Rank Order Centroid as a Method to Weight Dimensional Variables for Developing a Composite Index on Policing Activities in Mining and Quarrying Areas

Bhakti suhendarwan
IPB University, and Indonesia National Police (POLRI), Indonesia
Email: bhakti.suhendarwan@gmail.com
*Correspondence: bhakti.suhendarwan@gmail.com

Abstract: Objective: Dimensional variable weighting is required to calculate the composite index of policing activities in mining and quarrying activities. The purpose of weighting is to determine the Ranking and priority of each indicator and dimension, considering that each indicator does not necessarily have the same value in the actual situation. The weighting method used in this study uses a subjective method using expert opinion. **Method:** The Ranking carried out by experts is then calculated using rank order centroids. The results of this weighting show that expert opinion can be used to aggregate weights with specific values that can be used as weights for each dimension. **Conclusion:** The results of this study show that weighting by Ranking by experts through subjective methods can be used to compile rankings or weights of variables for index preparation.

Keywords: Rank Order Centroid, Weighting, Composite Index, Policing, Mining, And Quarrying.

INTRODUCTION

The mining and quarrying sector in Indonesia contributes approximately 9 percent of Indonesia's gross domestic product. The amount of contribution from the mining and quarrying sector is a gift and one of the police hazard variables that the police agency must observe. In some studies, extractive mining and quarrying activities have many problems, such as labor exploitation and the use of forbidden chemical substances (Hammond, 1988; Meutia et al., 2023; Salemdeeb et al., 2016; Zhang et al., 2022).

Measurement of policing activities in mining and quarrying areas can be used to improve these policing activities to support the area's progress. Traditionally, police activities are divided into three: maintaining social order, creating security, and acting as a crime prevention agency (Jones & Lister, 2019; Owens & Ba, 2021; Scheider et al., n.d.; Wood, 2020; Young, 2022). However, policing has a broader field dimension, including territorial and spatial

dimensions (Wood, 2020), which enable policing to be helpful for any condition.

In the context of measurement, Hodgkinson (2019) mentions that the use of policing performance has been used by the United Kingdom for several years to reach police reforms (Hodgkinson et al., 2019). Measuring policing activities on mining and quarrying activities is vital to increase awareness, especially regarding obedience to environmental law, control, and supervision (Massaquoi et al., 2021).

Preparation of a composite index of policing activities is required, especially if we want to describe several complex phenomena and variables into a single indicator, such as policing activities specific to a region or economic activities in a particular region (Dialga & Vallée, 2021).

In order to ensure the objectivity of the composite index, it is important to keep the composite index close to the situation in the field. Weighting needs to be done on each dimension and variable used. Weighting is carried out in each dimension, considering that it can be possible for some variables to have higher urgency than other variables.

For this reason, this research is essential to implement a relatively simple decision assistant system in weighting composite indices. Using rank-order centroids will facilitate the creation of weighting with the expert judgment method. Furthermore, the purpose of this study is to provide a reference for the use of an easy Decision support system in making composite indexes.

METHODS

The quantitative research design uses a Rank order centroid. The basic concept of the Rank order centroid (ROC) method is to give weights based on the importance of the criteria (I Made Arya Budhi Saputra, 2020), Which can be written in the formula as follows:

$$Cr1 \geq Cr2 \geq Cr3 \geq \ldots \geq Cn$$

....
......(1)

So, the weight of W1 will be larger than the weight of W2, and so on.

$$W1 \geq W2 \geq W3 \geq \ldots \geq Wn$$

....
........(2)

Where C is the criterion, W is the weight of C., and then if k is the number of criteria, then:

$$W1 = \frac{1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{k}}{k}$$

....
....................(3)

$$W2 = \frac{0 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{k}}{k}$$

....
....................(4)

$$W3 = \frac{0 + 0 + \frac{1}{3} + \cdots + \frac{1}{k}}{k}$$

....
....................(5)

$$Wk = \frac{0 + \cdots + 0 + \frac{1}{k}}{k}$$

....
.....................(6)

In the ROC method, the only necessary judgment is the ordering of the importance of the criteria. This process is more straightforward and

transparent to decision-makers, especially when the decision-making process is more complex and involves many alternatives and criteria to be analyzed (Mussoi & Teive, 2021).

