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Weighting on Systemic Important Banking (SIB) in Indonesia: The Official Versus PCA Approaches

Abstract: In determining its Domestic Systemic Important Banking (D-SIB), Indonesia implemented the Global Systemic Important Banking (G-SIB) based on three of five indicators, those being size, interconnectedness, and complexity. Both the G-SIB and the Indonesian D-SIB use an equal weight for each indicator, that is, 1/5 and 1/3 respectively. However, the weight could be modified by using the eigenvector of the Principal Component Analysis (PCA). We showed that this new weighting system was better than the official weighting system (referred to in this paper as the POJK approach) based on the Financial Services Authority (OJK) regulation No.46/POJK.03/2015.

Keywords: Eigenvectors, Indonesia, Principal Component Analysis, Systemic Important Banking, Weighting.

JEL Codes: C38, E52, E58.

1. Introduction

The Basel Committee on Banking Supervision (BCBS) developed a methodology for identifying Global Systemically Important Banking (G-SIB) and standards for requiring the G-SIB to hold more common equity (Basel Committee on Banking Supervision - BCBS, 2013). The G-SIB was developed as a template for a country to determine their Domestic Systemic Important Banking (D-SIB). The G-SIB

consisted of 5 indicators, namely size, cross-jurisdictional activity, interconnectedness, substitutability of the financial institution infrastructure, and complexity. However, different countries may have different policies in determining indicators of the D-SIB based on their economic and monetary conditions. As an example, Indonesia only uses three of G-SIB's indicators in determining its SIB, namely size, interconnectedness, and complexity.

In the literature, the SIB has been studied on different methods and perspectives. According to Gu & Zhu (2015), there are two methods that can be used to assess SIB, namely the contribution method and the participation method. The contribution method consists of two methods, the additive assessment method using the Shapley Value method and the non-additive assessment method using the Conditional VaR model. The participation method only consists of the additive assessment method using the Marginal Expected Loss model. There are several researchers who worked on those methods. Tarashev, Borio, & Tsatsaronis, (2010) and Gauthier, Lehar, & Souissi (2010) worked on the Shapley Value method, Andrian & Brunnermeier (2008, 2011) and Zeb & Rashid (2015) studied the Conditional VaR model, while the Marginal Expected Loss model was studied by Huang, Zhou, & Zhu (2009) and Brownlees & Engle (2012).

The BCBS gives equal weight for each indicator, that being 20% (Basel Committee on Banking Supervision - BCBS, 2013). This policy was adopted by the Financial Services Authority (OJK) in coordination with the Indonesian Central Bank (BI). The OJK regulation No.46/POJK.03/2015 states that the calculation of Systemic Important Banking (SIB) of a bank uses equal weight for all indicators: size, interconnectedness, and complexity, i.e., one third for each indicator (Otoritas Jasa Keuangan - OJK, 2015). The equal weighting system policy that applied in both the G-SIB and D-SIB disowned the possibility that an indicator may show a higher contribution in determining the data structure of a SIB assessment component than others. As an example, a study by Moratis & Sakellaris (2017) showed that the SIB in China for periods January 2008 to June 2017 was not adequately captured by its size. That means the size indicators should be given a different weight instead of being equal.

However, this weighting system might be modified by other alternative methods. In the previous work, Anwar (2018) offered an alternative weighting system to calculate SIB based on eigenvectors of the first Principal Component (PC) in the Principal Component Analysis (PCA). This approach was presented by Filmer & Pritchett (1999) in determining the household asset index. The approach later adopted by Harapan et al. (2016a, 2016b, 2016c) measured the asset index in determining the level of household socioeconomic status. Even though those

researchers used a cross-sectional data set, Danyang, Yuan, & Donghui (2015) showed that the PCA still can be used with a time series data set as they did in analyzing a meteorological (weather) data set. They employed the PCA to reduce the data's dimensionality and calculated the eigenvalue and its respective eigenvector to be used in a clustering time series. According to Peña & Poncela (2006), the PC for time series data can be useful if the variables have a similar measurement scale. Härdle & Simar (2003) suggested transforming the data set into a standardized score before applying the PCA. The standardization process would not change the time series pattern/ structure, its only change being the measurement scale. Accordingly, the PCA can still be used for a time series dataset after standardization.

In the previous work, Anwar (2018) simulated the PCA approach in assessing the SIB in Indonesia for 6 banking groups, namely State- Owned Banks, Foreign Exchange Commercial Banks, Non-Foreign Exchange Commercial Banks, Regional Development Banks, Joint Venture Banks, and Foreign Owned Banks for the periods January 2011 to April 2016. However, the study did not calculate the SIB based on the official approach according to the OJK regulation No.46/ POJK.03/2015, and the performance comparison between the official (termed the POJK approach) and PCA approach was not done. Therefore, there was no scientific evidence as to which method performed better in assessing the SIB of a bank in Indonesia.

The recent study employed a similar approach to assess the SIB for longer periods, starting from January 2011 to April 2018. We used both approaches, the PCA and POJK and then compared their results in order to assess which method performed better in assessing the SIB of the banking groups. Knowing a better approach in assessing the SIB is very important. According to the OJK Regulation, the SIB is used as an indicator in determining the capital surcharge of a bank. A capital surcharge is additional capital which serves to reduce the negative impact on the financial system and economic stability in the event of a SIB failure. This is through increasing the Bank's ability to absorb losses (Otoritas Jasa Keuangan - OJK, 2015). The failure of any bank could pose risks to the financial system; accordingly, some banks in the United States have been subjected to enhanced regulation since the 2007 - 2009 financial crisis (Office of Financial Research - OFR, 2017). A misleading decision in categorizing a bank's SIB would lead to worsening economic conditions, especially during an economic crisis such as experienced by Indonesia in 1997/1998. During the crisis, the economic growth was negative 13 percent, and poverty increased significantly (Tambunan, 2010).

In addition, the crisis can be regarded as a proof that the idea of self-regulation in a private sector could not be maintained (Đuraskovic, Radovic, & Konatar, 2018). The Indonesian government, together with OJK and BI, needs to make appropriate monetary policies to minimize losses caused by the crisis. Twinoburyo & Odhiambo (2018) showed that monetary policies were relevant in supporting economic growth, especially in a country with developed financial economics condition. Moreover, the crisis has posed numerous challenges to the traditional monetary policy involving one instrument and one goal, i.e. the interest rate and price stability (Fabris, 2018). An innovation is urgently required to prevent any possible future crisis. A better approach in calculating SIB will be useful to reduce the potential crisis associated with the failure of the banking system in Indonesia.

2. Data and variables

Data were collected from the Financial Services Authority (OJK) of Indonesia covering the periods from January 2011 to April 2018 (88 months). These were the monthly data set of Indonesia Banking Statistics (SPI) that related to the SIB indicators of a banking group (Otoritas Jasa Keuangan - OJK, 2018). There were six banking groups investigated in this study, namely State-Owned Banks, Foreign Exchange Commercial Banks, Non-Foreign Exchange Commercial Banks, Regional Development Banks, Joint Venture Banks, and Foreign Owned Banks.

As mentioned earlier, there are three indicators used in assessing the SIB in Indonesia, namely size, interconnectedness, and complexity. Each indicator consists of several sub-indicators. According to the OJK regulation No.46/POJK.03/2015, both the indicators of size and interconnectedness consist of three sub-indicators, while the indicator of complexity consists of four sub-indicators. Due to the restriction of data accessibility, there were only two sub-indicators of size and only one sub-indicator of complexity analyzed. However, the sub-indicator of complexity was divided into 5 more sub-indicators used in this study. For the indicator of interconnectedness, all sub-indicators were used. Table 1 shows the list of sub-indicator variables used in the study. Note that those sub-indicators were estimated by other related sub-indicators due to the restriction of data accessibility. We used these estimated sub-indicators to simulate the calculation of the SIB using both the official (POJK) and PCA approaches and then compared their results to determine which weighting system is better in assessing the SIB in Indonesia.

Table 1: Indicators and sub-indicator variables

Indicators	Symbols	Estimated sub-indicators	Scale
Size (X_1)	X_{11}	Growth of Commercial Banks Assets	Billion Rupiah
	X_{12}	Committed Liabilities and Contingent Liabilities	Billion Rupiah
Interconnectedness (X_2)	X_{21}	Interbank Placement	Billion Rupiah
	X_{22}	Interbank Liabilities	Billion Rupiah
	X_{23}	Issued Securities	Billion Rupiah
Complexity (X_3)	X_{31}	Margin Deposits	Billion Rupiah
	X_{32}	Current Irrevocable L/C	Billion Rupiah
	X_{33}	Third Party Funds	Billion Rupiah
	X_{34}	Credit	Billion Rupiah
	X_{35}	Total Bank Offices	Unit

Source: Author`s table based on data from the SPI bulletin.

