanwhile, this study focuses on the contribution of systemic risk in conventional banks in Indonesia using the Conditional Value at Risk Model (CoVaR).

## **LITERATURE REVIEW**

The financial system plays a very important role in the economy. As part of the economic system, the financial system has the function of allocating funds from the surplus party to those who have a deficit. If the financial system is unstable and does not function efficiently, the allocation of funds will not run well so that it can disrupt economic growth. An unstable financial system, especially if it causes a crisis, requires a very high cost for its rescue efforts (Bank Indonesia, 2018).

Macroprudential policy is a policy aimed at increasing the resilience of the financial system and for systemic risk mitigation arising from the linkages between institutions and the tendency of financial institutions to follow the economic cycle (procyclical) to increase systemic risk (Working Group G-20, 2010). There are several instruments in macroprudential policies that can be applied to maintaining financial system stability. Among other things are Loan to Value (LTV), Minimum Mandatory Current Account (GWM), Basic Loan Interest Rate (SBDK), Capital Adequacy Ratio (CAR), Net Opening Position (NOP), Net Open Position (NOP) and others.

The theory underlying the vulnerability of banking on the liability side is the theory of Prisoners' Dilemma. When the public trust in the bank is lost, it will cause the simultaneous and immediate withdrawal of funds (rush or run). Bank vulnerability occurs because of the interaction between liquid liabilities which are generally short-term and illiquid assets which are generally long-term (Apriadi et al., 2017). In general, according to Ayomi, et al (2013) the source of bank failure can be distinguished as follows: a) excessive bank credit expansion, b) asymmetric information especially when the bank's economic conditions deteriorate, c) shocks starting from outside the banking system, regardless of

financial conditions banks and d) institutional and legal restrictions that weaken banks and cause bankruptcy.

Roengpita and Rungcharoenkitkul (2010) carried out a study entitled "Measuring Systemic Risk and Financial Linkages in the Thai Banking System". This study aims to measure systemic risk and financial relationships among the six major commercial banks in Thailand during the 1996Q2 - 2009Q1 period. This study uses the Conditional Value at Risk (CoVaR) model referring to the research of Adrian and Brunnermeier (2009). The results reveal that there are additional risks that are charged to the system as a whole by each bank during the Asian crisis period and in the following period. Then, there are inter-bank linkages that make banks have to anticipate if other banks experience distress.

Another research is also made by Sri Ayomi & Bambang Hermanto (2013) with the title "Measuring Systemic Risk and Financial Linkages of Banking in Indonesia". This study has four objectives, including a) knowing the default probability value of each bank based on the Merton model; b) measure the level of risk individually for each bank and the contribution of each bank towards the risk of the banking system as a whole; and c) measuring financial linkage between banks in the banking system in Indonesia. This study used a sample of 30 banks during the period 2002 to 2013. The results obtained included: 1) the average probability of bank defaults during the study period is above 50% which was strongly influenced by the magnitude the volatility of the returns from bank assets; 2) the value of the unconditional VaR of each bank can be used to describe the risks to the banking system; 3) the analysis of financial linkage between banks shows that each bank gives a very diverse added risk when the bank experiences distress and 4) the higher the contribution of risk, the higher the percentage contribution of systemic risk.

Furthermore, research conducted by Alfredo Zebua, Hermanto Siregar and Hendro Sasongko entitled "Analysis of Systemic Risk of Indonesian Banking". The purpose of this study is to measure the level of systemic risk of individual banks, to analyze interbank financial linkage, and to analyze CAMEL financial risk against the systemic risk of individual banks. The outcome obtained from this study include: a) each sample in the bank contributes additional risk (weekly average  $\Delta\text{CoVaR}$ ) to overall system risk, which means that if a bank experiences distress, it can lead to increase risk in the Indonesian banking system; b) individual bank risk ranking (bank VaR) with a systemic level of risk for individual banks have a weak relationship, while banks with larger size tend to have larger levels of individual systemic risk; and c) financial linkages present that the individual risk of a bank that is conditioned towards the risk of other banks has an ancillary impact of various risks, henceforth when a bank itself experiences distress, the bank does not necessarily put pressure on the risk of other individual banks.

## **METHOD**

### **Data**

This study uses a quantitative approach and secondary data. This study uses purposive sampling in determining data samples. This study uses the Conditional Value at Risk (CoVaR) model with Eviews software. Conditional

Value at Risk (CoVaR) developed by Adrian & Brunnermeier (2009) can be used to measure systemic risk in conventional commercial banks in Indonesia.

