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Analyzing the Drivers of Green Manufacturing Practices Using Fuzzy TOPSIS Case Study Bandarharjo Fish Smoked Industry Centre

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Abstract: It is not easy for SMEs to implement green manufacturing (GM) practice. There are so many drivers drive the SMEs to implement GM practices. This study aims to determine the importance of each driving factor in realizing GM practices at Bandarharjo Fish Smoked Industry Centre using fuzzy technique for order preference by similarity to ideal situation (TOPSIS) method, determine the driving factors that are a priority in realizing GM practices at Bandarharjo Fish Smoked Industry Centre using fuzzy TOPSIS method, and arrange the recommendations that can be applied based on priority factors. There are 3 alternatives and 14 criteria, and the data used for fuzzy TOPSIS is collected through a questionnaire to 9 decision makers as an expert. The result of the study indicated that the commitment of top management is the top-ranked driver for each criterion individually (environmental, social, economic) and also for aggregate criteria. The result of the study also indicated that the second, third, and fourth prioritization of GM practices based on the perspective of individual criteria (environmental, social, and economic) and aggregate criteria are generally different.

Keywords: Bandarharjo; drivers; green manufacturing; fuzzy TOPSIS; SMEs of smoked fish.

1. Introduction

In Indonesia, Small and Medium Enterprises (SMEs) have significant roles for national economic development [1]. According to reference [2] and [3], the SMEs have several characteristics that make their business significant for national economic development. Despite the contribution of overall of SMEs for national economic development, it can be found that many of SME of Indonesian manufacturing do not have environmental consciousness and have a significant contribution for a large amount of pollution and resource depletion due to inefficient equipment usage [4]. According to Blackman [5], SMEs are more ‘pollution-intensive’ than ‘big businesses’ although their real environmental impact is not known and may be difficult to assess. Estimates of their contribution to pollution are as high as 60% to 70% of total industrial pollution [6]. Since the SMEs in Indonesia play a crucial role for national economic development and it is found that many of SMEs of Indonesian manufacturing have a contribution for a large amount of pollution and resource depletion, one of the strategies to face this condition is implement the green manufacturing (GM) practice. There are so many definitions of GM. GM is also known as

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ecologically conscious manufacturing, environmentally conscious manufacturing, environmentally friendly manufacturing, manufacturing for the environment, clean production, and sustainable manufacturing. One definition is given by Govindan et al [7]. According to them, GM can be defined as GM as a system that integrates product and process design issues with issues of manufacturing planning and control in such a manner as to identify, quantify, assess and manage the flow of environmental waste with the goal of reducing and ultimately minimizing environmental impact while also trying to maximize resource efficiency.

It is not easy for SMEs to implement GM practice. There are so many barriers and drivers faced by the SMEs. The SMEs faced different drivers and barriers compared to large enterprises. It is because the SMEs usually lack resource, data, technical expertise, and also experience needed to implement green initiatives. Most of SMEs, especially in Indonesia, is driven by the intention of the owners of SMEs in achieving environmental performance. Moreover, the characteristics of SMEs vary significantly among geographical regions. Based on this condition, there is a critical need to identify the barriers and drivers of GM practices in SMEs in order to accelerate the implementation of such practices in SMEs. However, rather than focus on the barriers to implement GM practices, this study will focus on the drivers to implement GM practices. In this case, this study use previous research in past to identify the drivers for green manufacturing such as Mittal and Sangwan [8] and Gandhi et al. [9] and this study use Bandarharjo Fish Smoked Industry Centre as a case study since our preliminary study found some large amount of pollution their production process.

A preliminary study indicated that production process carried out by most of SMEs in Bandarharjo Fish Smoked Industry Centre is still traditional and has a negative impact on the environment due to solid, liquid and smoke waste [10]. Liquid waste, such as residual blood, fish mucus, and used water from washing fish can cause environmental pollution such as toxicity and decreases the level of Oxygen Demand (DO) [11]. This industrial center already has a Waste Water Treatment Plant (WWTP) but it is not yet perfect and this condition causes the wastewater comes out of the filter still contain dangerous pollutants. The condition of fresh water of 15 from 21 SMEs of fish smoked do not meet the requirements because it's containing Coliform Bacteria greater than 10 / 100ml [12]. Moreover, the results of interviews with 73 residents (71.4%) around the location of Fish Smoked Center stated that as many as 28 residents (38.4%) felt disturbed because of the unpleasant smell of the waste. The smoke produced by the production process of the smoked fish contains Total Suspended Particulate (TSP) and Particulate Matter 2.5 (PM2.5). The results showed that the concentration of TSP and PM2.5 reached 872,877 µg / Nm^3 and 4018 µg / Nm^3 respectively. That value is greater than the quality standard threshold value set by the Central Java Governor Decree No. 8 of 2001, amounting to 230 µg / Nm^3 for TSP and 65 µg / Nm^3 for PM2.5. In addition, the smoke produced from the fumigation process contains H_2S which destroys the flavor and reduces the availability of cysteine in the product [13].

