Conference Paper

How We Predict the Stability of Financial Sector: The Conditional Value at Risk Technique Approach

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Abstract

This study aims to identify the level of systemic risk of each bank and the financial linkages between banks in Indonesia. In this study, researcher uses 41 banks that have been actively traded on the Indonesia Stock Exchange in the period 2013-2018. The data of stock capitalization of banks are used as prices in a portfolio of banking system. The method used in this study is the CVaR (Conditional Value at Risk) method which was introduced by Adrian and Brunerrmeir in 2008. The equilibrium of the system is assumed reached at optimum portfolio of the system. At this situation each bank contribution to systemic risk is analyzed, as well as its impact onto it when there is a change in capitalization of a certain bank. The result shows the impact of bank onto systemic risk is not always follow its size in contribution the systemic risk.

Due to covariance's among banks are some positive and others are negative, some banks have negative contribution to systemic risk while others' are positive. There are 4 banks that have different behavior. These banks have negative contribution to the systemic risk. These banks are BMRI, PNBN, PNBS and NAGA. The negative impact to systemic risk is dominated by BMRI as much as -0.17%, and by PNBN as much as -0.04%. There are 2 major banks that have contribution to systemic risk; BBCA (3,01% or Rp 59,1 trillion) and BBRI (0,54% Rp 10,62 trillion). However their impact on systemic risk are different. The parameters of impact on systemic for BBCA and BBRI are 14,99% and 52,94% respectively. Thus the stability of the system is more sensitive to the volatility of Bank Rakyat Indonesia (BBRI) than of Bank Central Asia (BBCA).

Keywords: Systemic Risk, Financial Linkage, Value at Risk, Conditional Value at Risk, covariance banking

1. Background

The rapid development of information and technology has been penetrating into the economic world caused all economic sectors, and economic institutions (Anagnostis and Alexios 2014; Gaftea 2014). More over it makes all economic actors be more connected and able to easily interact each other. This is often referred to as integrated system. The integration of this system has a devastating implications compared to broken or partial

systems. In a partial system where one section is separated from the other, if there is an incident in a certain part of the system it impacts only on that part only and does not cause the collapse of the system. Whereas if the system is integrated, then the damage one part will be penetrated and impact on the system as a whole can tear down the system. (Gravelle and Li 2013, Iachini and Nobili 2016)

The incident in Indonesia several years ago about the Century bank which caused a long debate about whether the bank has a systemic impact or not shows at least two important things to be examined. Firstly, that the systemic impact should not be underestimated. It should be handled seriously even with costly price. Secondly, the systemic impact measurement is still weak, causing prolonged polemic (Zulverdi, Gunadi et al. 2007, Agusman, Cullen et al. 2014, Heykal, Siagian et al. 2014). With an increasingly integrated or inherent part of the system with the other, the systemic impact can be a very seriously risk (Landier, Sraer et al., Gil-Alana, Yaya et al. 2015, Milcheva and Zhu 2016).

Interestingly, when Bank Mandiri (one of the Indonesia prominent bank), in August 2019, had some problem of confused database problem, it seems that there is no much impact to financial or banking system stability. Therefore, it needs to be sought the form of systemic impact caused by of each bank risk.

2. Theory

2.1. Risk

The state of risk is defined as the probability to get loss. The higher the probability is the higher the risk. A person who wants to be a client of a bank firstly identifies whether a bank is riskier or not. Clients prefer a lowly risky bank. If a bank has a good process in screening those who want to be clients, the bank would get good quality of clients, unless it will get the low. The lower the quality of clients tend to be the higher the risk of the individual clients (Dong and Guo 2011; Azmat, Skully et al. 2015). Eventually, for whole bank the risk tends to be higher. Individual client's risk in some certain condition could strengthen the risk of the bank, because good clients could be infected mentally by the bad ones. Thus, starting from the problem of adverse selection could drive the case of moral hazard. This is the risk transformation from individual risk to the firm level risk and finally to systemic risk.