This research uses a sample of 6 conventional commercial banks. In this study monthly data is used with the period from January 2012 to December 2018. The data used are stock prices and macro data (SBI rate, JIBOR, and IHSG). For stock price data and IHSG obtained from the Yahoo Finance website ([www.yahoofinance.com](http://www.yahoofinance.com)), while the SBIS rate and JIBOR data come from the official website of Bank Indonesia ([www.bi.go.id](http://www.bi.go.id)).

### Value at Risk (VaR)

Value at Risk (VaR) is a risk measurement method using statistical techniques developed by JP Morgan and has a lot in measuring risk in the financial market. Jorion (2001) explains that Value at Risk (VaR) is a method used to measure the maximum losses that may occur in a certain period and level of trust ( $\theta$ ). This VaR method has the advantage of focusing on downside risk, not depending on the assumption of the distribution of returns, and can be used in a variety of financial products traded.

In 2011, Adrian and Brunnermeier (2009) explained VaR as a conditional quantum  $\theta$  to assets  $R^i$  or denoted as follows.

$$Pr(R^i \leq VaR^i) = \theta$$

Dowd and Blake (2006) explained that there are 3 (three) basic methods of calculating value-at-risk, including parametric methods, nonparametric methods (historical simulation), and Monte Carlo methods. The most widely used method for estimating VaR is a nonparametric method because it can capture non-linear and stronger relationships compared to parametric methods because it is not based on the distribution.

Adrian and Brunnermeier (2009) explain  $CoVaR_{\theta}^{j|i}$  is a conditional VaR of an institution (or financial system) for several events  $\mathbb{C}(R^i)$  at an institution  $i$ . This measure is based on the concept of value-at-risk, expressed by VaR ( $\theta$ ), which is the maximum loss in the interval% confidence interval. So that CoVaR corresponds to market yield VaR obtained conditionally on several events  $\mathbb{C}(R^i)$  observed from the institution  $i$ .  $CoVaR_{\theta}^{j|i}$  is implicitly defined by the quintile  $\theta$  of the conditional probability distribution:

$$Pr(R^i \leq CoVaR_{\theta}^{j|\mathbb{C}(R^i)} | \mathbb{C}(R^i)) = \theta$$

so that the institution's contribution to the  $j$  institution (or financial system) can be denoted as follows:

$$\Delta CoVaR_{\theta}^{j|i} = CoVaR_{\theta}^{j|R^i=VaR_{\theta}^i} - CoVaR_{\theta}^{j|R^i=Median^i}$$

Adrian and Brunnermeier (2009) focus on conditioning events  $\{X^i = VaR_{\theta}^i\}$  and simplifying the notation  $CoVaR_{\theta}^{j|i}$ , where  $j = \text{system}$ , ie when the portfolio of all financial institutions is at the level The VaR. In this case the superscript  $j$  is omitted, so that  $\Delta CoVaR_i$  shows the difference between the conditional financial system VaR towards the distressing financial institution and the financial system VaR conditional on the institution  $i$  in the median condition.

The contemporary measure of  $\Delta CoVaR_i$  quantifies the spillover effect by measuring how many institutions contribute to the overall risk in the financial system. Spillover effects can be transmitted directly through contractual links

between financial institutions. From the definition of CoVaR by Adrian and Brunnermeier shows that financial institutions experiencing distress that coincide with financial systems that are distressed will have a high measure of systemic risk.

After the asset return is calculated, the VaR of the bank  $i$  and the system VaR can be defined. If  $R^i$  is a bank return  $i$  and has a distribution  $F$ , then given a confidence level  $(1 - \theta)$ , then  $VaR^i(R)^i$  can be defined as follows:

$$VaR^i(R)^i = \inf\{x: F(R)^i \geq \theta\}$$

VaR is basically a quintile  $\theta$  of the return distribution  $F$ . Specifically VaR with a level of trust  $\theta$  is defined by the following equation:

$$\Pr(R^i \leq VaR^i) = \theta$$

it means there is a possibility  $(100 \times \theta)\%$  return is smaller than VaR for a certain period or in other words, with a level of trust  $(1-\theta)$ , the return will not be smaller than VaR. After that, you can calculate the banking system VaR as a standard VaR without conditions.

$$\Pr(R^{SYS} \leq VaR^{SYS}) = \theta$$

Or conditional VaR on an event where a particular bank is under stress (for example) a bank return reaches its VaR level, which can be called a conditional VaR (CoVaR).

$$\Pr(R^{SYS} \leq VaR^{SYS|i} | R^i = VaR^i) = \theta$$

### Data Estimation Stage

There are 3 stages of data processing used in this study:

#### 1. The first

The first step in processing data in calculating the value of banking assets. This study uses price data to measure the market value of bank assets. The growth in the market value of the assets of each bank and the market value of the assets of the banking system can be measured by the following formula.