3. Methodology

In this study, we employed two approaches to simulate the SIB calculation. The first was to use the official (POJK) approach based on the OJK regulation No.46/POJK.03/2015 and the second used the PCA approach based on the study by Anwar (2018). These two approaches are different weighting systems for calculating the SIB. The POJK approach gives equal weight for each indicator/sub-indicator, while the PCA approach gives different weights depending on the ability of those indicators/sub-indicators to contribute to the variation in the data set. Moreover, the data set in the POJK approach was transformed into a basis point, while in the PCA approach the data set was transformed into a standardized score. In the final section, we compare the performance of the POJK and PCA approaches with a correlation analysis using Pearson's product moment correlation (r) or Spearman's rank correlation (r_s) when applicable. We introduce both the POJK and PCA approaches in this section briefly.

3.1 POJK approach

The POJK approach is the official approach that the Financial Services Authority (OJK) uses in calculating the SIB. The methodology in calculating the SIB of a bank was explained in detail in the OJK regulation No.46/POJK.03/2015 (Otoritas Jasa Keuangan - OJK, 2015). Briefly, the SIB calculation in the POJK approach is divided into five main steps.

1. Transforming each sub-indicator value into a basis point by calculating the proportion of each sub-indicator against the aggregate value of the banking industry. The basis point transformation can be written as the following equation:

$$Y_i = \left(\frac{x_i}{\sum_{i=1}^{n} x_i}\right) * 100 \quad (1)$$

where Y_i is the i^{th} basis point transformation for the ith data set, and x_i is the i^{th} data set.

2. Each weighted sub-indicator value was calculated by multiplying each sub-indicator value on the first step (basis point) by its respective weight. Note that each sub-indicator has equal weight and the total weight is equal to one.
3. To calculate each indicator's value, all respective weighted sub-indicator values were added for the second step for the indicators of size, interconnectedness, and complexity; this can be written with the respective equations as follow:

$$I_A = (Y_{A1} * \delta 1_{A1}) + (Y_{A2} * \delta 1_{A2}) \quad (2)$$

$$I_B = (Y_{B1} * \delta 1_{B1}) + (Y_{B2} * \delta 1_{B2}) + (Y_{B3} * \delta 1_{B3}) \quad (3)$$

$$I_C = (Y_{C1} * \delta 1_{C1}) + (Y_{C2} * \delta 1_{C2}) + (Y_{C3} * \delta 1_{C3}) + (Y_{C4} * \delta 1_{C4}) + (Y_{C5} * \delta 1_{C5}) \quad (4)$$

4. Each weighted indicator value was calculated by multiplying each indicator value on the third step by its respective weight. Similar to the second step, each indicator had equal weight with the total weight being one.
5. The calculation of the Systemic Important Banking was accomplished by adding all weighted indicator values on the fourth step and can be written in the following equation:

$$SIB = (I_A * \delta 1_A) + (I_B * \delta 1_B) + (I_C * \delta 1_C) \quad (5)$$

Note:

I_A : indicator value of size.
Y_{Aj} : basis point for the sub-indicator size of j^{th} items.
$\delta 1_{Aj}$: weight for the sub-indicator size of j^{th} items.
I_B : indicator value of interconnectedness.
Y_{Bj} : basis point for sub-indicator interconnectedness of j^{th} items.
$\delta 1_{Bj}$: weight for sub-indicator interconnectedness of jth items.
I_C : indicator value of complexity.
Y_{Cj} : basis point for sub-indicator complexity of j^{th} items.

$\delta 1_{Cj}$: weight for the sub-indicator complexity of j^{th} items.
SIB : Systemic Important Banking.
I_k : indicator value of k^{th} items.
$\delta 1_k$: weight for the indicator of k^{th} items.

3.2 PCA Approach

The PCA approach is an alternative approach for the SIB calculation presented by Anwar (2018). This approach employs the Principal Component Analysis (PCA) to determine the SIB weights by the eigenvector of the first PC. The first PC is used since it is able to cover the largest variation in the data set. The later PCs do not suggest being harder to use in the interpretation of the real situation (Filmer & Pritchett, 1999). The SIB calculation based on the PCA approach can also be divided into the five following main steps:

1. Transforming each sub-indicator value into a standardized score, as the sub-indicator variables do not use a similar data scale. According to Roussas (1997), standardized data is found by employing the Z-score transformation using the following equation:

$$Z_i = \frac{(x_i - \overline{X})}{\sigma} \tag{6}$$

   where Z_i is the i^{th} standardized data, x_i is the i^{th} data set, $\overline{X}$ is the average data value, and σ is the standard deviation of the data value.
2. Each weighted sub-indicator value was calculated by multiplying each sub-indicator value on the first step (Z-score) by its respective weight determined by eigenvectors of the first PC. Note that the total weight is not necessarily equal to one.
3. Calculating each indicator value was performed by adding all respective weighted sub-indicator values on the second step. However, since the weighted sub-indicator values are on the standardized scale, we needed to transform them back to the original scale. The third step for the indicator of size, interconnectedness and complexity were determined using the following equations:

$$I_A = ((Z_{A1} * \gamma 1_{A1}) * \sigma_{A1} + \mu_{A1}) + ((Z_{A2} * \gamma 1_{A2}) * \sigma_{A2} + \mu_{A2}) \tag{7}$$

$$I_B = ((Z_{B1} * \gamma 1_{B1}) * \sigma_{B1} + \mu_{B1}) + ((Z_{B2} * \gamma 1_{B2}) * \sigma_{B2} + \mu_{B2}) + ((Z_{B3} * \gamma 1_{B3}) * \sigma_{B3} + \mu_{B3}) \tag{8}$$

$$I_C = ((Z_{C1} * \gamma 1_{C1}) * \sigma_{C1} + \mu_{C1}) + ((Z_{C2} * \gamma 1_{C2}) * \sigma_{C2} + \mu_{C2}) + ((Z_{C3} * \gamma 1_{C3}) * \sigma_{C3} + \mu_{C3}) + ((Z_{C4} * \gamma 1_{C4}) * \sigma_{C4} + \mu_{C4}) + ((Z_{C5} * \gamma 1_{C5}) * \sigma_{C5} + \mu_{C5}) \tag{9}$$

4. To calculate each weighted indicator value, each indicator value on the third step was multiplied by its respective weight that was determined by the eigenvectors of the first PC. Note that the total weight is also not necessarily equal to one.
5. Calculating the Systemic Important Banking was accomplished by adding all the weighted indicator values on the fourth step. However, since the weighted indicator values are on the standardized scale, we needed to transform them back to the original scale. The fifth step was done using the following equation:

$$SIB = ((I_A * \gamma 1_A) * \sigma_A + \mu_A) + ((I_B * \gamma 1_B) * \sigma_B + \mu_B) + ((I_C * \gamma 1_C) * \sigma_C + \mu_C) \quad (10)$$

Note:

I_A : indicator value of size.
Z_{Aj} : Z-score for the sub-indicator size of j^{th} items.
$\gamma 1_{Aj}$: eigenvector for the sub-indicator size of j^{th} items on the first PC.
σ_{Aj} : standard deviation value of the original data on the sub-indicator size of jth items.
μ_{Aj} : mean value of the original data on the sub-indicator size of j^{th} items.
I_B : indicator value of interconnectedness.
Z_{Bj} : Z-score for the sub-indicator of the interconnectedness of j^{th} items.
$\gamma 1_{Bj}$: eigenvector for the sub-indicator interconnectedness of j^{th} items on the first PC.
σ_{Bj} : standard deviation value of the original data on the sub-indicator interconnectedness of j^{th} items.
μ_{Bj} : mean value of the original data on the sub-indicator interconnectedness of j^{th} items.
I_C : indicator value of complexity.
Z_{Cj} : Z-score for sub-indicator complexity of j^{th} items.
$\gamma 1_{Cj}$: eigenvector for sub-indicator complexity of j^{th} items on the first PC.
σ_{Cj} : standard deviation value of the original data on sub-indicator complexity of j^{th} items.
μ_{Cj} : mean value of the original data on sub-indicator complexity of j^{th} items.
SIB : Systemic Important Banking.
I_k : indicator value of k^{th} items.
$\gamma 1_k$: eigenvector for the indicator of k^{th} items on the first PC.
σ_{Ck} : standard deviation value of the original data on the indicator of k^{th} items.
μ_k : mean value of the original data on the indicator of k^{th} items.