2.2. Banking risk

Banking risk is not just risk from individual behavior, but also from many other aspects such as market risk, liquidity risk, credit risk, operational risk and many other types of risk. All factors causing risk are divided into internal factors and the external ones. The external could be from domestic such as interaction among domestic banks or from other economies risks. The internal factors could be explained from some arguments such as systemic risk. While the external risk factors that could impact on domestic banking situation has been discussed from several views with different theoretical arguments such as Spillover effect arguments or Contagion effect arguments.

2.3. Systemic risk

There are three concepts that are often used in bank systemic risk, namely: 1. "Big" shock or macroshock that creates a large and simultaneous adverse effect on the domestic economy or system(Giglio, Kelly et al. 2016). In this case, an event that affects the entire banking system, financial or economic, not just one or several institutions (Zakir and Malik 2013). 2. Systemic risk is the probability of cumulative losses resulting from an event that is driven from a series of successive losses along the chain reaction of an institution or market of a system (Markose, Giansante et al. 2012). That is, systemic risk is the risk of a chain of reactions between the fall of interconnected dominoes. 3. On spillover from external shocks that do not involve direct causal relationships and have weak and indirect relationships (Angelini and Farina 2012). This emphasizes the similarity in third party risk exposure between the units involved. When a unit experiences adverse effects from a shock, it will cause uncertainty on other related units that also have the potential to experience these effects.

It is acknowledged that there is no general acceptable definition of systemic risk (Martínez-Jaramillo, Pérez et al. 2010). A systemic risk is expressed as a possibility if an institution experiences distress, this can trigger other institutions in the banking industry to become distressed so that it can cause a bank run and the collapse of the banking financial system (Huang, Zhou et al. 2009; Bluhm and Krahnen 2014; Ellis, Haldane et al. 2014; Capponi and Chen 2015).

In a broad sense, systemic risk is also defined as macroeconomic shocks that have a negative impact on the overall financial system (Tomuleasa 2015; Giglio, Kelly et al. 2016).

Martínez-Jaramillo (2010) claims that it is generally acknowledged that systemic risk is the risk of the occurrence of an event that threatens the well functioning of the system of interest (financial, payments, banking, etc.). Martínez-Jaramillo (2010) analysis the systemic risk into two main components: a random shock that weakens one or more financial institutions and a transmission mechanism which transmits and possibly exacerbates such negative effects to the rest of the system. In such analysis, the contagion effect could be identified. In order to evaluate if the system tend to more or less riskiness, the Conditional Value at Risk could be applied (Martínez-Jaramillo, Pérez et al. 2010)

According to Capponi (2015)the sensitivity of systemic risk varies in interbank liabilities as well as to their correlation structure. In assessing the systemic risk, it should be paid attention to assymetric information and also the size of bank. Ignoring asymmetries that feature tail-interdependences may lead to a severe underestimation of systemic risk. Moreover, the downward bias in systemic-risk measuring from abandoning this asymmetric pattern increases with the size of bank (López-Espinosa, Moreno et al. 2015).

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3. Methods

In this study, the systemic risk measurement used is Conditional Value at Risk (CVaR), because it is easier to use and the data needed to use the CVaR method was easier to obtain.

4. Model

Suppose financial system is seen as a portfolio containing many banks (assets). Consider the portfolio consisting of N assets in respective quantities $n_1,..., n_N$. If the price of the j th assets is termed P_j, the price P_P of the portfolio will of course be given by:

$$P_p = \sum_{j=1}^{N} n_j P_j \tag{1}$$

The variation of price will follow the same relation:

$$\Delta P_p = \sum_{j=1}^{N} n_j \Delta P_j \tag{1a}$$

Once the distribution of the various ΔP_j elements is known, it is not easy to determinethe distribution of the ΔP_P elements: the probability law of a sum of random variableswill only be easy to determine if these variables are independent, and this is clearly notthe case here. It is, however, possible to find the expectation and variance for ΔP_P onthe basis of expectation, variance and covariance in the various ΔP_j elements:

$$E\Delta P_p = \sum_{j=1}^{N} n_j E\Delta P_j \tag{1b}$$

$$Var(\Delta P_p) = \sum_{i=1}^{N} \sum_{j=1}^{N} n_i n_j Cov\left(\Delta P_i, \Delta P_j\right) \tag{2}$$

Under the hypothesis of normality, the *VaR* of the portfolio can thus be calculated onthe basis of these two elements using the formula:

$$VaR_q = E\left(\Delta P_p\right) - Z_q.\sigma\left(\Delta P_j\right) \tag{2a}$$

where σ stands for standard deviation.