Shortly, this study aims to determine the importance of each driving factor in realizing GM practices at Bandarharjo Fish Smoked Industry Centre using fuzzy technique for order preference by similarity to ideal situation (TOPSIS) method, determine the driving factors that are a priority in realizing GM practices at Bandarharjo Fish Smoked Industry Centre using fuzzy TOPSIS method, and arrange the recommendations that can be applied based on priority factors.

2. Method of the Research

2.1 Drivers of Green Manufacturing Practices

Green manufacturing is a system that integrates product and process design issues with issues of manufacturing, planning, and control in such a manner to identify, quantify, assess and manage the flow of environmental waste with the goal of reducing environmental impact while also trying to maximize the resource efficiency [14]. According to Mittal and Sangwan [8], GM practices related to designing, manufacturing, delivering, and disposing of products that have at least negative impacts on both environment and society and that are economically viable. According to Mittal and Sangwan (2014), there are three different aspects should be engaged in order to implement GM practices, namely the planet, people, and prosperity. This three aspects will motivate the enterprise to prioritize the drivers for implementing the GM practice using environmental (i.e. planet), social (i.e. people) and economic (i.e. prosperity) perspectives. Related to drivers of GM practices, this study prefers to choose the drivers of GM practices from Mittal and Sangwan [8] and Govindan et al [7] although the drivers of GM practices can be seen from several authors. There are fourteen drivers of GM practices from Mittal and Sangwan (2014) namely the commitment of top management, current regulation, future regulation, public pressure, peer pressure, supply chain pressure, public image, competitiveness, the demand of customers, resource of the organization, technology, cost savings, and incentives. There is one driver of GM practices from Govindan et al [7] namely environmental conservation.

2.2 Data Collection Procedure

The data used for fuzzy TOPSIS is collected through a questionnaire. There are two kinds of questionnaire. The first kind of questionnaire is used to compare the ratings of criteria with respect to GM practices. This questionnaire is using scale l-5 (1= the criteria has very low effect on GM practices/VL; 2= this criterion has a low effect on GM practices/L; 3= the criteria has medium effect on GM practices/M; 4= this criterion has a high effect on GM practices/H; and 5= the criteria has a very high effect on GM practices/VH). The second questionnaire is used to compare the ratings of alternatives with respect to the criteria. This questionnaire is also using scale l-5 (1= not important/NI; 2= low important/LI, 3= fairly important/FI; 4= important/I; and 5= very important/VI). Moreover, the linguistic variables for the rating of criteria and alternatives can be explained as follow. VL and NI are corresponding to TFN (1, 1, 3), L and LI are corresponding to TFN (1, 3, 5), M and FI are corresponding to (3, 5, 7), H and I are corresponding to TFN (5, 7, 9), VH and VI are corresponding to TFN (7, 9, 9).

This first and second questionnaire is distributed to nine experts. Three of them are experts in the field of environment, represented by the officials from Semarang City Environmental Agency, officials from Semarang City Fisheries Agency, and community leader. Three of them are experts in the field of social, represented by the officials from the Semarang City Regional Planning and Development Agency, representative of North Semarang District, and head of Bandarharjo Village. Three of them are experts in the field of economic, represented by the officials from the Semarang City Industrial Agency, head of Bandarharjo Fish Craftsmen Cooperative, and the representative of fish craftsmen.

2.3 Data Processing

One of the classical methods for solving multi-criteria decision making (MCDM) is the technique for Order Performance by similarity to Ideal solution (TOPSIS). This method is established by Hwang and Yoon [15]. TOPSIS is based on two principles, namely negative ideal solution, and a positive ideal solution. The negative ideal solution maximizes the cost criteria and minimizes the benefit criteria; whereas, the positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria. In short, the positive ideal solution is the one which has the best level for all attributes considered, whereas the negative ideal solution is the one which has the worst attribute values. In classical TOPSIS, the rating and weight of the criteria are recognized exactly. However, in many actual circumstances, crisp data are insufficient to model actual life condition since the judgments from human thinking are ambiguous and cannot be assessed with exact numeric values [15]. So, to resolve that ambiguity that often arising in information from the judgments from human thinking, the fuzzy set theory has been combined in many MCDM methods including TOPSIS.