4. Results

In this section, the Systemic Important Banking (SIB) for each banking group was calculated using the POJK and PCA approaches. We went through the 5 steps to determine the SIB for both approaches. In the last section, the SIB based on the POJK and PCA approaches were compared in the sense of a correlation.

4.1 POJK approach

As mentioned in the methodology section, the calculation of SIB using the POJK approach was divided into 5 main steps. After the data transformation on the basis point in the first step, the data were further processed for the second through the fifth steps. The weights on the second step were equal, depending on how many sub-indicators existed for each indicator. Similar to the fourth step, each indicator also shared an equal weight. The weighting system on the second and fourth steps was similar to all banking groups as presented in Table 2.

Table 2: Sub-indicators and indicators for weighting values on the POJK approach

	Size (X_1)		Interconnectedness (X_2)			Complexity (X_3)				
	X_{11}	X_{12}	X_{21}	X_{22}	X_{23}	X_{31}	X_{32}	X_{33}	X_{34}	X_{35}
Sub-Indicator weighting values (second step)	1/2	1/2	1/3	1/3	1/3	1/5	1/5	1/5	1/5	1/5
	Size (X_1)		Interconnectedness (X_2)			Complexity (X_3)				
Indicator weighting values (fourth step)	1/3		1/3			1/3				

Source: Author`s table based on relevant data from the OJK regulation No.46/POJK.03/2015.

Since the indicator of size has only two sub-indicators, its weight on the second step was equal to 1/2 for both sub-indicators. The indicator of interconnectedness and complexity had 3 and 5 sub-indicators, respectively. Accordingly, the weight of those sub-indicators on the second step for interconnectedness and complexity were 1/3 and 1/5, respectively. For step four, since there were only 3 indicators, the weight was shared with the same value, i.e. 1/3 for each indicator. Those given weights were similar for all banking groups investigated. After completing all calculation steps, we finally arrived at the SIB of each banking group for all periods as presented in Table 3.

Table 3: Systemic Important Banking (SIB) based on the POJK approach

		Banking Groups					
Year	Month	State Owned Banks	Foreign Exchange Commercial Banks	Non-Foreign Exchange Commercial Banks	Regional Development Banks	Joint Venture Banks	Foreign Owned Banks
2011	1	3,111.06	3,632.15	333.86	841.29	697.18	1,384.46
	2	3,043.92	3,712.43	321.01	909.77	681.74	1,331.13
	3	3,073.62	3,652.12	327.13	934.80	676.73	1,335.61
	4	3,020.39	3,747.41	325.49	936.95	643.88	1,325.88
	5	3,041.57	3,742.70	312.01	993.72	653.63	1,256.37
	6	3,005.82	3,757.25	339.27	1,020.01	652.01	1,225.66
	7	3,037.93	3,688.02	322.27	1,100.31	661.24	1,190.23
	8	2,997.23	3,645.64	351.67	1,128.77	666.20	1,210.49
	9	3,078.35	3,596.07	348.69	1,111.67	592.91	1,272.30
	10	3,117.40	3,556.06	351.18	1,073.38	655.10	1,246.88
	11	3,116.22	3,546.01	349.95	1,082.59	649.52	1,255.71
	12	3,400.52	3,484.69	343.96	1,046.23	572.45	1,152.16
2012	1	3,370.23	3,527.87	310.37	996.28	608.39	1,186.87
	2	3,232.08	3,487.22	320.95	994.65	631.75	1,333.35
	3	3,307.56	3,520.18	305.26	1,069.94	615.91	1,181.15
	4	3,465.77	3,360.77	292.02	1,027.51	619.76	1,234.17
	5	3,476.60	3,368.16	292.75	1,046.98	633.76	1,181.74
	6	3,467.75	3,388.54	310.12	1,029.30	623.46	1,180.83
	7	3,418.78	3,356.15	308.64	971.64	657.32	1,287.48
	8	3,486.48	3,348.27	347.04	963.01	679.89	1,175.32
	9	3,450.96	3,355.80	366.72	1,110.98	612.82	1,102.72
	10	3,330.09	3,421.84	336.88	1,040.52	637.07	1,233.60
	11	3,401.05	3,425.40	338.34	1,027.94	634.62	1,172.65
	12	3,315.04	3,530.45	345.05	1,072.70	671.99	1,064.77

2013	1	3,409.84	3,519.00	339.82	1,006.43	659.40	1,065.50
	2	3,416.30	3,526.72	320.07	973.61	659.15	1,104.15
	3	3,474.52	3,460.53	326.42	964.75	655.54	1,118.25
	4	3,525.24	3,521.11	329.41	983.14	655.63	985.47
	5	3,546.38	3,480.45	317.65	979.51	638.19	1,037.81
	6	3,420.07	3,477.49	328.38	1,044.95	661.57	1,067.54
	7	3,513.65	3,457.40	341.94	910.59	657.81	1,118.62
	8	3,592.38	3,359.16	333.21	899.35	700.05	1,115.85
	9	3,511.41	3,355.42	325.67	950.90	688.08	1,168.52
	10	3,590.73	3,293.78	332.20	932.01	697.02	1,154.26
	11	3,545.18	3,354.00	330.45	940.73	721.61	1,108.02
	12	3,394.78	3,427.57	345.26	966.36	715.34	1,150.70
2014	1	3,426.64	3,471.06	331.55	885.01	760.67	1,125.07
	2	3,451.81	3,489.14	339.14	911.59	728.63	1,079.68
	3	3,385.80	3,497.13	351.58	928.53	686.96	1,150.00
	4	3,443.67	3,421.16	343.21	992.19	683.45	1,116.33
	5	3,503.51	3,403.11	331.15	929.52	683.07	1,149.63
	6	3,467.16	3,394.05	358.49	978.34	658.00	1,143.96
	7	3,506.39	3,460.66	354.23	822.80	731.72	1,124.19
	8	3,558.59	3,491.83	343.45	897.74	668.13	1,040.26
	9	3,558.57	3,426.19	351.59	970.17	620.72	1,072.77
	10	3,675.23	3,388.25	309.20	987.88	606.71	1,032.73
	11	3,680.29	3,378.54	309.50	943.57	639.41	1,048.69
	12	3,676.32	3,360.33	353.39	954.90	630.28	1,024.78
2015	1	3,657.51	3,448.92	303.41	887.81	640.00	1,062.36
	2	3,660.24	3,420.22	307.15	911.45	661.73	1,039.20
	3	3,569.15	3,393.41	289.45	898.75	653.79	1,195.45
	4	3,526.54	3,416.31	273.68	922.95	640.87	1,219.64
	5	3,506.60	3,438.95	267.27	939.23	623.64	1,224.31
	6	3,487.25	3,445.54	288.15	949.15	628.20	1,201.69
	7	3,651.68	3,357.31	276.85	893.59	642.68	1,177.88
	8	3,578.13	3,401.97	261.72	904.89	634.18	1,219.09
	9	3,464.63	3,439.25	273.46	913.66	662.13	1,246.87
	10	3,497.52	3,485.53	276.19	917.14	657.48	1,166.14
	11	3,588.41	3,343.97	265.71	871.66	690.87	1,239.38
	12	3,566.99	3,437.14	290.19	820.17	681.60	1,203.91

2016	1	3,575.38	3,528.69	121.15	875.03	690.11	1,209.65
	2	3,651.59	3,466.65	120.00	802.36	694.66	1,264.73
	3	3,620.73	3,461.06	127.50	908.36	691.10	1,191.26
	4	3,632.33	3,392.04	118.52	928.09	709.23	1,219.79
	5	3,661.42	3,391.47	115.12	908.62	672.29	1,251.10
	6	3,685.10	3,496.16	132.21	832.81	615.35	1,238.36
	7	3,733.86	3,471.00	107.00	874.16	614.48	1,199.51
	8	3,699.48	3,456.20	104.81	905.19	604.47	1,229.84
	9	3,733.95	3,383.02	111.41	859.11	635.53	1,276.99
	10	3,839.80	3,382.99	108.90	832.65	632.77	1,202.89
	11	3,785.00	3,428.63	123.48	795.60	636.77	1,230.52
	12	3,715.04	3,533.91	102.96	847.48	632.63	1,167.98
2017	1	3,883.71	3,427.83	83.49	759.36	664.19	1,181.41
	2	3,868.41	3,446.40	84.71	783.65	631.77	1,185.06
	3	3,866.57	3,368.01	87.81	889.48	651.31	1,136.82
	4	3,795.18	3,727.40	80.13	851.82	639.66	905.82
	5	3,860.73	3,635.74	80.25	859.47	652.78	911.03
	6	3,818.57	3,740.55	89.16	769.28	637.41	945.03
	7	3,807.39	3,670.10	111.74	843.10	629.74	937.93
	8	3,891.40	3,623.96	106.22	810.50	608.99	958.93
	9	3,850.71	3,660.69	111.49	837.37	617.32	922.42
	10	3,833.04	3,651.44	107.38	855.03	629.36	923.75
	11	3,841.53	3,707.94	108.15	799.52	653.94	888.91
	12	3,862.27	3,678.60	114.02	838.76	623.31	883.04
2018	1	3,896.39	3,658.85	111.83	772.01	618.88	942.04
	2	3,922.55	3,685.23	108.64	759.89	599.17	924.52
	3	3,875.31	3,659.98	110.73	826.60	612.07	915.32
	4	3,896.31	3,634.05	107.26	836.61	618.81	906.97