5. Components of the VaR of a portfolio

In this and the following paragraph, we will be working under the hypothesis of normality and with the version of *VaR* that measures the risk in relation to the average variation in value:

$$VaR^*_q = VaR - E\left(\Delta P\right) = -Z_q.\sigma\left(\Delta P\right) \tag{2b}$$

5.1. Individual VaR

The individual *VaR* of the security (*j*) within the portfolio is the *VaR* of all of these securities; if their number is *nj*, we will have:

$$VaR^*_j = -Z_q.\sigma\left(\Delta\left(n_j P_j\right)\right) \tag{3}$$

5.2. Marginal VaR

The marginal *VaR* measures the alteration to the *VaR* of a portfolio following a minor variation in its composition. More specifically, it relates to the variation rate $VaR_P^* = -pP$

$\cdot z_q \cdot \sigma_P$, explained by the variation in σ_P brought about by an infinitesimal increase in the proportion (Xj) of the security (j) while the other proportions remain constant. It is therefore equal to:

$$\Delta VaR^*_{\ j} = -P_p . Z_q . \sigma_P X'_j \tag{3a}$$

$$\Delta VaR^*_{\ j} = -P_p . Z_q . \frac{\sigma_{jP}}{\sigma_P} \tag{3b}$$

$$\Delta VaR^*_{\ j} = VaR^*_{\ p} \beta_{jp} \tag{3c}$$

As in parallel of regression parameters, essentially, it is a conditional value at risk of bank i given bank j.

Thus, it can be written as:

CVaR is the expected value of X given A or is written as $CVaR_q = E(X|A)$ where A denotes set $X \le q$ or $X \ge q$ for negatives and positive tails respectively.

In individual asset, CVaR measure, denoted by $CVaR_q^{i|j}$ is VaR_q of bank i conditional on bank j at its level of VaR_q or

$$CVaR_q^{i|j} = E(VaR_q^{\ i} | VaR_q^{\ j}) \ .$$

It could be written as

$$\Pr \left(R_{i,t} \le CVaR_q^{i|j} \ \middle| R_{j,t} = VaR_q^{\ j} \right) = q$$

where $R_{i,t}$ and $R_{j,t}$ can be any default risk measure for bank i and j at time t respectively {Wong, 2011 #50461}.

5.3. Components of VaR (CmVaR)

We have seen that it is not possible to split the *VaR* on the basis of individual *VaR* values, as these values do not 'benefit' from the diversification effect. The solution is to define the *VaR component* that relates to the security (j) through the marginal *VaR* affected by a weight equal to the X_j proportion of (j) within the portfolio:

$$CmVaR_j^{\ *} = X_j \cdot \Delta VaR_j^{\ *} \tag{4}$$

What we have, in fact, is:

$$\sum_{j=1}^{N} CmVaR_j^{\ *} = \sum_{j=1}^{N} X_j \cdot \Delta VaR_j^{\ *} = VaR^*_{\ p} . \sum_{j=1}^{N} X_j \beta_{jp} \tag{4a}$$

5.4. Conditional Value at Risk

For a portfolio, Conditional Value-at-Risk (CVaR) in the continuous case is expressed as follows. Let X be a continuous random variable representing loss. Given a parameter $0 < q < 1$, the q-CVaR of X is $CVaR_q(X) = E(X \mid X \geq VaR_q(X))$. Alternative names for CVaR found in the literature are Average Value-at-Risk, Expected Shortfall, or Tail Conditional Expectation. CVaR is defined as the expected shortfall, is a risk assessment measure that quantifies the amount of tail risk an investment portfolio has. CVaR is derived by taking a weighted average of the "extreme" losses in the tail of the distribution of possible returns, beyond the value at risk (VaR) cutoff point. Conditional value at risk is used in portfolio optimization for effective risk management.