In fuzzy TOPSIS, all the ratings and weights are defined by means of linguistic variables. Chen and Hwang [16] are the first researchers who applied the fuzzy number to create fuzzy TOPSIS. Later, the Chu and Lin [17] extended the fuzzy TOPSIS method based on alpha level sets with interval arithmetic, Chen and Lee [18] extended fuzzy TOPSIS based on type-2 fuzzy TOPSIS method in order to provide an additional degree of freedom to represent the uncertainties and fuzziness of the real world. There are so many shapes of a fuzzy number and the most popular is a triangular fuzzy number (TFN). In TFN, a fuzzy number denoted with three points, i.e. l, m, u.

According to Rahman and Shohan [19], the steps of fuzzy TOPSIS algorithm can be explained as follows. First, creating reasonable alternatives, determining the evaluation criteria, and setting a group of decision makers. Second, selecting the suitable linguistic variables for the importance weight of the criteria ($\widetilde{w} = l_{ij}, m_{ij}, u_{ij}$) and the linguistic rating for alternatives with respect to criteria ($\tilde{x}_{ij}$) as triangler fuzzy number. Third, aggregate the weight of criteria to get the aggregated fuzzy weight $\widetilde{w}_j$of criterion C_j and obtain the aggregated fuzzy rating ($\tilde{x}_{ij}$) of alternative A_i under criterion Cj evaluated by expert ($\tilde{x}_{ij} = \frac{1}{k}\left[\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \cdots \ldots + \tilde{x}_{ij}^k\right]$ where i= 1,2...m; j=1,2..., n; $\widetilde{w}_{ij} = \frac{1}{k}\left[\widetilde{w}_{ij}^1 + \widetilde{xw}_{ij}^2 \ldots + \widetilde{w}_{ij}^k\right]$ where $j = 1,2, \ldots n$). Fourth, construct the fuzzy decision matrix. The fuzzy decision matrix is

$$\widetilde{D} = \begin{matrix} A_1 \\ \vdots \\ A_m \end{matrix}\begin{bmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mn} \end{bmatrix}, \text{ i = 1, 2,…, m; j = 1, 2, ... n; } \widetilde{W} = [\widetilde{w}_1, \ \widetilde{w}_2, \widetilde{w}_3] \ldots\ldots \quad (1)$$

Fifth, normalize fuzzy decision matrix. The normalized fuzzy decision matrix denoted by $\tilde{R}$~ is obtained by formula as follows:

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{m\times n} \text{ , i = 1, 2,…, m; j = 1, 2,…, n where}$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^* = max_i\{c_{ij}\} \ldots\ldots \quad (2)$$

Sixth, construct the weighted normalized fuzzy decision matrix. It is calculated by multiplying the weight $\widetilde{w}_j$ of criterion with normalized fuzzy decision matrix $\tilde{r}_{ij}$

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n}, \text{ i = 1, 2,…, m; j = 1, 2,…, n, where } \tilde{v}_{ij} = \tilde{r}_{ij}.\widetilde{w}_j \ldots\ldots \quad (3)$$

Seventh, determine the fuzzy positive ideal solution (FPIS) S^+ and fuzzy negative ideal solution (FNIS) S^-.

$$S^+ = (\tilde{v}_1^+, \tilde{v}_2^+, \ldots, \tilde{v}_n^+), \text{ where } \tilde{v}_j^+ = max_i\{v_{ij3}\} \ldots\ldots \quad (4)$$

$$S^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-), \text{ where } \tilde{v}_j^- = min_i\{v_{ij3}\} \ldots\ldots \quad (5)$$

i = 1, 2,…, m; j = 1, 2,…, n

Eighth, calculate the distance of each alternative from FPIS (d+) and FNIS (d-). Using Vertex Method, the distance between two triangular fuzzy numbers $\tilde{a} = (a_1; a_2; a_3)$ and $\tilde{b} = (b_1; b_2; b_3)$ can be calculated as follow.

$$d(\tilde{a},\tilde{b}) = \sqrt{\frac{1}{3}[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2]} \quad (6)$$

$$d_i^* = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^*),\ i = 1, 2, \ldots, m \quad (7)$$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-),\ i = 1, 2, \ldots, m \quad (8)$$

Ninth, calculate the closeness coefficient (CCi).

$$CC_i = d_i^- / (d_i^- + d_i^*),\ i = 1, 2, \ldots, m \quad (9)$$

The value of CCi will be aggregated to find the order of CCi (alternatives) according to their coefficient. The main priority driving factors is the alternative with the highest proximity coefficient is first rank (closest to FPIS and farthest from FNIS).