Source: Author`s table based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

4.2 PCA approach

The Principal Component Analysis (PCA) showed several important statistics and information, including the eigenvalue, the eigenvector, and the explained variance for each PC. The maximum number of PCs was similar to the total number of variables used. However, in this study we only used the first PC, suggested by Filmer & Pritchett (1999). The higher PC is hard to interpret in a real

situation. Luckily, the first PC in the PCA explained the highest variance among others. Table 4 presents the eigenvalues and explained variances of the first PC for each sub-indicator of all banking groups investigated.

Table 4: Eigenvalues and explained variances of banking groups (sub-indicator variables)

Indicator	Banking Groups	Eigenvalue	Explained variance (%)
Size (X_1)	State-Owned Banks	1.951	86.37
	Foreign Exchange Commercial Banks	1.970	89.03
	Non-Foreign Exchange Commercial Banks	1.669	69.20
	Regional Development	1.455	62.03
	Joint Venture Banks	1.949	86.05
	Foreign Owned Banks	1.901	81.43
Interconnectedness (X_2)	State-Owned Banks	1.958	49.38
	Foreign Exchange Commercial Banks	2.649	66.09
	Non-Foreign Exchange Commercial Banks	1.623	44.71
	Regional Development	1.346	39.02
	Joint Venture Banks	1.881	49.19
	Foreign Owned Banks	2.141	52.93
Complexity (X_3)	State-Owned Banks	3.125	43.22
	Foreign Exchange Commercial Banks	3.035	43.39
	Non-Foreign Exchange Commercial Banks	3.254	46.86
	Regional Development	3.588	49.15
	Joint Venture Banks	2.620	37.02
	Foreign Owned Banks	2.462	36.18

Source: Author`s table based on the data from the SPI bulletin, January 2011 – April 2018, and analyzed.

Table 4 shows that for the first indicator (size), the explained variances of its sub-indicators varied from 62.03% to 89.03%. For the second indicator (interconnectedness), the first PC could explain the variances from 39.02% to 66.09%. The explained variances for the last indicator (complexity) varied from 36.18% to 49.15%. The weights in the PCA represented by the eigenvectors of the first PC are found in Table 5.

Table 5: Sub-indicator weighting values (eigenvectors of the first PC) of all banking groups (second step)

Banking group	Item sub-indicator				
	1	2	3	4	5
Size (X_1)	X_{11}	X_{12}			
State-Owned Banks	0.707	0.707	-	-	-
Foreign Exchange Commercial Banks	0.707	0.707	-	-	-
Non-Foreign Exchange Commercial Banks	0.707	0.707	-	-	-
Regional Development	0.707	0.707	-	-	-
Joint Venture Banks	0.707	0.707	-	-	-
Foreign Owned Banks	0.707	0.707	-	-	-
Interconnectedness (X_2)	X_{21}	X_{22}	X_{23}		
State-Owned Banks	0.534	0.578	0.617	-	-
Foreign Exchange Commercial Banks	0.584	0.573	0.575	-	-
Non-Foreign Exchange Commercial Banks	0.170	0.714	0.679	-	-
Regional Development Banks	0.594	-0.434	-0.677	-	-
Joint Venture Banks	0.321	0.674	0.665	-	-
Foreign Owned Banks	0.599	0.592	-0.539	-	-
Complexity (X_3)	X_{31}	X_{32}	X_{33}	X_{34}	X_{35}
State-Owned Banks	0.422	0.155	0.523	0.522	0.501
Foreign Exchange Commercial Banks	0.287	0.320	0.548	0.551	0.459
Non-Foreign Exchange Commercial Banks	0.393	0.121	-0.519	-0.514	-0.545
Regional Development Banks	-0.132	0.451	-0.502	-0.524	-0.502
Joint Venture Banks	0.410	0.023	0.584	0.592	0.375
Foreign Owned Banks	-0.176	-0.190	-0.611	-0.618	0.423

Source: Author`s table based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

As shown in Table 5, the eigenvectors may have positive or negative signs and represent the correlation among the sub-indicators in the first PC. A positive eigenvector indicates that the sub-indicators in the first PC had a positive correlation, while a negative eigenvector shows that the correlation among them was negative.

The weighted sub-indicator value was calculated by using the weight (eigenvector) and the standardized data (Z score) of each sub-indicator variable. We multiplied the Z score and its respective eigenvector for each sub-indicator variable. In this step, a weighted sub-indicator value was on a standardized scale. Therefore, we needed to transform it back to the original scale by multiplying it with a standard

deviation value and then adding the mean value of the sub-indicator variable. The next step was to calculate an indicator value by adding all its respective weighted sub-indicator values after being re-transformed. Those processes can be written as the equations 7, 8, and 9 for the indicator of size, interconnectedness, and complexity, respectively. The calculation processes were done for all banking groups to get their indicator values.

The following step was to calculate a weighted indicator value using the same technique as we did on the sub-indicator level. The first PC for the indicator variables was different in explaining the total variance of a banking group. The eigenvalues and explained variances of the first PC on the indicator level are presented in Table 6.

Table 6: Eigenvalues and explained variances of banking groups (indicator variables)

Banking Groups	Eigenvalue	Explained Variance (%)
State-Owned Banks	2.882	81.05
Foreign Exchange Commercial Banks	2.913	82.67
Non-Foreign Exchange Commercial Banks	2.785	77.08
Regional Development Banks	2.246	62.04
Joint Venture Banks	2.823	75.08
Foreign Owned Banks	2.575	65.60

Source: Author`s table based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

According to Table 6, the first PC has the ability to explain the variance for the State-Owned Banks, with as much as 81.05% of the total variation. For the Foreign Exchange Commercial Banks, Non-Foreign Exchange Commercial Banks, Regional Development Banks, Joint Venture Banks, and Foreign Owned Banks, the explained variances are 82.67%, 77.08%, 62.04%, 75.08% and 65.60%, respectively.

The respective weight and eigenvector for the indicator level are determined using the PCA analysis. Similar to the sub-indicator level, an eigenvector for the indicator level may have a positive or negative sign. This depends on the correlation among the indicator variables for the first PC. A positive sign shows that there is a positive correlation among the indicator variables for the first PC. A negative sign indicates that the correlation among those indicators is negative. The weighted indicator value is calculated using eigenvector and the standardized data (z-score) of the indicator values that we calculated previously. The eigenvectors of the indicator variables for the first PC are shown in Table 7.

Table 7: Indicator weighting values (eigenvector of the first PC) of all banking groups (fourth step)

Banking Groups	Indicator Items		
	Size (X_1)	Interconnectedness (X_2)	Complexity (X_3)
State-Owned Banks	0.583	0.566	0.583
Foreign Exchange Commercial Banks	0.583	0.570	0.580
Non-Foreign Exchange Commercial Banks	0.587	0.553	-0.591
Regional Development Banks	0.646	0.408	-0.646
Joint Venture Banks	0.587	0.566	0.579
Foreign Owned Banks	0.611	0.547	-0.573

Source: Author`s table based on data from the SPI bulletin January, 2011 – April 2018, and analyzed.

However, a weighted indicator value is in a standardized form, so we needed to transform it back to the original scale by multiplying with a standard deviation and then adding a mean value for each indicator variable. In the final step, the weighted indicator values after being re-transformed were added to get the SIB of a banking group. This calculation process can be written as the equation 10. The SIB calculation was done for each banking group for all periods of study as presented in Table 8.