Fundamental properties of *Conditional Value-at-Risk* (CVaR), as a measure of risk with significant advantages over Value- at- Risk, are derived for loss distributions in finance that can involve discreetness. Such distributions are of particular importance in applications because of the prevalence of models based on scenarios and finite sampling. Conditional Value- at- Risk is able to quantify dangers beyond Value-at-Risk, and moreover it is coherent. It provides optimization shortcuts which, through linear programming techniques, make practical many large- scale calculations that could otherwise be out of reach. These calculations can be obtained with numerical efficiency and stability.

For continuous loss distributions, the CVaR at a given confidence level is the expected loss given that the loss is greater than the VaR at that level, or for that matter, the expected loss given that the loss is greater than or equal to the VaR.

Let f(x, y) be a loss function depending upon a decision vector x = (x1,..., xn) and a random vector y = (y1,..., ym)

VaR is α percentile of loss distribution (a smallest value such that probability that losses exceed or equal to this value is greater or equal to α)

CVaR diversified in three measurements; $CVaR^+$ ("upper CVaR") is expected losses strictly exceeding VaR (also called Mean Excess Loss and Expected Shortfall), $CVaR^-$ ("lower CVaR") is expected losses weakly exceeding VaR, i. e., expected losses which are equal to or exceed VaR (also called Tail VaR), and CVaR is a weighted average of VaR and $CVaR^+$. All these measurements, it holds $VaR < CVaR^- < CVaR < VaR^+$.

Technically, preserved of convexity of f function: if *f(x,ξ)* is convex in *x* then

$$CVaR_A(X) = F_A(X, \xi)$$

$$\underset{X}{Min}\, CVaR_A(X) = \underset{X,\xi}{Min} F_A(X, \xi)$$

(5)

The optimum would be:

$$CVaR_\alpha(X*) = F_\alpha(X*, \xi*) \quad \text{and} \quad f(X*, \xi*)$$

Optimization at level α would be:

$$\underset{X,\xi}{M}ing(X) \quad s.t \quad CVaR_\alpha(X) \leq w_i; i = 1, 2, \cdots, K$$

or

$$\underset{X,\xi_1}{M}ing(X)$$

$$subject \ \ to$$

$$F_\alpha(X, \xi_i) \leq w_i; i = 1, 2, \cdots, K$$

From the optimum condition, each bank would be identified its contribution onto the risk of the system and also the impact onto its stability if either there is a change in any bank or an acquisition of a certain bank.

5.5. Portfolio Return

Value of Portfolio is express following:

$$P_p = \sum_{j=1}^{N} n_j P_j$$

Portfolio Rate of Return

$$\frac{P_{pt} - P_{pt-1}}{P_{pt-1}} = \sum_{j=1}^{N} n_j \frac{P_{jt} - P_{jt-1}}{P_{jt-1}} \qquad (6)$$
$$or$$
$$\dot{P}_p = \sum_{j=1}^{N} n_j \dot{P}_j$$

Data in this analysis taken from Indonesian Stock Exchange, consist of 41 banks listed in Indonesian Stock market. Variables of interest in this study are stock prices, Volume of transaction, and their capitalization.