3. Result and Discussion

There is 3 criteria, 14 alternatives, and 9 decision makers in this study. Using the linguistic rating, the conversion of the data from the 9 decision makers become fuzzy rating and aggregated fuzzy weights for the criteria can be seen in Table 1. Moreover, the result of the conversion of the data from the questionnaire become fuzzy rating for alternatives can be seen in Table 2. Then, the aggregate fuzzy weights for alternatives and normalized fuzzy decision matrix for alternatives can be seen in Table 3. The aggregate fuzzy weights for alternatives in Table 3 are normalized using equation 2. As example, the altenative commitment of top management in the criteria environmental have aggregate fuzzy weights (7, 9, 9), so the maximum value is 9. Then, the normalized fuzzy decision matrix of the alternative commitment of top management in the criteria environmental is $\tilde{r}_{11} = \left(\frac{a_{11}}{c_1^*}, \frac{b_{11}}{c_1^*}, \frac{c_{11}}{c_{11}^*}\right) = \frac{7}{9}, \frac{9}{9}, \frac{9}{9} = 0.7778;\ 1;\ 1.$

Table 1. The conversion of the data from questionnaire become fuzzy rating and the aggregate fuzzy weights for criteria.

	Envionmental			Social			Economy			Aggregate fuzzy weight
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9	
C1	(7;9;9)	(7;9;9)	(5;7;9)	(7;9;9)	(5;7;9)	(7;9;9)	(7;9;9)	(7;9;9)	(5;7;9)	(5; 8,3333; 9)
C2	(3;5;7)	(7;9;9)	(5;7;9)	(5;7;9)	(5;7;9)	(7;9;9)	(7;9;9)	(7;9;9)	(5;7;9)	(3; 7,6667; 9)
C3	(5;7;9)	(5;7;9)	(5;7;9)	(5;7;9)	(7;9;9)	(7;9;9)	(5;7;9)	(5;7;9)	(3;5;7)	(3; 7,2222; 9)

Table 2. The conversion of the data from questionnaire become fuzzy rating for alternatives.

Alt.	Envionmental			Social			Economy		
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9
D1	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)
D2	(5; 7; 9)	(3; 5; 7)	(3; 5; 7)	(5; 7; 9)	(3; 5; 7)	(3; 5; 7)	(3; 5; 7)	(3; 5; 7)	(3; 5; 7)
D3	(7; 9; 9)	(5; 7; 9)	(3; 5; 7)	(5; 7; 9)	(5; 7; 9)	(7; 9; 9)	(5; 7; 9)	(3; 5; 7)	(3; 5; 7)
D4	(5; 7; 9)	(5; 7; 9)	(7; 9; 9)	(3; 5; 7)	(5; 7; 9)	(5; 7; 9)	(5; 7; 9)	(3; 5; 7)	(1; 3; 5)
D5	(3; 5; 7)	(1; 3; 5)	(1; 3; 5)	(1; 3; 5)	(3; 5; 7)	(3; 5; 7)	(1; 3; 5)	(1; 3; 5)	(1; 3; 5)
D6	(1; 3; 5)	(3; 5; 7)	(1; 3; 5)	(1; 3; 5)	(1; 3; 5)	(3; 5; 7)	(3; 5; 7)	(1; 3; 5)	(1; 3; 5)
D7	(5; 7; 9)	(7; 9; 9)	(7; 9; 9)	(5; 7; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(5; 7; 9)	(5; 7; 9)
D8	(3; 5; 7)	(3; 5; 7)	(5; 7; 9)	(5; 7; 9)	(3; 5; 7)	(5; 7; 9)	(5; 7; 9)	(3; 5; 7)	(3; 5; 7)
D9	(5; 7; 9)	(5; 7; 9)	(7; 9; 9)	(5; 7; 9)	(7; 9; 9)	(5; 7; 9)	(5; 7; 9)	(3; 5; 7)	(3; 5; 7)
D10	(7; 9; 9)	(7; 9; 9)	(5; 7; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(5; 7; 9)
D11	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)
D12	(7; 9; 9)	(7; 9; 9)	(5; 7; 9)	(7; 9; 9)	(5; 7; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)