Weighting is carried out on several variables and dimensions of data that will be processed into a composite index with the following data structure:
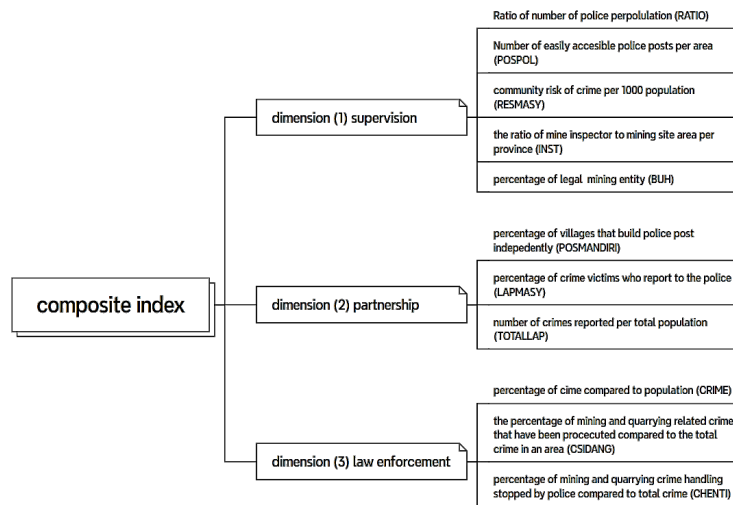

Figure 1. The dimensional structure and indicators in the composite index are to be weighted.

As for weighting, it is carried out by a panel of experts who are qualified at least or former officials at the first echelon level from Ministries and Institutions who have competence in the field of mining and quarrying in Indonesia. The experts used in weighting amounted to 6 (six) people. The index calculation instrument uses the direct rank weighting method against expert opinions, which is then aggregated with centroid order rank techniques(Hatefi, 2023; I Made Arya Budhi Saputra, 2020; Kunsch & Ishizaka, 2019).

RESULTS AND DISCUSSION
Result

Data is collected using questionnaires to experts to provide a ranking of indicators and dimensions of the composite index, as described in Figure 1. The Ranking is based on expert preferences and knowledge related to the indicators and dimensions used to form the composite index. The results of ranking and calculating weights with the Rank Order Centroid of each indicator and dimension, as explained in Figure 1, are as follows:

Table 1. Ranking of Dimension 1 Indicators – Supervision – Based on Expert Opinion

Expert	Dimension 1 – supervision				
	RATIO	POSPOL	RESMASY	INST	BUH
Expert 1	1	2	5	3	4
Expert 2	4	3	5	1	2
Expert 3	5	3	4	1	2
Expert 4	5	4	3	2	1
Expert 5	5	4	3	1	2
Expert 6	5	4	1	2	3

Table 2 shows the result of calculating the weight of dimension one indicator using ROC.

Expert	Dimension 1 – supervision (ROC value)				
	RATIO	POSPOL	RESMASY	INST	BUH
Expert 1	0,457	0,257	0,040	0,157	0,090
Expert 2	0,090	0,157	0,040	0,457	0,257
Expert 3	0,040	0,157	0,090	0,457	0,257
Expert 4	0,040	0,090	0,157	0,257	0,457
Expert 5	0,040	0,090	0,157	0,457	0,257
Expert 6	0,040	0,090	0,457	0,257	0,157
Average	0,12	0,14	0,16	0,34	0,25

Table 3. Ranking of indicator dimension 2 – partnership- based on expert opinion.

Expert	Dimension 2 – partnership		
	POSMANDIRI	LAPMASY	TOTALLAP
Expert 1	3	1	2
Expert 2	3	2	1
Expert 3	3	1	2
Expert 4	3	2	1
Expert 5	3	1	2
Expert 6	5	4	1

Table 4. shows the result of calculating the weight of the second-dimensional indicator using ROC.

Expert	Dimension 2 – partnership (ROC value)

	POSMANDIRI	LAPMASY	TOTALLAP
Expert 1	0,11	0,61	0,28
Expert 2	0,11	0,28	0,61
Expert 3	0,11	0,61	0,28
Expert 4	0,11	0,28	0,61
Expert 5	0,11	0,61	0,28
Expert 6	0,11	0,28	0,61
average	0,11	0,44	0,44

Table 5. Ranking of third dimension indicators – law enforcement - based on expert opinion

Expert	Dimension 3 – law enforcement		
	CRIME	CSIDANG	CHENTI
Expert 1	3	1	2
Expert 2	2	1	3
Expert 3	2	1	3
Expert 4	2	1	3
Expert 5	3	1	2
Expert 6	2	1	3

Table 6. shows the result of calculating the weight of the third-dimension indicator using ROC.

Expert	Dimension 3 – law enforcement (ROC value)		
	CRIME	CSIDANG	CHENTI
Expert 1	0,11	0,61	0,28
Expert 2	0,28	0,61	0,11
Expert 3	0,28	0,61	0,11
Expert 4	0,28	0,61	0,11
Expert 5	0,11	0,61	0,28
Expert 6	0,28	0,61	0,11
average	0,22	0,61	0,17

Table 7. Dimensional Ranking based on Expert Opinion

Expert	Dimension rank		
	Supervision	Partnership	Law enforcement
Expert 1	1	3	2
Expert 2	1	3	2
Expert 3	1	2	3

Expert 4	1	2	3
Expert 5	1	3	2
Expert 6	1	2	3

Table 8. shows the result of dimensional weight calculation using ROC.