Table 8: Systemic Important Banking (SIB) for banking groups based on the PCA approach

Year	Month	Banking Groups					
		State Owned Banks	Foreign Exchange Commercial Banks	Non-Foreign Exchange Commercial Banks	Regional Development Banks	Joint Venture Banks	Foreign Owned Banks
2011	1	4,429,410.84	4,965,489.20	278,554.98	1,002,077.16	714,044.73	1,103,989.71
	2	4,411,362.51	4,980,548.55	278,744.67	1,014,555.43	710,584.09	1,101,546.83
	3	4,441,095.06	5,004,703.88	281,487.94	1,020,776.59	715,018.36	1,114,815.41
	4	4,434,103.89	5,010,318.80	282,886.27	1,023,525.96	711,971.30	1,102,944.16
	5	4,452,164.56	5,027,512.59	283,950.98	1,033,676.27	717,932.67	1,102,742.77
	6	4,480,410.69	5,049,356.81	287,717.34	1,042,164.45	725,203.77	1,101,189.04
	7	4,482,329.72	5,067,116.61	289,247.28	1,043,294.80	727,613.50	1,102,420.80
	8	4,495,480.10	5,094,446.80	292,268.57	1,035,775.59	729,306.24	1,103,557.53
	9	4,530,581.95	5,129,989.78	295,356.76	1,059,592.07	723,752.32	1,120,710.83
	10	4,551,274.63	5,143,210.96	297,632.64	1,056,506.35	734,382.31	1,123,293.48
	11	4,567,046.72	5,173,369.02	299,782.98	1,062,181.24	741,108.34	1,130,953.65
	12	4,700,531.08	5,230,857.95	305,481.37	1,054,578.05	740,263.78	1,148,268.48

2012	1	4,621,237.96	5,233,317.03	305,257.83	1,059,126.07	745,754.66	1,156,785.28
	2	4,609,970.25	5,242,150.55	306,532.84	1,071,939.05	750,427.80	1,202,536.32
	3	4,637,291.61	5,268,404.05	308,344.32	1,103,634.09	755,525.47	1,177,410.99
	4	4,657,373.16	5,268,256.53	310,646.32	1,109,487.97	761,674.06	1,180,820.38
	5	4,700,598.18	5,300,670.31	310,864.09	1,110,692.54	770,892.70	1,188,819.32
	6	4,724,663.03	5,342,079.91	315,355.28	1,121,910.56	771,257.61	1,193,981.04
	7	4,703,261.26	5,353,811.39	316,406.61	1,119,757.08	775,703.57	1,212,321.33
	8	4,722,242.34	5,373,178.85	319,447.13	1,112,748.26	779,480.66	1,187,093.90
	9	4,743,944.25	5,399,788.45	323,414.99	1,145,019.87	778,248.79	1,199,585.01
	10	4,752,756.86	5,414,337.64	324,095.03	1,138,791.75	782,567.39	1,251,756.65
	11	4,791,590.94	5,441,709.06	326,577.12	1,137,642.38	782,046.56	1,235,501.35
	12	4,871,419.65	5,494,010.50	332,715.12	1,115,173.68	788,051.60	1,191,622.86
2013	1	4,846,929.62	5,495,354.43	332,008.04	1,112,719.45	787,513.73	1,198,340.05
	2	4,845,976.98	5,510,997.21	331,958.74	1,128,330.73	794,703.32	1,204,818.01
	3	4,858,072.83	5,530,346.54	337,857.56	1,143,495.29	804,624.66	1,215,994.53
	4	4,890,789.52	5,541,671.36	338,577.33	1,163,483.57	812,067.42	1,206,385.76
	5	4,900,278.48	5,571,723.17	341,090.23	1,161,313.17	806,303.28	1,222,713.06
	6	4,936,092.78	5,577,049.40	344,773.57	1,168,786.21	815,455.64	1,221,844.65
	7	4,957,663.28	5,615,853.43	345,266.69	1,159,524.96	823,757.02	1,244,297.56
	8	4,985,868.16	5,633,767.12	343,971.23	1,156,355.71	837,565.79	1,261,426.56
	9	5,021,476.64	5,676,795.86	347,202.00	1,183,669.74	847,482.47	1,296,062.56
	10	5,028,092.40	5,681,034.01	347,139.71	1,173,674.65	838,904.16	1,294,325.61
	11	5,056,298.37	5,768,474.09	348,927.85	1,177,293.28	852,682.53	1,318,582.09
	12	5,114,760.67	5,775,152.31	356,898.74	1,143,644.56	865,406.03	1,324,310.56
2014	1	5,066,840.63	5,764,809.66	354,070.80	1,146,704.84	869,410.40	1,286,816.13
	2	5,091,835.44	5,761,252.72	354,918.24	1,166,502.06	866,419.04	1,268,359.38
	3	5,085,093.79	5,772,444.54	357,405.26	1,166,288.37	857,609.25	1,323,500.16
	4	5,118,578.74	5,790,554.60	357,672.68	1,188,464.02	858,898.28	1,311,113.74
	5	5,142,631.34	5,828,789.82	360,609.87	1,201,459.21	863,446.58	1,329,831.61
	6	5,185,689.09	5,861,692.87	365,795.60	1,221,275.34	871,974.71	1,355,260.33
	7	5,212,824.75	5,820,799.99	367,125.36	1,178,691.62	873,215.17	1,292,327.02
	8	5,248,224.12	5,864,824.31	366,594.60	1,199,230.93	839,475.30	1,291,816.42
	9	5,297,486.62	5,911,050.06	369,912.02	1,244,951.92	847,597.12	1,323,918.64
	10	5,316,006.50	5,934,240.45	370,747.03	1,245,600.06	854,414.81	1,319,469.35
	11	5,343,554.58	5,951,093.50	373,579.24	1,241,589.68	861,257.01	1,310,671.76
	12	5,427,559.42	5,986,152.19	379,179.00	1,198,214.73	868,169.83	1,319,462.22

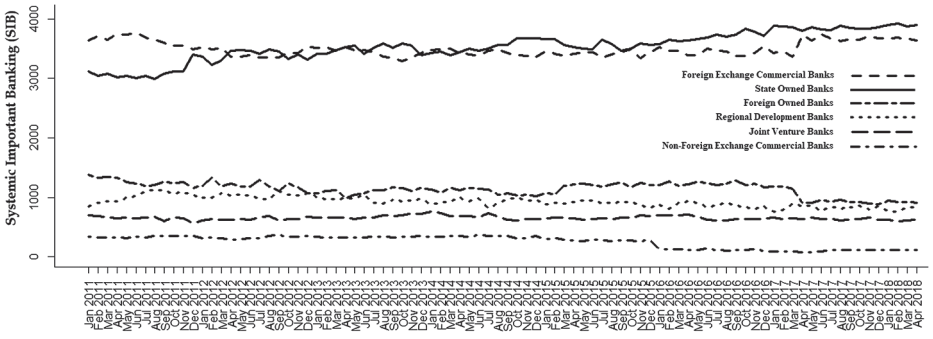
2015	1	5,393,570.44	6,002,112.63	375,658.84	1,208,937.59	873,009.84	1,340,814.22
	2	5,418,434.11	6,000,259.42	376,543.14	1,219,979.91	879,689.35	1,342,711.68
	3	5,391,150.51	6,044,715.81	380,322.77	1,253,713.61	880,054.24	1,442,138.77
	4	5,361,849.71	6,071,169.59	380,670.95	1,284,520.92	874,862.03	1,456,175.54
	5	5,368,339.10	6,101,238.80	377,823.09	1,292,506.83	874,225.95	1,468,804.34
	6	5,438,474.69	6,118,878.08	381,615.39	1,303,156.36	872,952.14	1,499,273.86
	7	5,457,444.82	6,112,224.79	381,247.95	1,285,977.57	877,408.59	1,472,869.79
	8	5,483,839.94	6,140,751.35	381,583.03	1,288,473.94	890,745.68	1,507,025.05
	9	5,516,961.09	6,190,249.43	385,737.93	1,314,545.78	901,651.19	1,539,424.33
	10	5,482,338.13	6,150,953.73	385,355.41	1,305,040.23	886,398.43	1,475,859.70
	11	5,509,560.78	6,140,479.25	379,664.24	1,286,477.10	887,946.08	1,466,343.79
	12	5,619,685.64	6,166,718.74	385,736.22	1,224,811.22	896,727.27	1,449,131.29
2016	1	5,565,745.78	6,250,066.33	293,814.11	1,255,881.05	900,931.28	1,454,039.20
	2	5,571,891.85	6,236,093.42	294,168.12	1,258,298.63	895,453.65	1,449,366.12
	3	5,603,655.74	6,252,530.16	296,732.25	1,282,499.08	894,376.38	1,441,010.50
	4	5,601,965.64	6,249,067.34	297,135.08	1,300,592.27	896,110.85	1,439,217.94
	5	5,618,438.76	6,280,002.14	299,062.92	1,307,720.23	900,800.46	1,456,943.01
	6	5,714,972.96	6,301,397.46	301,923.97	1,287,802.43	888,345.81	1,448,427.38
	7	5,692,402.63	6,312,516.81	295,373.69	1,303,273.90	892,305.44	1,441,930.55
	8	5,698,910.86	6,328,703.09	291,193.86	1,311,561.83	897,499.76	1,451,026.07
	9	5,780,855.46	6,325,190.82	291,800.59	1,302,050.20	899,946.51	1,439,932.88
	10	5,803,140.13	6,334,991.04	292,566.74	1,301,837.22	903,684.97	1,444,796.33
	11	5,857,403.04	6,380,242.51	295,174.55	1,294,593.47	916,511.23	1,480,176.34
	12	5,946,152.54	6,449,829.13	277,680.11	1,263,749.40	915,134.67	1,444,972.73
2017	1	5,924,446.96	6,450,739.60	276,140.23	1,275,704.22	931,915.46	1,446,152.16
	2	5,914,463.89	6,465,765.31	277,239.80	1,293,464.79	912,090.68	1,448,070.96
	3	5,957,368.78	6,468,008.72	279,296.00	1,325,499.66	924,914.50	1,446,601.99
	4	5,920,597.27	6,644,422.89	279,846.65	1,349,336.60	918,458.08	1,349,079.36
	5	5,985,652.72	6,618,347.68	280,933.64	1,358,701.96	923,190.28	1,346,115.83
	6	6,027,649.97	6,669,133.01	283,172.50	1,352,399.89	918,978.05	1,352,664.65
	7	6,000,450.03	6,661,836.47	284,722.48	1,353,379.58	913,492.00	1,341,079.61
	8	6,029,969.09	6,676,449.03	285,355.60	1,356,590.66	918,361.17	1,351,041.22
	9	6,077,713.15	6,713,948.55	287,607.15	1,378,747.71	930,545.08	1,364,013.04
	10	6,070,300.09	6,730,268.12	287,702.72	1,395,617.38	939,738.45	1,361,893.23
	11	6,107,388.55	6,742,209.55	288,760.17	1,383,943.90	944,397.42	1,358,375.92
	12	6,247,643.29	6,769,194.71	290,583.81	1,333,733.21	943,097.81	1,348,057.82
2018	1	6,218,375.22	6,788,173.37	290,066.70	1,344,732.57	944,983.78	1,363,927.30
	2	6,251,352.65	6,821,477.22	290,791.87	1,351,858.23	952,263.51	1,386,258.22
	3	6,280,489.77	6,834,853.59	292,136.61	1,373,928.81	961,349.21	1,390,244.14
	4	6,276,503.92	6,849,451.40	292,231.13	1,389,521.42	964,525.20	1,396,976.16