Alt.	Envionmental			Social			Economy		
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9
D13	(1; 3; 5)	(1; 3; 5)	(3; 5; 7)	(1; 3; 5)	(3; 5; 7)	(3; 5; 7)	(3; 5; 7)	(1; 3; 5)	(3; 5; 7)
D14	(7; 9; 9)	(5; 7; 9)	(5; 7; 9)	(5; 7; 9)	(7; 9; 9)	(7; 9; 9)	(5; 7; 9)	(7; 9; 9)	(7; 9; 9)

D1= the commitment of top management, D2=current regulation, D3=future regulation, D4=public pressure, D5=peer pressure, D6=supply chain pressure, D7=public image, D8=competitiveness, D9=demand of customers, D10=resource of organization, D11=environmental conservation, D12=technology, D13=cost savings, D14= incentives.

Table 3. The aggregate fuzzy weights and normalize fuzzy decision matrix for alternative.

Alt.	Aggregate fuzzy weight			Normalized fuzzy decision matrix		
	Environmental	Economic	Social	Environmental	Economic	Social
D1	(7; 9; 9)	(7; 9; 9)	(7; 9; 9)	(0.7778; 1; 1)	(0.7778; 1; 1)	(0.7778; 1; 1)
D2	(3; 5.6667; 9)	(3; 5.6667; 9)	(3; 5; 7)	(0.3333; 0.6296; 1)	(0.3333; 0.6296; 1)	(0.3333; 0.5556; 0.7778)
D3	(3; 7; 9)	(5; 7.6667; 9)	(3; 5.6667; 9)	(0.3333; 0.7778; 1)	(0.5556; 0.8519; 1)	(0.3333; 0.6296; 1)
D4	(5; 7.6667; 9)	(3; 6.3333; 9)	(1; 5; 9)	(0.5556; 0.8519; 1)	(0.3333; 0.7037; 1)	(0.111; 0.5556; 1)
D5	(1; 3.6667; 7)	(1; 4.3333; 7)	(1; 3; 5)	(0.111; 0.4074; 0.7778)	(0.111; 0.4815; 0.7778)	(0.111; 0.333; 0.5556)
D6	(1; 3.6667; 5)	(1; 3.6667; 7)	(1; 3.6667; 7)	(0.111; 0.4074; 0.5556)	(0.111; 0.4074; 0.7778)	(0.111; 0.4074; 0.7778)
D7	(5; 8.3333; 9)	(5; 8.3333; 9)	(5; 7.6667; 9)	(0.5556; 0.9259; 1)	(0.5556; 0.9259; 1)	(0.5556; 0.8519; 1)
D8	(3; 5.6667; 9)	(3; 6.3333; 9)	(3; 5.6667; 9)	(0.3333; 0.6296; 1)	(0.3333; 0.7037; 1)	(0.3333; 0.6296; 1)
D9	(5; 7.6667; 9)	(5; 7.6667; 9)	(3; 5.6667; 9)	(0.5556; 0.8519; 1)	(0.5556; 0.8519; 1)	(0.3333; 0.6296; 1)
D10	5; 8.3333; 9)	(7; 9; 9)	(5; 8.3333; 9)	(0.5556; 0.9259; 1)	(0.7778; 1; 1)	(0.5556; 0.9259; 1)
D11	(5; 7.6667; 9)	(5; 8.3333; 9)	(5; 7; 9)	(0.5556; 0.8519; 1)	(0.5556; 0.9259; 1)	(0.5556; 0.7778; 1)
D12	5; 8.3333; 9)	5; 8.3333; 9)	(7; 9; 9)	(0.5556; 0.8519; 1)	(0.5556; 0.9259; 1)	(0.7778; 1; 1)
D13	(1; 3.6667; 7)	(1; 4.3333; 7)	(1; 4.3333; 7)	(0.111; 0.4074; 0.7778)	(0.111; 0.4815; 0.7778)	(0.111; 0.4815; 0.7778)
D14	(5; 7.6667; 9)	(5; 8.3333; 9)	(5; 8.3333; 9)	(0.5556; 0.8519; 1)	(0.5556; 0.9259; 1)	(0.5556; 0.9259; 1)

D1= the commitment of top management, D2=current regulation, D3=future regulation, D4=public pressure, D5=peer pressure, D6=supply chain pressure, D7=public image, D8=competitiveness, D9=demand of customers, D10=resource of organization, D11=environmental conservation, D12=technology, D13=cost savings, D14= incentives.