$$X_t^i = \left( \frac{A_t^i - A_{t-1}^i}{A_{t-1}^i} \right)$$

$$X_t^{SYS} = \left( \frac{A_t^{SYS} - A_{t-1}^{SYS}}{A_{t-1}^{SYS}} \right)$$

$A_t^{SYS}$  is  $\sum A_t^i$ . Whereas  $X_t^{SYS}$  shows the return of the overall stock price of the banking system; and  $A_{t-1}^{SYS}$  shows the total assets of the banking system in the previous period. The equation to estimate the return value of bank assets is as follows.

$$X_t^i = \alpha^i + \beta^i M + \varepsilon_t^i$$

$$X_t^{SYS} = \alpha^{SYS} + \beta^{SYS} M + \varepsilon_t^{SYS}$$

#### 2. The second

In the second step, there will be measurements of individual bank risks and the banking system in general. To estimate the value of individual VaR and the banking system VaR, use the following equation.

$$VaR_t^i = \hat{\alpha}^i + \hat{\beta}^i M$$

$$VaR_t^{SYS} = \hat{\alpha}^{SYS} + \hat{\beta}^{SYS} M$$

$VaR_t^i$  is the value at risk of bank  $i$  in period  $t$ , and  $VaR_t^{sys}$  is the value at risk of the banking system in period  $t$ .  $M$  is a macro variable vector including SBI, JIBOR, and IHSG which is calculated in its growth value using the following formula.

$$SBI_t = \frac{SBI_t - SBI_{t-1}}{SBI_{t-1}}$$

$$JIBOR_t = \frac{JIBOR_t - JIBOR_{t-1}}{JIBOR_{t-1}}$$

$$IHSG_t = \frac{IHSG_t - IHSG_{t-1}}{IHSG_{t-1}}$$

### 3. The third

This step will measure the Conditional Value at Risk (CoVaR) parameter based on Value at Risk in individual banks and the entire banking system. This CoVaR value shows systemic risk, namely the influence of a bank on the banking system as a whole. Ayomi et al (2013) explained that technically, the estimation of  $CoVaR_t^i$  was carried out using the results of the banking system return estimation and substituting the estimated results  $VaR_t^i$  in the coefficient  $\gamma^{sys|i}$ .

$$X_t^{sys} = \alpha^{sys|i} + \beta^{sys|i} M + \gamma^{sys|i} X_t^i + \varepsilon_t^{sys|i}$$

$$CoVaR_t^{sys} = \hat{\alpha}^{sys|i} + \hat{\beta}^{sys|i} M + \hat{\gamma}^{sys|i} X_t^i$$

Where  $CoVaR_t^i$  is the conditional value at risk of the banking system in bank  $i$  VaR, whereas  $\hat{\alpha}^{sys|i}$ ,  $\hat{\beta}^{sys|i}$ ,  $\hat{\gamma}^{sys|i}$  are estimated parameters. After that, systemic risk contributions from the banking system were measured from each bank using the following formula:

$$\Delta CoVaR_t^i = CoVaR_{t,\theta}^i - CoVaR_{t,50\%}^i$$

## RESULTS AND DISCUSSION

Bank failure (distress) of a bank can affect other banks in a financial system. Prevention of bank failures must be carried out continuously to maintain the level of public trust or moral hazard in the banking industry. The Value at Risk (VaR) estimation using quantile regression produces 5% quantile regression and median VaR which is a maximum probability of loss of 5% and median. The estimated VaR results show that Bank E has the highest VaR value of 55.54%. This means that there is a 5% possibility that investors will lose more than 55.54% of the portfolio value. Or it can be interpreted also, Bank E has a 95% chance of not losing more than 14.56% of the portfolio. Meanwhile, the highest VaR value was found in Bank A at 9.03%. This means that Bank A has a 5% chance that investors will lose more than 9.03%. In other words, Bank A has a 95% chance of loss not exceeding 9.03% of the portfolio.

Table 1. Value at Risk 5% and Median

Bank	VaR 5%	VaR Median
Bank A	-0.090325	-0.014308
Bank B	-0.125796	-0.024896
Bank C	-0.160476	-0.158905
Bank D	-0.116839	-0.176859
Bank E	-0.555451	-0.342089

Bank F	-0.459140	-0.589053
Bank G	-0.174740	-0.128628

**Sources:** Data Processed, 2019

Based on reports from banking publications in 2018, Bank E's performance does not show a side of improvement. This is because the ratio of non-performing loans (NPLs) is high at 3.04% or increased compared to the 2017 ratio of 2.84%. Meanwhile, Bank A that obtained the lowest VaR (individual risk) recorded a good performance in 2018. This is indicated by the increase in net profit by 21.2% compared to 2017.