Source: Author`s table based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

4.3 SIB comparison based on the POJK and PCA approaches

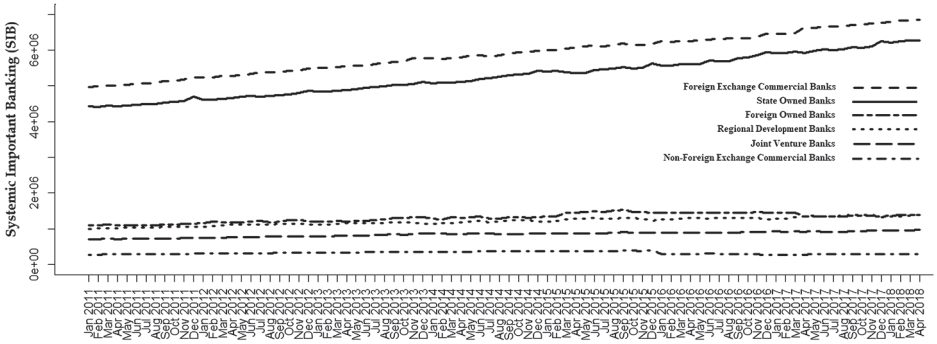
As seen earlier, Tables 3 and 8 present the SIBs of all banking groups based on the POJK and PCA approaches respectively. The SIB based on the PCA approach was much higher than the POJK approach due to a different data transformation. The POJK performs with the basis point transformation, while the PCA performs with the standardized score transformation. The SIB for each banking group based on the PCA approach tends to increase against the time. For the POJK approach, most banking groups have both increasing and decreasing patterns. Those SIB tables can also be described in Graphs 1 and 2, respectively.

Graph 1: Systemic Important Banking (SIB) based on the POJK approach



Source: Author`s figure based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

Graph 2: Systemic Important Banking (SIB) based on the PCA approach



Source: Author`s figure based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

According to those graphs, the trends of the SIB based on the PCA approach are smoother than the POJK approach. The first two highest SIB values were based on the PCA approach. The Foreign Exchange Commercial Banks are always higher than State-Owned Banks. Moreover, both banking groups have positive trends, and they are parallel with each other. Similarly, the SIB of the rest of the banking groups was based on the PCA approach, with mostly an increase and parallel position to each other. For the POJK approach, the SIB of Foreign Exchange Commercial Banks and State-Owned Banks were found to intersect with each other several times at some periods. Further, the SIB based on the POJK approach for other banking groups mostly does not increase constantly. Overall, the order of banking groups based on both the POJK and PCA approaches was similar for most periods evaluated. The Foreign Exchange Commercial Banks came in first place, and the Non-Foreign Exchange Commercial Banks were in the last place as the lowest systemic risk banking group in Indonesia.

To determine which approach has better performance in assessing the SIB, a correlation analysis was employed. A correlation analysis is a statistical method used to assess a possible linear association between two continuous variables (Mukaka, 2012). There are several types of correlations in the literature. Pearson's product moment correlation coefficient (r) and Spearman's rank correlation coefficient (r_s) are the most frequently used correlation coefficients (Udovicic et al., 2007). In this study, either Pearson's product moment or Spearman's rank correlation was used in evaluating which approach is better in determining the systemic risk for each banking group in Indonesia. According to Rebekić et al. (2015), Pearson's product moment correlation is employed for two variables on an interval or ratio scale that is in linearly related where each variable is normally distributed. Spearman rank correlation is based on the ranks given to observations instead of their actual values. It is also used when the assumptions of Pearson's product moment are not met (Gogtay & Thatte, 2017).

The correlation measures the strength of an association between the SIB and its indicator or sub-indicator variables. An approach with a higher correlation indicates that it has a better performance in assessing the SIB. We applied three ways to evaluate the relationship, through the sub-indicator (X_{11}, X_{12}, …, X_{35}, 10 schemes) and indicator variables (X_1, X_2 and X_3, 3 schemes), and also through the total variables (1 scheme, not including X_{35} because it is measured on a different data scale (unit)). Therefore, there were 14 schemes of correlation applied to evaluate which approach is better in determining the systemic risk of banking groups in Indonesia.

Before employing a correlation analysis, the first step is to check whether all data sets meet the normality assumption using the Shapiro-Wilk test. The Shapiro-Wilk test is generally more powerful than the Kolmogorov-Smirnov test (Hanusz, Tarasinska & Zielinski, 2016; Razali & Wah, 2011). The Shapiro-Wilk test can be used when the sample size is between 3 and 5,000 (Royston, 1995). The null hypothesis states that the data set follows a normal distribution. The null hypothesis will likely reject when a p-value is smaller than 0.05. Table 9 presents the results of the Shapiro-Wilk test for all variables included in the correlation analysis.

Table 9: Shapiro-Wilk test

Variable	W	p-value	Decision
X_{11}	0.948	0.001	Not Normal
X_{12}	0.944	<0.001	Not Normal
X_{21}	0.991	0.816	Normal
X_{22}	0.968	0.026	Not Normal
X_{23}	0.904	<0.001	Not Normal
X_{31}	0.967	0.023	Not Normal
X_{32}	0.524	<0.001	Not Normal
X_{33}	0.955	0.004	Not Normal
X_{34}	0.950	0.002	Not Normal
X_{35}	0.605	<0.001	Not Normal
X_{1}	0.954	0.003	Not Normal
X_{2}	0.979	0.159	Normal
X_{3}	0.955	0.004	Not Normal
Total	0.954	0.004	Not Normal
SIB POJK (State Owned Banks)	0.945	0.001	Not Normal
SIB PCA (State Owned Banks)	0.954	0.003	Not Normal
SIB POJK (Foreign Exchange Commercial Banks)	0.918	<0.001	Not Normal
SIB PCA (Foreign Exchange Commercial Banks)	0.961	0.010	Not Normal
SIB POJK (Non Foreign Exchange Commercial Banks)	0.769	<0.001	Not Normal
SIB PCA (Non Foreign Exchange Commercial Banks)	0.886	<0.001	Not Normal
SIB POJK (Regional Development Banks)	0.983	0.327	Normal
SIB PCA (Regional Development Banks)	0.960	0.008	Not Normal
SIB POJK (Joint Venture Banks)	0.976	0.097	Normal
SIB PCA (Joint Venture Banks)	0.933	<0.001	Not Normal
SIB POJK (Foreign Owned Banks)	0.948	0.001	Not Normal
SIB PCA (Foreign Owned Banks)	0.944	<0.001	Not Normal

Source: Author`s table based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

According to Table 9, there are only four variables that meet the normality assumption indicated by the p-values of the Shapiro-Wilk test that are larger than 0.05. Those variables are X_{21}, X_2, SIB POJK (Regional Development Banks) and SIB POJK (Joint Venture Banks). The other variables could not meet the normality assumptions due to the small p-value.