The normalized fuzzy decision matrix (see Table 3) multiplied by the weights of evaluation criteria (see Table 1) to get the weighted normalized matrix of the alternative. In detail, the result of weighted normalized alternatives can be seen in Table 4. This is an example to calculate the weighted normalized of alternative commitment of top management in the criteria environmental $\tilde{v}_{11} = \tilde{r}_{11}.\tilde{w}_1 = (0.7778;\ 1;\ 1) \cdot (5;\ 8.333;\ 9) = (3.8889;\ 8.333;\ 9)$

Table 4. Weighted normalized alternatives.

Alternative	Environmental	Economic	Social
D1	(3.8889; 8.3333; 9)	(2.333; 8.3333; 9)	(2.3333; 7.2222; 9)
D2	(1.6667; 5.2469; 9)	(1; 5.5269; 9)	(1; 4.0124; 7)
D3	(1.6667; 6.4815; 9)	(1.6667; 7.0988; 9)	(1; 4.5473; 9)
D4	(2.7778; 7.4774; 9)	(1; 5.8642; 9)	(0.3333; 4.0124; 9)
D5	(0.5556; 3.3951; 7)	(0.3333; 4.0124; 7)	(0.3333; 2.4074; 5)
D6	(0.5556; 3.3951; 5)	(0.3333; 3.3951; 7)	(0.3333; 2.9424; 7)
D7	(2.7778; 7.7161; 9)	(1.6667; 7.7161; 9)	(1.6667; 6.1523; 9)
D8	(1.6667; 5.2469; 9)	(1; 5.8642; 9)	(1; 4.5473; 9)
D9	(2.7778; 7.0988; 9)	(1.6667; 7.0988; 9)	(1; 4.5473; 9)
D10	(2.7778; 7.7161; 9)	(2.333; 8.333; 9)	(1.6667; 6.6872; 9)
D11	(2.7778; 7.0988; 9)	(1.6667; 7.7161; 9)	(1.6667; 5.6173; 9)
D12	(2.7778; 7.7161; 9)	(1.6667; 7.7161; 9)	(2.3333; 7.2222; 9)
D13	(0.5556; 3.3951; 7)	(0.3333; 4.0124; 7)	(0.3333; 3.4774; 7)
D14	(2.7778; 7.0988; 9)	(1.6667; 7.7161; 9)	(1.6667; 6.6872; 9)
FPIS (S^+)	(9; 9; 9)	(9; 9; 9)	(9; 9; 9)
FNIS (S^-)	(0.5556; 0.5556; 0.5556)	(0.3333; 0.3333; 0.3333)	(0.3333; 0.3333; 0.3333)

FPIS and FNIS of alternatives are computed in the last two rows of Table 4. Then, based on the value of FPIS and FNIS, the distance of each weighted alternative from the FPIS and the FNIS is calculated. The following is an example of FPIS and FNIS calculations for an alternative commitment of top management to environmental criteria. In detail, it can be seen in Table 5.

$$d(\tilde{a},\tilde{b}) = \sqrt{\frac{1}{3}[(a_1-b_1)^2+(a_2-b_2)^2+(a_3-b_3)^2]} = \sqrt{\frac{1}{3}[(9-3.889)^2+(9-8.333)^2+(9-9)^2]}$$

$$d_1^+ = \sum_{j=1}^{3} d_v(\tilde{v}_{11}.\tilde{v}_1^*) = \sum_{j=1}^{3} 2.9759+3.8682+3.9835 = 10.8276$$

$$d_1^- = \sum_{j=1}^{3} d_v(\tilde{v}_{11}.\tilde{v}_1^-) = \sum_{j=1}^{3} 6.9020+6.9068+6.4953 = 20.3041$$

Table 5. Distance of each alternative (GM drivers) from FPIS dan FNIS.