6. Result and Discussion

The portfolio rate of return daily, run erratically. Its volatility is not homogenous. It could reach 0.6% (peak) and -0.3% (bottom). Mostly vary between 0.2% and-0.25%.
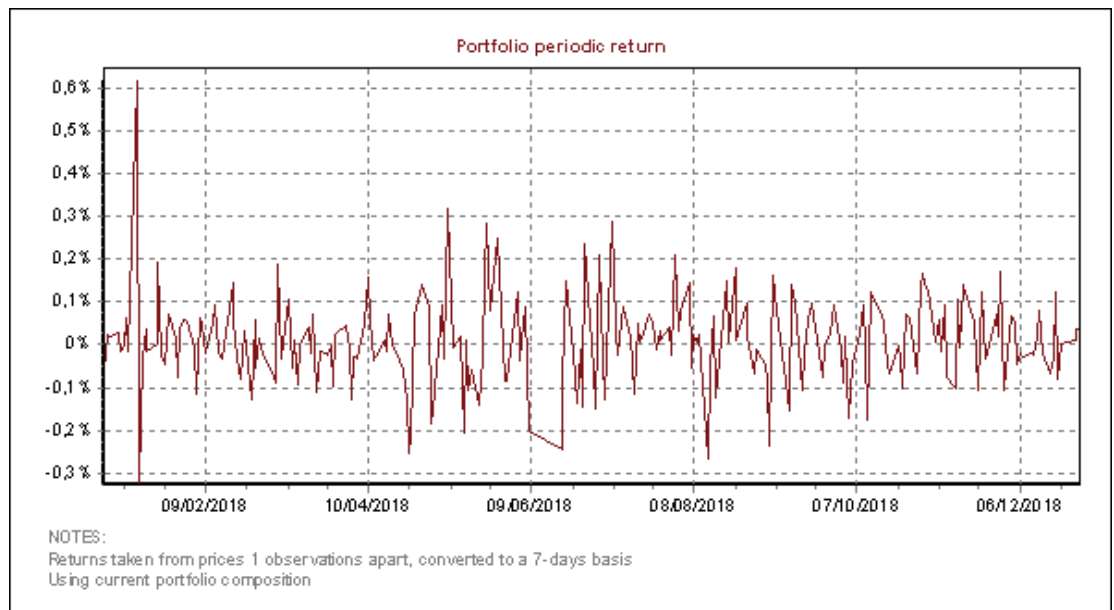
Figure 1: Rate of Return Portfolio System.

The rate of return of the portfolio of the system is as figured in above diagram (Figure 1). Return is fluctuated around zero and varying mostly between 0.2% and -0.2%. In one case, the rate of return jumped over until 0.6% and dropped down until more than -0.3%. The above distribution can be re-graphed in bar-chart as figure below, in terms of return (Figure 2).
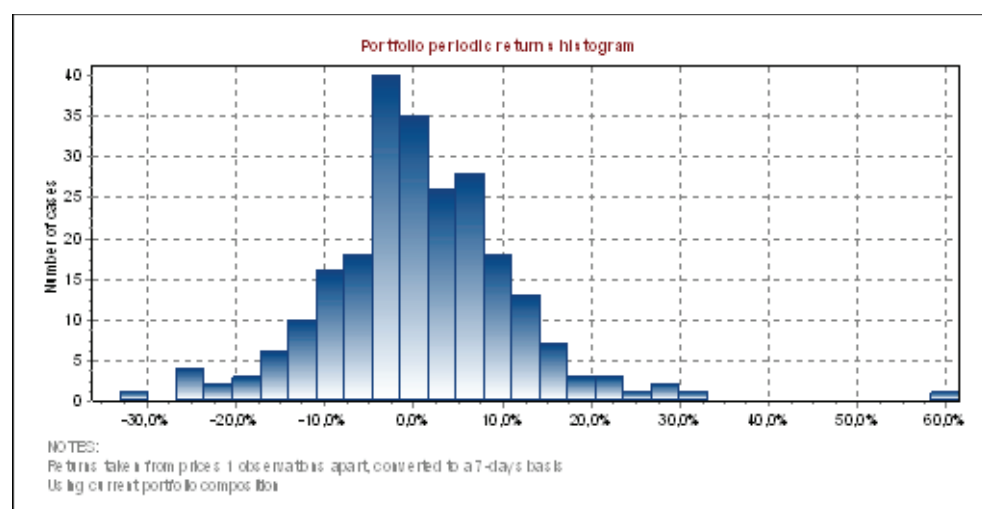

Figure 2: Return of the Portfolio.

In some case the return is as higher as 60%, but other case it losses until 30%.

CVaR of the portfolio from time to time is shown in below graph (Figure 3).

Figure 3 shows that the value of CVaR varies across time. Its depends on many factors affected by spillover effect or contagious effect.

Figure 3: CVaR for Portfolio in different Date.

Figure 4: Component VaR of banks in the System.

In Figure 4, the Value at Risk of the portfolio is decomposed based on the contribution of each bank inside the system. Due to covariance among the banks, some other have positive while other negative relationship. The contribution of banks into the value at risk of the portfolio also have the same situation.