As stated earlier in this study, we applied either Pearson's product moment correlation or Spearman's rank correlation when applicable. Pearson's product moment correlation is used when both compared variables distribute normally. Spearman's rank correlation is an alternative method used when the variables are not normally distributed. Accordingly, there are only four possible comparisons using Pearson's product moment correlation based on the Shapiro-Wilk test results. Those are the SIB based on the POJK approach for Regional Development Banks vs X_{21}, SIB based on the POJK approach for Joint Venture Banks vs X_{21}, SIB based on the POJK approach for Regional Development Banks vs X_2, and SIS based on the POJK approach for Joint Venture Banks vs X_2. Other comparisons were performed with Spearman's rank correlation analysis. The coefficient correlations for all banking groups for both approaches are presented in Table 10.

The correlation coefficient could be negative or positive depending on the direction of the relationship between those compared variables. In this study, the direction (negative or positive) of correlation was treated equally due to the fact that the relation between two variables might be positive or negative. Accordingly, we assumed the relationship was strong whether it was highly negative or positive (close to -1 or +1). We compared the correlation between both approaches for each banking group in all schemes. In this study, the PCA approach was given one point when its absolute correlation coefficient was higher than the POJK approach for each scheme. Therefore, the maximum that can be achieved by the PCA approach in each banking group is 14 points for a maximum comparison scheme, with the minimum point being zero.

For simplicity, the total points achieved are represented by a percentage scale, i.e. 100% if the PCA approach had a higher correlation on all schemes. Graph 3 presents a summary of the correlation analyses for each banking group. It can be seen that the PCA approach had a higher correlation for all banking groups. The percentages for the State-Owned Banks, Foreign Exchange Commercial Banks, Non-Foreign Exchange Commercial Banks, Regional Development Banks, Joint Venture Banks and Foreign Owned Banks, are 78.57%, 100.00%, 85.71%, 85.71%, 92.86%, and 85.71%, respectively. On average, the percentage that the PCA approach had a higher correlation than the POJK approach for all banking groups was 88.10%. According to these results, it can be concluded that the PCA

approach performs better than the POJK approach in assessing the SIB of those banking groups. The PCA approach gives more robust weights on each indicator or sub-indicator variable than the POJK approach. Indicator or sub-indicator variables that determine a larger variance in the SIB assessment would be given more weight than others in the PCA approach. Accordingly, this weighting system can be implemented in Indonesia or other countries that recently applied an equal weight policy in determining their D-SIB.

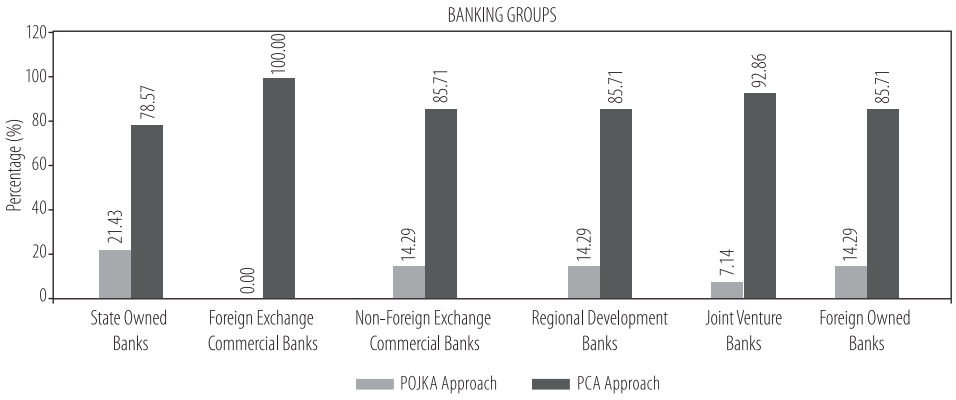
Table 10: Correlation matrix of SIB using the POJK and PCA approaches for all banking groups

Scheme	Correlation	State Owned Banks		Foreign Exchange Commercial Banks		Non-Foreign Exchange Commercial Banks		Regional Development Banks		Joint Venture Banks		Foreign Owned Banks	
		POJK	PCA	POJK	PCA	POJK	PCA	POJK	PCA	POJK	PCA	POJK	PCA
1	SIB vs. X_{11}	0.926	1.000	0.039	1.000	0.464	0.999	-0.733	0.998	-0.137	0.994	-0.084	0.966
2	SIB vs. X_{12}	0.935	0.972	0.019	0.981	-0.283	0.575	-0.344	0.509	-0.184	0.985	-0.023	0.981
3	SIB vs. X_{21}	0.539	0.437	0.146	0.865	-0.262	0.397	-0.073[r]	0.574	0.385[r]	0.447	-0.159	0.672
4	SIB vs. X_{22}	0.670	0.659	0.109	0.905	0.489	0.770	-0.563	0.607	-0.080	0.885	-0.027	0.800
5	SIB vs. X_{23}	0.910	0.986	0.048	0.927	0.753	0.775	0.300	-0.151	-0.273	0.857	0.522	-0.713
6	SIB vs. X_{31}	0.499	0.496	0.160	0.160	-0.685	-0.433	-0.313	0.253	0.131	0.664	0.419	0.240
7	SIB vs. X_{32}	0.253	0.317	0.048	0.284	-0.150	-0.013	0.781	-0.823	0.228	-0.295	0.158	0.011
8	SIB vs. X_{33}	0.923	0.999	0.039	0.999	0.454	0.998	-0.693	0.990	-0.090	0.947	0.019	0.862
9	SIB vs. X_{34}	0.924	0.999	0.039	0.999	0.431	0.998	-0.802	0.975	-0.095	0.977	-0.092	0.877
10	SIB vs. X_{35}	0.920	0.994	-0.186	0.685	0.713	0.880	-0.807	0.970	0.248	-0.030	0.382	-0.800
11	SIB vs. X_{1}	0.929	0.999	0.033	1.000	0.418	0.998	-0.736	0.999	-0.179	0.997	-0.067	0.997
12	SIB vs. X_{2}	0.908	0.911	0.112	0.946	0.593	0.887	-0.202[r]	0.695	0.088[r]	0.906	-0.097	0.768
13	SIB vs. X_{3}	0.925	1.000	0.037	0.999	0.446	0.999	-0.753	0.998	-0.089	0.969	-0.031	0.912
14	SIB vs.Total	0.926	1.000	0.039	1.000	0.440	1.000	-0.729	1.000	-0.145	0.999	-0.075	1.000

Source: Author`s table based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

[r] Pearson's product moment correlation.

Graph 3: Comparison analysis between the POJK and PCA approaches



Source: Author`s figure based on data from the SPI bulletin, January 2011 – April 2018, and analyzed.

The limitations of this study should be acknowledged. First, sub-indicator variables used in this study were estimated by using other related variables due to the limitation of data accessibility. As such, the results may not represent the real condition for each banking group. Secondly, there were only 10 sub-indicator variables used in this study. Having more variables would likely improve the PCA performance since the PCA was initially applied to high-dimensional data problems. Nevertheless, it is believed that the study has simulated a fair comparison for the SIB assessment between the official (POJK) and PCA approaches, as they employed the same data set. Moreover, the POJK approach was based on the official methodology as written in the OJK regulation No.46/POJK.03/2015. The PCA approach was based on the previous study by Anwar (2018). The results of this study provide scientific evidence from which to inform policy-makers, central bank (BI) governors' councils, the OJK commissioner board, and other relevant stakeholders in the determination of the systemic important banking and capital surcharge in Indonesia.