	Environmental	Economic	Social	d_i^+		Environmental	Economic	Social	d_i^-
d(D1,D⁺)	2.9759	3.8682	3.9835	10.8276	d(D1,D⁻)	6.9020	6.9068	6.4953	20.3041
d(D2,D⁺)	4.7562	5.1018	5.5641	15.4221	d(D2,D⁻)	5.6140	5.7648	4.4130	15.7918
d(D3,D⁺)	4.4766	4.3739	5.2860	14.1365	d(D3,D⁻)	5.9905	6.3943	5.5771	17.9619
d(D4,D⁺)	3.7564	4.9610	5.7732	14.4905	d(D4,D⁻)	6.2997	5.9483	5.4359	17.6839
d(D5,D⁺)	5.9644	5.8875	6.6976	18.5495	d(D5,D⁻)	4.0659	4.3962	2.9484	11.4105
d(D6,D⁺)	6.2908	6.0698	6.2130	18.5737	d(D6,D⁻)	3.0450	4.2355	4.1333	11.4138
d(D7,D⁺)	3.6681	4.2983	4.5419	12.5083	d(D7,D⁻)	6.5197	6.6180	6.0759	19.2136
d(D8,D⁺)	4.7562	4.9610	5.2860	15.0032	d(D8,D⁻)	5.6140	5.9483	5.5771	17.1394
d(D9,D⁺)	3.7564	4.3739	5.2860	13.4163	d(D9,D⁻)	6.2997	6.3943	5.5771	18.2712
d(D10,D⁺)	3.6681	3.8682	4.4395	11.9758	d(D10,D⁻)	6.5197	6.9068	6.2520	19.6785
d(D11,D⁺)	3.7564	4.2983	4.6626	12.7173	d(D11,D⁻)	6.2997	6.6180	5.9107	18.8284
d(D12,D⁺)	3.6681	4.2983	3.9835	11.9499	d(D12,D⁻)	6.5197	6.6180	6.4953	19.6330
d(D13,D⁺)	5.9644	5.8875	6.0446	17.8965	d(D13,D⁻)	4.0659	4.3962	4.2556	12.7176
d(D14,D⁺)	3.7564	4.2983	4.4395	12.4941	d(D14,D⁻)	6.2997	6.6180	6.2520	19.1697

The distance of each alternative from FPIS and FNIS (see Table 5) is used to calculate the closeness coefficient (CCi). The following is the example of the calculation of the closeness coefficient for the alternative commitment of top management individually and aggregate. In detail, the result of the calculation the closeness coefficient for the alternative commitment of top management individually and aggregate can be seen in Table 6.

$$CC_{1\,(ind)} = {}^{\mathrm{d(D1},D^-)}/_{(\mathrm{d(D1},D^-)+\mathrm{d(D1},D^+))} = 6.9020 \,/\, ((6.9020+2.9759)) = 0.6987$$

$$CC_{1\,(aggre)} = {}^{d_1^-}/_{(d_1^-+d_1^*)} = {}^{20.3041}/_{(20.3041+10.8276)} = 0.6522$$

Table 6. Closeness coefficient for each alternative (individually and aggregate).

Alternative (Driver of GM)	CCi Environmental	CCi Economic	CCi Social	CCi aggregate
D1	0.6987	0.6410	0.6199	0.6522
D2	0.5414	0.5305	0.4423	0.5059
D3	0.5723	0.5938	0.5134	0.5596
D4	0.6265	0.5453	0.4850	0.5496
D5	0.4054	0.4275	0.3057	0.3809
D6	0.3262	0.4110	0.3995	0.3806
D7	0.6400	0.6062	0.5722	0.6057
D8	0.5414	0.5453	0.5134	0.5332
D9	0.6265	0.5938	0.5134	0.5766
D10	0.6400	0.6410	0.5848	0.6217
D11	0.6265	0.6062	0.5590	0.5969
D12	0.6400	0.6062	0.6199	0.6216
D13	0.4054	0.4275	0.4132	0.4154
D14	0.6265	0.6062	0.5848	0.6054

The value of aggregate closeness coefficient for each alternative (see Table 7) indicated the ranking of the driver of GM individually (based for certain criteria) dan the ranking of the driver of GM in aggregate. In detail, the ranking of the driver of GM individually and in aggregate can be seen in Table 7.

Table 7. The ranking of driver of GM individually.