As confirmed through Figure 5 and Figure 6, there are 4 banks that have negative contribution to the portfolio: BMRI(-80,48%), PNBN(-17,35%), PNBS(-1,69%) and NAGA(-0,48%) (see Table 1).

Other 37 banks have positive contribution to the risk of the system (see Table 2).
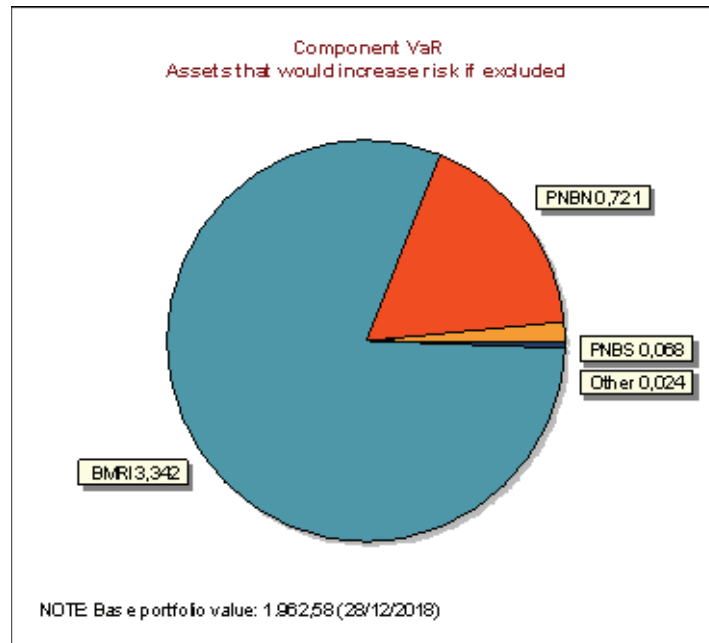

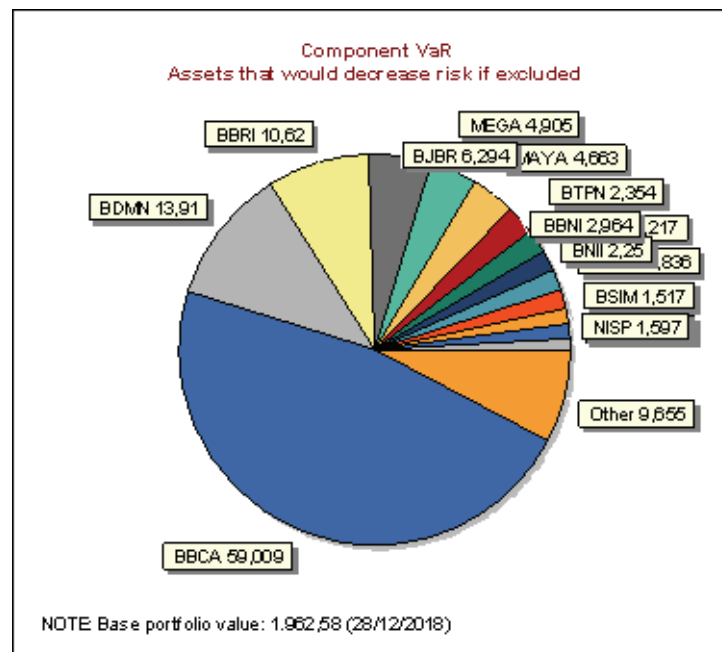**Figure** 5: Banks reducing Component VaR.

Figure 6: Banks boosting Component VaR.

There are 37 banks that have positive contribution to systemic risk. If there is a reduction of a bank in this group, the systemic risk will also reduce. If the asset becomes

bigger, the systemic risk also becomes larger due to the increase the contribution of the changing asset.

The major contribution (positive) the systemic risk are from the big 10: BBCA(47,19%), BDMN(11,12%), BBRI(8,49%), BJBR(5,03%), MEGA(3,92%), MAYA(3,73%), BBNI(2,37%) BTPN(1,88%), BNII(1,80%), and BBTN(1,78%).