Expert	Dimension weight (ROC)		
	Supervision (WAS)	Partnership (MITRA)	Law enforcement (GAKKUM)
Expert 1	0,61	0,11	0,28
Expert 2	0,61	0,11	0,28
Expert 3	0,61	0,28	0,11
Expert 4	0,61	0,28	0,11
Expert 5	0,61	0,11	0,28
Expert 6	0,61	0,28	0,11

Table 9. Dimensional weights and indicator weights are used in index calculations.

dimension	Dimensional weights	indicators	Indicators weights
(WAS)	0,61	(RASIO)	0,12
		(POSPOL)	0,14
		(RESMASY) (-)	0,16
		(INST)	0,34
		(BUH)	0,25
(MITRA)	0,19	(POSMANDIRI)	0,11
		(LAPMASY)	0,44
		(TOTALLAP)	0,44
(GAKKUM)	0,19	(CRIME) (-)	0,22
		(CSIDANG)	0,61
		(CHENTI)	0,17

DISCUSSION

Tables 1, 2, 3, 5, and 7 show the Ranking of each indicator given by experts according to their respective skills and preferences. The Ranking is then calculated through the ROC method according to the criteria of each dimension (Hatefi, 2023; I Made Arya Budhi Saputra, 2020; Kunsch & Ishizaka, 2019; Mussoi & Teive, 2021).

To describe using the ROC formula, we use partnership dimensions with the most criteria with five indicators. Calculations of the weight, which is considered as rank one, is $(1+(1/2)+(1/3)+(1/4)+(1/5))/5 = 0.457$, and the next rank is calculated, up to the calculation of rank 5, which is $(1/5)/5 = 0.040$.

Considering the number of experts totalling six people, the weight calculation results are then averaged to produce an aggregation value used as

the weight of each indicator and dimension, as attached in Table 9.

Mussoi and Teive (2021) explain that weighting using the ROC method is relatively more straightforward than weighting using the AHP or topsis method. This convenience allows decision-makers to calculate weights.

Table 9 shows that the supervisory dimension has the highest score compared to the other two dimensions, namely the partnership and law enforcement dimensions. It shows that supervisory activities in policing activities take precedence based on the expert panel's opinion. It also shows that the ROC method can be used as a decision-making tool, primarily related to several complex variables, as well as other MCDM methods such as AHP and topsis (Cinelli et al., 2020; D'Adamo et al., 2021; Gupta et al., 2020; Leal, 2020; Mohammadi & Rezaei, 2020; Naveed et al., 2020).

In addition, the ROC score, as shown in Table 9, can be used as a weighting score in the preparation of a composite index by multiplying the weight by the value of the variable to be calculated after data normalization (Khanna et al., 2019; Rahma et al., 2019). This weighting is needed to provide space for observations related to actual conditions in the field, where these observations can justify the difference in the impact of each dimension or indicator used in the composite index (Dialga & Vallée, 2021).

CONCLUSIONS

Rank order centroid, as one of the weighting methods, can be used for weighting for the development of a composite index of policing activities in mining areas. This weighting is essential considering that several variables of policing activities, namely supervision, partnership, and law enforcement, impact their implementation in the field differently.

From the results of the expert panel's data collection, the supervisory dimension has the highest score compared to the other two dimensions, namely partnership and law enforcement. It shows that in implementation in the field, the supervisory dimension is considered to have a higher urgency to be carried out compared to the other two dimensions, especially in the context of policing activities in mining areas.

REFERENCES

'Cinelli, M., Kadziński, M., Gonzalez, M., & Słowiński, R. (2020). How to support the application of multiple criteria decision analysis? Let us start with a comprehensive taxonomy. *Omega (United Kingdom)*, *96*. https://doi.org/10.1016/j.omega.2020.102261

D'Adamo, I., Gastaldi, M., Imbriani, C., & Morone, P. (2021). Assessing regional performance for the Sustainable Development Goals in Italy. *Scientific Reports*, *11*(1), 1–10. https://doi.org/10.1038/s41598-021-03635-8

Dialga, I., & Vallée, T. (2021). The index

of economic freedom: methodological matters. *Studies in Economics and Finance*, *38*(3), 529–561. https://doi.org/10.1108/SEF-07-2015-0181

Gupta, H., Kusi-Sarpong, S., & Rezaei, J. (2020). Barriers and overcoming strategies to supply chain sustainability innovation. *Resources, Conservation and Recycling*, *161*(March), 104819. https://doi.org/10.1016/j.resconrec.2020.104819