The ranking of driver of GM individually									The ranking of driver of GM individually
Environmental			Social			Economic			
Driver of GM	CC_i	*Ranking*	Driver of GM	CC_i	*Ranking*		CC_i	*Ranking*	
Commitment of top management	0.6987	1	Commitment of top management	0.6410	1	Commitment of top management	0.6199	1	1 (0.6522)
Public image	0.6400	2	Resource of organization	0.6410	1	Technology	0.6199	1	4 (0.6057)
Technology	0.6400	2	Public image	0.6062	3	Resource of organization	0.5848	3	3 (0.6216)
Resource of organization	0.6400	2	Environmental conservation	0.6062	3	Incentives	0.5848	3	2 (0.6217)
Public pressure	0.6265	5	Technology	0.6062	3	*Public Image*	0.5722	5	9 (0.5496)
Demand of customers	0.6265	5	Incentives	0.6062	3	Environmental conservation	0.5590	6	7 (0.5766)
Environmental conservation	0.6265	5	Future regulation	0.5938	7	Future regulation	0.5134	7	6 (0.5969)
Incentives	0.6265	5	Demand of customers	0.5938	7	Competitiveness	0.5134	7	5 (0.5969)
Future regulation	0.5723	9	Public pressure	0.5453	9	Demand of customers	0.5134	7	8 (0.5596)
Current regulation	0.5414	10	Competitiveness	0.5453	9	Public pressure	0.4850	10	11 (0.5059)
Competitiveness	0.5414	10	Current regulation	0.5305	11	Current regulation	0.4423	11	10 (0.5332)
Peer pressure	0.4054	12	Peer pressure	0.4275	12	Cost savings	0.4132	12	13 (0.3809)
Cost savings	0.4054	12	Cost savings	0.4275	12	Supply chain pressure	0.3995	13	12 (0.4154)
Supply chain pressure	0.3262	14	Supply chain pressure	0.4110	14	Peer pressure	0.3057	14	14 (0.3806)

Different with the result of the study conducted by Mittal and Sangwan [8], in this study, the results of the ranking of GM drivers using inputs from nine respondents indicated that commitment of top management is the top-ranked driver for each criterion individually (environmental, social, economic) and also for aggregate criteria. In the result of the study conducted by Mittal and Sangwan [8], the commitment of top management did not appear as the top-ranked drivers for each criterion and also for aggregate criteria. The result of this study indicated that top management has an important capability to influence, support and champion the actual formulation and deployment of environmental initiatives across the organization [20]. For any strategic program, the top management should derive much of support for its success [21, 22].

The study proposes a recommendation to increase the implementation of GM practices based on top-ranked drivers. The government's efforts need to be directed for improving the commitment from top management through socialization and training about the GM practices to all owners of SMEs. The material of socialization and training will consist of the explanation about the importance of implementation of GM practices and its benefits, the current regulation related with GM practices, and various methods and technologies associated with GM practices. In addition to socialization and training, the government must have an evaluation process to determine the success of the socialization and training programs that have been carried out. The government should have a program to monitor the level of progress of the implementation of GM practices by the SMEs whose owners have received training. Moreover, since organization resource and technology also the important drivers of GM practices, the government should facilitate the SMEs to have enough resource and technology needed for implementing GM practices. Although incentives only appear as the top four drivers on economic criteria, the government can offer incentives to the SMEs to encourage them to conduct GM practices in forms of environmental performance awards, tax rebates, etc.

4. Conclusion

To successfully apply GM practices to SMEs of smoked fish, we need to investigate the GM drivers and their prioritization based on triple bottom line dimensions namely environmental, social and economic. Based on the results of literature review, this study puts forward 14 important drivers for implementing GM practices, namely commitment of top management, current regulation, future regulation, public pressure, peer pressure, supply chain pressure, public image, competitiveness, demand of customers, resource of organization, environmental conservation, technology, cost savings, and incentives. Based on the results of this study, the “commitment of top management” was found to be the most significant driver for the successful implementation of GM practices. This primarily happens because the performance of most SMEs in Indonesia is very dependent on the vision and mission of their leader.

Not different from the other study. This study had some limitations. The study does not include all the SMEs of smoked fish as the object of research. This study only focuses on SMEs located in one industrial center of smoked fish. To overcome this limitation, this study can be expanded by taking data from the same industry in other regions or from different industries, since the result of prioritization of driver of GM practices may be different for another region and another industry. Furthermore, this study only identified and ranked the driving factors of GM practices, leaving the question of how various drivers drive the implementation of GM practices unanswered. In addition, since GM practice is a systematic project including disposal, reduction, recycling, design and many other processes for the environment, further study is needed to analyze each driver of GM practices and its impact on the enterprise's performance.

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