In terms of the impact of bank behavior toward the systemic risk, the impact of all each bank has been shown in following graph (see Figure 7).
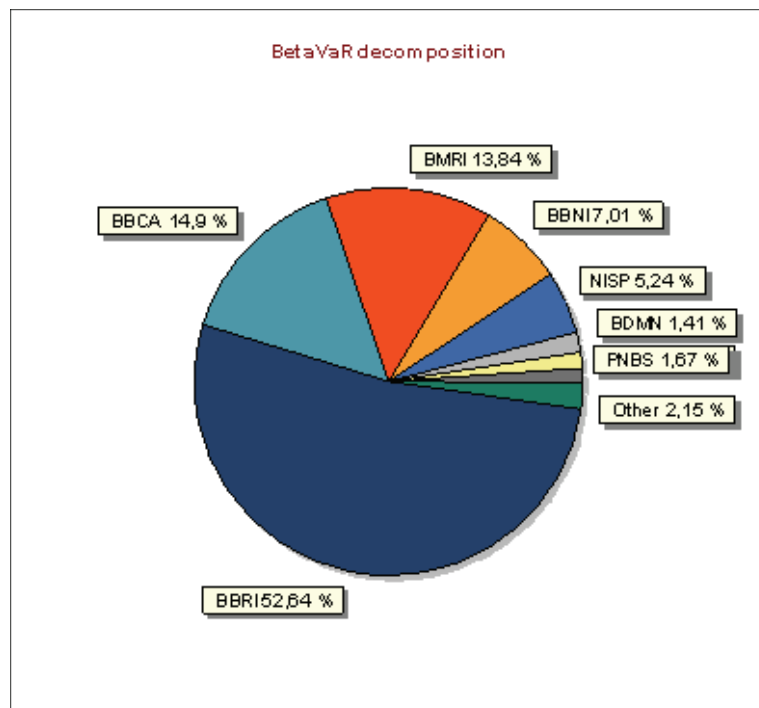

Figure 7: Beta VaR or Marginal VaR (or $CVaR_q^{i|j}$).

The top 5 banks having big impact on systemic risk are BBRI (52,64%), BBCA (14,9%), BMRI(13,84%), BBNI(7,01%) and NISP(5,15%). The complete figure of impact is shown in Table 3 Beta VaR or Marginal VaR.

7. Conclusion

Banking system could be analyzed by applying Conditional value at Risk for whole portfolio (CVaR). CVaR varies over time and depends on many factors. In accounting approach of portfolio risk, it is contributed by risk of all its bank members in the system. In functional approach, the systemic risk is affected by behavior of its members' risk. As system of banks, all members live in cohabitation and interact each other directly or indirectly. The covariance among banks are positive or could be negative. Out or

41 banks in the system, there are 37 banks have positive contribution to systemic risk. If each bank from this group excluded from the system then the systemic risk will reduce. The major contribution the systemic risk are from the big 10: BBCA(47,19%), BDMN(11,12%), BBRI(8,49%), BJBR(5,03%), MEGA(3,92%), MAYA(3,73%),BBNI(2,37%) BTPN(1,88%), BNII(1,80%), and BBTN(1,78%).

Other group consists of banks that have negative contribution to systemic risk. If one bank of this group is excluded, the risk of the system will increase. There are 4 banks that have different behavior. These banks have negative contribution to the systemic risk. These banks are BMRI, PNBN, PNBS and NAGA. The negative impact to systemic risk is dominated by BMRI as much as -2,76%, and by PNBN as much as -0,60%. Other two are small.

The major banks that have contribution to systemic risk; BBCA(47,19%), BDMN(11,12%), BBRI(8,49%), BJBR(5,03%), MEGA(3,92%), MAYA(3,73%), BBNI(2,37%).

However their impact on systemic risk are different. It is about Conditional Value at Risk of each bank given others or $CVaR_q^{i|j}$. Banks that have major impact on systemic are BBRI (52,64%), BBCA (14,9%), BMRI(13,84%), BBNI(7,01%) and NISP(5,15%). The impact of each bank is not necessarily linearly follow the size of the contribution of the bank onto the systemic risk. The contribution on the systemic risk is related to their positions or their capitalization, while the impacts are to their own behavior.