CoVaR developed by Adrian and Brunnermeier (2011) is measured using the quantile regression coefficient of return on conditional assets on each bank and macro variables (economic factors). The estimation of the CoVaR value of each bank uses the coefficients generated from 5% quantile regression (at distress) and 50% (median) in table 2 below.

Table 2. Conditional Value at Risk 5% and Median

<b>Bank</b>	<b>CoVaR 5%</b>	<b>CoVaR Median</b>
Bank A	-0,844185	-0,821087
Bank B	-0,801151	-0,709357
Bank C	-0.893206	-0.816753
Bank D	-0,702317	-0,613397
Bank E	-0.895420	-0.722890
Bank F	-0,710352	-0,465944
Bank G	-0,719742	-0,564267

**Sources:** Data Processed, 2019

The results of the average estimation of Conditional Value at Risk (CoVaR) in critical conditions (5% quintile) in the closing period indicate that Bank E obtained the highest CoVaR value, which was 89.54%. Meanwhile, the lowest CoVaR is at Bank D of 70.23%. Meanwhile, marginal CoVaR is the CoVaR difference in the distress and CoVaR conditions at the median time. Based on the estimation results using quantile regression, the marginal value of CoVaR is obtained as shown in table 3 below.

Table 3. Marginal Conditional Value at Risk ( $\Delta$ CoVaR)

<b>Bank</b>	<b>(<math>\Delta</math>CoVaR)</b>
Bank A	-0.0231
Bank B	-0.09179
Bank C	-0.07645
Bank D	-0.08892
Bank E	-0.17253
Bank F	-0.24441
Bank G	-0.15548

**Sources:** Data Processed, 2019

The margin of CoVaR (oCoVaR) in table 3 shows the systemic risk contribution from each bank. It was seen that the biggest systemic risk was contributed by Bank F at 24.44% and then followed by Bank E at 17.25%.

Meanwhile, the lowest systemic risk contribution is found in Bank A. The banking publications report in 2018 shows that Bank F experienced a significant decline in share prices by 51.57% during 2018. Bank F PBV (price to value book) at the level of 0.4 times or much lower than the banking industry average above 1.6 times. This makes Bank F share prices tend to be cheaper than the other banking industry average.

The results of this study support the research conducted by Zhou (2010) that the systemic risk of banks is not related to size. In this result, there is no opinion which states that the greater the assets of the bank, the greater the contribution of systemic risk. This is because the assets of Bank F and Bank E are not as large as Bank A or other banks in the BUKU Bank IV category. Erwin and Muharam (2017) added that bank size is not the only reference to the magnitude of systemic risk contributions. Small banks can raise the risk of a bank rush which can then be contagious and have a systemic impact.

Other related research is research conducted by Pais and Stork (2013) which states that large banks tend to have a slightly higher value at risk (VaR) and also found that banks with large assets have a contribution to systemic risk higher.

Based on Indonesian Banking Statistics data, the total assets of commercial banks in 2018 have reached Rp 8,068 trillion. Meanwhile, the total assets of new Islamic banking is Rp 316 trillion. Based on this amount, it means that the ratio of Islamic banks to conventional commercial banks is only 3.91%. Therefore, conventional commercial banks contribute greatly to the financial system compared to Islamic commercial banks.

The results of this study are several implications, both for regulators and bank management. The implication for regulators is to increase supervision and attention to banks. Both banks with assets that are large or small because each bank has a negative externality so that it can cause a bank rush and systemic impact. Regulators also need to reinforce macroprudential policies to reduce systemic risk using a countercyclical buffer and capital surcharge.

Besides, the regulator is expected to not only save large banks when experiencing distress, but also small banks. For bank management, this research has implications for always maintaining stability by managing risk well. One of them is through tightening liquidity and strengthening capital that serves to cover risks.

Also, banks need insurance on deposits that can be accomplished through the Deposit Insurance Corporation (LPS). This LPS serves to guarantee deposits of depositors and actively participates in maintaining the stability of the banking system in accordance with their authority. This can amplify the bank's liquidity position when the bank is being distressed, therefore it can prevent bankruptcy (Zebua, 2011). Banks also need to strengthen the division of risk management to prevent or anticipate various possibilities of distress or anticipation of various negative macroeconomic shocks and other banks.

## **CONCLUSION**

The magnitude of the individual bank's risk is directly proportional to the bank's contribution to the banking systemic risk. Banks that have large individual risks are also likely to have a large systemic risk contribution. Systemic risk is not related to the size of banks. Each bank has a negative externality so that it can

cause a bank rush and systemic impact. The results of this study provide implications for regulators to increase supervision and attention to banks, both banks with large assets and small banks. Regulators also need to strengthen macroprudential policies to reduce systemic risk using buffer countercyclical and capital surcharge. For the development of further research, there are several suggestions including: the amount of observation data; and to examine deeply about the use of threshold.

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