Hammond, A. A. (1988). Mining and quarrying wastes: A critical review. *Engineering Geology*, *25*(1), 17–31. https://doi.org/10.1016/0013-7952(88)90016-6

Hatefi, M. A. (2023). An Improved Rank Order Centroid Method (IROC) for Criteria Weight Estimation: An Application in the Engine/Vehicle Selection Problem. *Informatica (Netherlands)*, *34*(2), 249–270. https://doi.org/10.15388/23-INFOR507

Hodgkinson, T., Caputo, T., & McIntyre, M. L. (2019). Beyond crime rates and community surveys: A new approach to police accountability and performance measurement. *Crime Science*, *8*(1), 1–7. https://doi.org/10.1186/s40163-019-0108-x

I Made Arya Budhi Saputra. (2020). Penentuan Lokasi Stup Menggunakan Pembobotan Rank Order Centroid (ROC) dan Simple Additive Weighting (SAW). *Jurnal Sistem Dan Informatika (JSI)*, *15*(1), 48–53. https://doi.org/10.30864/jsi.v15i1.340

Jones, T., & Lister, S. (2019). Localism and police governance in England &

Wales: Exploring continuity and change. *European Journal of Criminology*, *16*(5), 552–572. https://doi.org/10.1177/1477370819860689

Khanna, R. A., Li, Y., Mhaisalkar, S., Kumar, M., & Liang, L. J. (2019). Comprehensive energy poverty index: Measuring energy poverty and identifying micro-level solutions in South and Southeast Asia. *Energy Policy*, *132*(November 2018), 379–391. https://doi.org/10.1016/j.enpol.2019.05.034

Kunsch, P. L., & Ishizaka, A. (2019). A note on using centroid weights in additive multi-criteria decision analysis. *European Journal of Operational Research*, *277*(1), 391–393. https://doi.org/10.1016/j.ejor.2019.02.021

Leal, J. E. (2020). AHP-express: A simplified version of the analytical hierarchy process method. *MethodsX*, *7*. https://doi.org/10.1016/j.mex.2019.11.021

Meutia, A. A., Bachriadi, D., & Gafur, N. A. (2023). Environment Degradation, Health Threats, and Legality at the Artisanal Small-Scale Gold Mining Sites in Indonesia. *International Journal of Environmental Research and Public Health*, *20*(18). https://doi.org/10.3390/ijerph20186774

Mohammadi, M., & Rezaei, J. (2020). Ensemble ranking: Aggregation of rankings produced by different multi-criteria decision-making methods. *Omega (United Kingdom)*, *96*, 102254. https://doi.org/10.1016/j.omega.20

20.102254

Mussoi, F. L. R., & Teive, R. C. G. (2021). An integrated multicriteria decision-making approach for distribution system expansion planning. *International Journal of Intelligent Systems*, *36*(9), 4962–4989. https://doi.org/10.1002/int.22498

Naveed, Q. N., Qureshi, M. R. N., Tairan, N., Mohammad, A. H., Shaikh, A., Alsayed, A. O., Shah, A., & Alotaibi, F. M. (2020). Evaluating critical success factors in implementing E-learning system using multi-criteria decision-making. *PLoS ONE*, *15*(5), 1–25. https://doi.org/10.1371/journal.pone.0231465

Owens, E., & Ba, B. (2021). The Economics of Policing and Public Safety. *Journal of Economic Perspectives*, *35*(4), 3–28. https://doi.org/10.1257/jep.35.4.3

Rahma, H., Fauzi, A., Juanda, B., & Widjojanto, B. (2019). Development of a composite measure of regional sustainable development in Indonesia. *Sustainability (Switzerland)*, *11*(20), 1–16. https://doi.org/10.3390/su11205861

Salemdeeb, R., Al-Tabbaa, A., & Reynolds, C. (2016). The UK waste input-output table: Linking waste generation to the UK economy. *Waste Management and Research*, *34*(10), 1089–1094. https://doi.org/10.1177/0734242X16658545

Scheider, M. C., Spence, D. L., & Mansourian, J. (n.d.). *The Relationship Between Economic Conditions, Policing, and Crime Trends*.

Wood, J. D. (2020). Private Policing and Public Health: A Neglected Relationship. *Journal of Contemporary Criminal Justice*, *36*(1), 19–38. https://doi.org/10.1177/1043986219890191

Young, A. (2022). Architecture as affective law enforcement: Theorising the Japanese Koban. *Crime, Media, Culture*, *18*(2), 183–202. https://doi.org/10.1177/17416590921993527

Zhang, S., Hua, X., Huang, G., Shi, X., & Li, D. (2022). What Influences Miners' Safety Risk Perception? *International Journal of Environmental Research and Public Health*, *19*(7). https://doi.org/10.3390/ijerph19073817