Appendix

TABLE 1: Negative Contribution to Component VaR.

No	Asset	CmpVaR(% of all)	CmpVaR	CmpVaR(% of all negative)
1	BMRI	-2,76%	-3,34	-80,48%.
2	PNBN	-0,60%	-0,72	-17,35%
3	PNBS	-0,06%	-0,07	-1,69%
4	NAGA	-0,02%	-0,02	-0,48%

TABLE 2: Positive Contribution to Component.

Asset	CmpVaR (% of all)	CmpVaR	CmpVaR (% of all Positive)
BBCA	48,81%	59,01	47,19%
BDMN	11,51%	13,91	11,12%
BBRI	8,78%	10,62	8,49%
BJBR	5,20%	6,29	5,03%

Asset	CmpVaR (% of all)	CmpVaR	CmpVaR (% of all Positive)
MEGA	4,05%	4,9	3,92%
MAYA	3,85%	4,66	3,73%
BBNI	2,45%	2,96	2,37%
BTPN	1,94%	2,35	1,88%
BNII	1,86%	2,25	1,80%
BBTN	1,84%	2,22	1,78%
BNGA	1,52%	1,84	1,47%
NISP	1,32%	1,6	1,28%
BSIM	1,26%	1,52	1,22%
NOBU	1,06%	1,28	1,02%
BJTM	0,84%	1,02	0,82%
SDRA	0,79%	0,95	0,76%
BBMD	0,75%	0,91	0,73%
AGRO	0,64%	0,77	0,62%
MCOR	0,64%	0,77	0,62%
AGRS	0,57%	0,69	0,55%
BINA	0,55%	0,66	0,53%
BNLI	0,49%	0,59	0,47%
BKSW	0,37%	0,45	0,36%
BBKP	0,31%	0,37	0,30%
BACA	0,26%	0,31	0,25%
BSWD	0,24%	0,29	0,23%
BBNP	0,23%	0,28	0,22%
BVIC	0,23%	0,28	0,22%
BBYB	0,21%	0,25	0,20%
BMAS	0,20%	0,24	0,19%
BBHI	0,16%	0,19	0,15%
BABP	0,14%	0,17	0,14%
BGTG	0,12%	0,15	0,12%
BNBA	0,08%	0,1	0,08%
DNAR	0,08%	0,1	0,08%
INPC	0,06%	0,07	0,06%
ARTO	0,02%	0,03	0,02%

Table 3: Beta VaR or Marginal VaR.

Asset	Position($)	BetaVar(%)
BBRI	446,93	52,94%
BBCA	634,62	14,99%
BMRI	340,72	13,92%

Asset	Position($)	BetaVar(%)
BBNI	162,47	7,05%
NISP	9,54	5,27%
PNBS	1,19	1,68%
BDMN	72,11	1,42%
BBTN	26,63	1,14%
BNGA	22,77	0,41%
BNLI	17,35	0,34%
BTPN	19,89	0,23%
PNBN	27,29	0,21%
MEGA	33,09	0,13%
BJBR	19,68	0,12%
AGRO	6,55	0,12%
BJTM	10,23	0,07%
BKSW	3,15	0,05%
BNII	13,82	0,04%
MCOR	2,34	0,03%
BBKP	3,14	0,02%
BINA	3,75	0,02%
SDRA	5,54	0,02%
AGRS	1,25	0,01%
BVIC	1,63	0,01%
BBNP	1,74	0,01%
BBYB	1,46	0,01%
BGTG	0,91	0,01%
INPC	0,97	0,01%
BSIM	8,65	0,01%
BACA	2,17	0,00%
BNBA	0,64	0,00%
BABP	1,08	0,00%
BBHI	0,71	0,00%
BBMD	5,59	0,00%
BSWD	1,66	0,00%
ARTO	0,21	0,00%
NAGA	0,4	0,00%
BMAS	1,53	-0,01%
DNAR	0,7	-0,01%
NOBU	4,61	-0,01%
MAYA	43,88	-0,25%

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