5. Conclusions

In the present study, we offered an alternative way of calculating the Systemic Important Banking (SIB). The official regulation (OJK regulation No.46/POJK.03/2015) in Indonesia gives equal weight for indicator and sub-indicator variables of the SIB component. We considered a new way by employing the PCA analysis to find an alternative weighting system that is the eigenvectors of the

first PC. Simulation results on 6 banking groups have shown that the weighting system based on the PCA approach is better than the POJK as the official approach in assessing the SIB, and this was based on correlation analysis. The SIB based on the PCA approach had a higher correlation on 14 schemes compared to the POJK approach. For all banking groups, the PCA approach had an 88.10% higher correlation than the POJK approach. Accordingly, this approach can be used as an alternative way of determining the SIB, not only in Indonesia but also in other countries that recently adopted the G-SIB with an equal weighting policy.

References

1. Andrian, T. and Brunnermeier, M. K. (2008). CoVaR, Federal Reserve Bank of New York, Staff Report 348.
2. Andrian, T. and Brunnermeier, M. K. (2011). CoVaR, National Bureau of Economic Research (NBER), *Working Paper* 17454.
3. Anwar, S. (2018). Modifikasi Pembobotan Systemic Important Score dengan Principal Component Analysis. *Jurnal Ekonomi dan Pembangunan Indonesia*, 18(2), 128–151. https://doi.org/10.21002/jepi.v18i2.748
4. BCBS [Basel Committee on Banking Supervision]. (2013). *Global systemically important banks: updated assessment methodology and the higher loss absorbency requirement*. Basel: Bank for International Settlements (BIS). Available at https://www.bis.org/publ/bcbs255.htm
5. Brownlees, C. T. & Engle, R. (2012). Volatility, Correlation and Tails for Systemic Risk Measurement. *Social Science Research Network (id 1611229)*, 1-55. Available at https://faculty.washington.edu/ezivot/econ589/VolatilityBrownlees.pdf
6. Danyang, C., Yuan, T. & Donghui, B. (2015). Time Series Clustering Method Based on Principal Component Analysis. *Proceedings of the 5th International Conference on Information Engineering for Mechanics and Materials (ICMM)*, 888–895. https://doi.org/10.2991/icimm-15.2015.163
7. Đurašković, J., Radović, M. & Konatar, M. R. (2018). The Controversies of Modern Macroeconomic Theory in the Context of the Global Economic Crisis. *Journal of Central Banking Theory and Practice*, 7(2), 49–72. https://doi.org/10.2478/jcbtp-2018-0012
8. Fabris, N. (2018). Challenges for Modern Monetary Policy. *Journal of Central Banking Theory and Practice*, 7(2), 5–24. https://doi.org/10.2478/jcbtp-2018-0010
9. Filmer, D. & Pritchett, L. (1999). The Effect of Household Wealth on Educational Attainment: Evidence from 35 Countries. *Population and Development Review*, 25(1), 85–120. https://doi.org/10.1111/j.1728-4457.1999.00085.x
10. Gauthier, C., Lehar, A. and Souissi, M. (2010). Macroprudential Regulation and Systemic Capital Requirements, Bank of Canada, *Working Paper 2010–4*.
11. Gogtay, N. J. & Thatte, U. M. (2017). Principles of Correlation Analysis. *Journal of The Association of Physicians of India*, 65, 78–81. Available at http://www.japi.org/march_2017/12_sfr_principles_of_correlation.pdf
12. Gu, Y. & Zhu, S. (2015). Assessment of Systemically Important Banks-A Review. *International Journal of Business and Social Science*, 6(9), 132–139.

Available at http://ijbssnet.com/view.php?u=http://ijbssnet.com/journals/Vol_6_No_9_September_2015/15.pdf
13. Hanusz, Z., Tarasinska, J. & Zielinski, W. (2016). Shapiro-Wilk Test With Known Mean. *REVSTAT-Statistical Journal*, 14(1), 89–100. Available at https://www.ine.pt/revstat/pdf/rs160105.pdf
14. Harapan, H., Anwar, S., Bustaman, A., Radiansyah, A., Angraini, P., Fasli, R., … Mueller, R. (2016). Modifiable determinants of attitude towards dengue vaccination among healthy inhabitants of Aceh, Indonesia: Findings from a community-based survey. *Asian Pacific Journal of Tropical Medicine*, 9(11), 1115–1122. https://doi.org/10.1016/j.apjtm.2016.07.036
15. Harapan, H., Anwar, S., Bustaman, A., Radiansyah, A., Angraini, P., Fasli, R., … Müller, R. (2016). Community Willingness to Participate in a Dengue Study in Aceh Province, Indonesia. *PLOS ONE*, 11(7):e0159139. https://doi.org/10.1371/journal.pone.0159139
16. Harapan, H., Anwar, S., Setiawan, A. M., Sasmono, R. T. & Aceh Dengue Study. (2016). Dengue vaccine acceptance and associated factors in Indonesia: A community-based cross-sectional survey in Aceh. *Vaccine*, 34(32), 3670–3675. https://doi.org/10.1016/j.vaccine.2016.05.026
17. Härdle, W. K. & Simar, L. (2003). *Applied Multivariate Statistical Analysis*. Berlin: Springer.
18. Huang, X., Zhou, H. & Zhu, H. (2009). A Framework for Assessing the Systemic Risk of Major Financial Institutions A framework for assessing the systemic risk of major financial insti-tutions. *Journal of Banking & Finance*, 33(11), 2036–2049. https://doi.org/10.1016/j.jbankfin.2009.05.017
19. Moratis, G. and Sakellaris, P. (2017). Measuring the Systemic Importance of Banks, Bank of Greece, *Working Paper 240*.
20. Mukaka, M. M. (2012). A guide to appropriate use of correlation coefficient in medical research. *Malawi Medical Journal*, 24(3), 69–71. Available at https://preview.ncbi.nlm.nih.gov/pmc/articles/PMC3576830/pdf/MMJ2403-0069.pdf
21. OFR [Office of Financial Research]. (2017). Size Alone is Not Sufficient to Identify Systemically Important Banks, OFR [Office of Financial Research], Viewpoint 17-04. Available at https://www.financialresearch.gov/viewpoint-papers/files/OFRvp_17-04_Systemically-Important-Banks.pdf
22. OJK [Otoritas Jasa Keuangan]. (2015). Penetapan Systemically Important Bank dan Capital Surcharge. Jakarta: OJK [Otoritas Jasa Keuangan], 46/POJK.03/2015.
23. OJK [Otoritas Jasa Keuangan]. (2018, May 1). Statistik Perbankan Indonesia. Available at https://www.ojk.go.id/id/kanal/perbankan/data-dan-statistik/statistik-perbankan-indonesia/default.aspx

24. Peña, D. & Poncela, P. (2006). "Dimension Reduction in Multivariate Time Series". In *Balakrishnan N., Sarabia J.M., Castillo E*, ed. Advances in Distribution Theory, Order Statistics, and Inference. Statistics for Industry and Technology, 437-461. Boston: Birkhäuser. https://doi.org/10.1007/0-8176-4487-3_28
25. Razali, N. M. & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk , Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics*, 2(1), 21–33. Available at http://www.de.ufpb.br/~ulisses/disciplinas/normality_tests_comparison.pdf
26. Rebekić, A., Lončarić, Z., Petrović, S. & Marić, S. (2015). Pearson's or spearman's correlation coefficient-which one to use? *Poljoprivreda (Agriculture)*, 21(2), 47–54. https://doi.org/10.18047/poljo.21.2.8
27. Roussas, G. G. (1997). *A course in mathematical statistics*. Second edition. Singapore: Academic Press.
28. Royston, P. (1995). Remark AS R94: A Remark on Algorithm AS 181: The W-test for Normality. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 44(4), 547–551. https://doi.org/10.2307/2986146
29. Tambunan, T. T. H. (2010). The Indonesian Experience with Two Big Economic Crises. *Modern Economy*, 1(3), 156–167. https://doi.org/10.4236/me.2010.13018
30. Tarashev, N., Borio, C. and Tsatsaronis, K. (2010). Attributing systemic risk to individual institutions, Bank for International Settlements (BIS), *Working Paper 308*.
31. Twinoburyo, E. N. & Odhiambo, N. M. (2018). Monetary Policy and Economic Growth: A Review of International Literature. *Journal of Central Banking Theory and Practice*, 7(2), 123–137. https://doi.org/10.2478/jcbtp-2018-0015
32. Udovicic, M., Bazdaric, K., Bilic-Zulle, L. & Petrovecki, M. (2007). What we need to know when calculating the coefficient of correlation? *Biochemia Medica*, 17(1), 10–15. https://doi.org/10.11613/BM.2007.002
33. Zeb, S. & Rashid, A. (2015). Identifying Systemically Important Banks in Pakistan: A Quantile Regression Analysis. *International Journal of Economics and Finance*, 7(12), 155–167. https://doi.org/10.5539/ijef.v7n12p155.