SUSTAINABLE STRATEGIES SELECTION IN SMEs USING MCDM APPROACH

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ABSTRACT

Since the nineties, companies have started to recognize the relevance of integrating sustainability in their corporate strategies. However, despite this increasing awareness, integrating sustainability in corporate strategy remains a challenge for many organisations due to the need of dealing with a wide range of issues. This research discusses more about the sustainable strategies selection in a SME and develops a model based on integrated multicriteria decision making (MCDM) methods to solve such problems. The developed model applies Entropy weighting method and Vikor algorithm to effectively analyze the weight of each sustainability criteria and to select the best sustainable strategies while capturing all subjective and objective criteria. A case study is illustrated to test the proposed model in a Batik SME. Results show that profits and facility requirements are the two most important criteria in sustainable strategies selection. This implies that during sustainable strategies selection, it is suggested that emphasis should be placed on revenue generation and facilities needed of the respective strategies.

Keywords: sustainable, strategies selection, MCDM, entropy, vikor

INTRODUCTION

Recently, the conservation of environmental quality has become essential since the scarcity of natural resources and increasing population. In many aspects, environmental problems have affected regional and global cooperation and have even prompted conflicts (Zhao and Guo, 2014). Environmental deterioration and global warming have prompted public concern over sustainability and environmental issues. Such legislation forces manufacturers to decrease pollution during the whole production process. Hence, the practice of green activities has become mandatory to balance these conflicts; even manufacturing processes cannot make an exception. Green issues have gained more importance in contemporary globalization.

External pressure regarding the environmental issues encourages industrial creativity using cleaner technology of greener production process. Regarding with environmental issues that call for more stringent environmental regulations, there are future trends that yield a new impact on the future prosperity of business firms since they have to cover the extra cost for green materials and new designs or new processes. In practice, an environmental management system is seen as a tool to provide a framework for assessing environmental impacts and then to help management to form firm-level environmental strategies.

It is essential for firms to have a clearly identified their strategy to adapt with green policy which should describe the objectives and targets. Before planning and doing any stages, top management needs to refine and review the environmental objectives and policies of green policy to assure effective planning and implementation. More and more countries have regulated public procurements in favor of green products by granting some premiums. Taiwan set up a "governmental procurement law" for public enterprises or administrative offices in 1998. This law allows the purchaser, to buy green products at 10% higher prices than normal products with the same specifications. In the UK, some legal regulations have been imposed on potential pollution from industrial activities. Furthermore, Japan has set up time schedule for guiding the firms to engage in green purchasing.

Many manufacturers have adjusted their manufacturing philosophies and introduced environmental programs into their organizations. Some firms proactively recognize the urgency of environmental protection and have integrated environmental goals into their corporate strategies. Those firms with relatively limited resources must outsource some business functions or operations, or purchase raw materials or components/ sub-components from other suppliers to establish an interrelated supply-chain network. To advance their environmental performance, they must monitor their own operations and coordinate with other partners in their supply networks, including material suppliers, manufacturers, distributors, users, and so on. Supply-chain managers consider both traditional performance criteria and environmental criteria (Deshmukh and Vasudevan, 2014).

Poole and Simon (1997) suggested life-cycle analysis as a method of examining the overall environmental impact of a product. Kurk and Eagan (2008) also extracted environmental attributes from each phase of a product's lifecycle, including raw-material extraction, product manufacturing, packaging and transport, use and service, and final disposal. Most studies emphasize reduction, re-manufacturing, recycling product design, process design, manufacturing practices, procurement, and some mixture of items across managerial levels. Integrating environmental concepts into these business functions ameliorates environmental pollution. Effectively achieving corporate green goals means linking an environmental corporate strategy with every business functional strategy, thus eliminating obstacles to environmental integration.

Sustainable development ties together concern for the carrying capacity of natural systems with the social, political, and economic challenges faced by humanity.

Furthermore, the implementation of sustainable management system has emerged as an important research topic in recent years. An entrepreneurial activity, can be labelled as sustainable if satisfy the three aspects, People, Planet and Profit (Isaksson et. al, 2015).

There are many research on sustainable strategies implementation on larger companies (Elkington, 1994; Harms, et al, 2013; Egels-Zanden and Rosen, 2015). However, the studies of sustainable strategies implementation on SME's are somewhat limited, especially in Indonesia. The number of SME in Indonesia growth rapidly year by year. SMEs are found to have been weathering the crisis better than larger companies, though many have been hit hard too (Berry, et al, 2001). SMEs have historically been the main player in domestic economic . Therefore, the studies of sustainable strategies on SME's are something urgent.

Take for example the SME's of batik producers that have long been existed. This research explores Batik SME in Sidoarjo, East Java – Indonesia. In Batik production process, craftsmen may use synthetic or natural dyes. Synthetic dyes material is relatively easier found in the market and much cheaper compared to natural dyes material. Furthermore, using synthetic dyes makes the coloring process faster than using natural dyes. However, the synthetic dyes, such as napthol, indigosol, etc., are not environmentally friendly. If such synthetic wastes flow into the ground, those would damage the soil ecosystem because the soil bacteria are not able to degrade the chemicals.

Some SMEs with awareness about green issues and sustainability investigate the use of natural dyes and other technology which is considered more eco-friendly. On the other hand, they have a shortage of resources to implement the sustainable strategies into their production process. Therefore, the SME's should select the best sustainable strategies which is very compatible to be adopted to their business.

METHODOLOGY

Many SMEs face challenges to implement the sustainable policy into their organization. Most SMEs have shortage of resources, include money, manpower, and time as well (Fernández-Ortiz, R., et al., 2015). Studies have identified three key barriers to SME adoption of environmental practices. The first barrier is SMEs' perception that they have little individual impact on the environment (Sanchez-Medina et. al., 2014; Wilson et. al., 2012; Williams S., and Schaefer A., 2013). The second barrier is the lack of expertise and understanding of strategies to address environmental issues (Govindan K. et al., 2014; Arena M., 2012; Mathiyazhagan, K., 2013). And finally, cost is a major barrier to more proactive environmental behavior in SMEs, in which the managers perceive that there is only little financial benefit from environmental investments (Brophy, M., 2014).

Obviously, changes in the use of dyes in Batik can not simply be implemented. Many factors must be taken into consideration, such as the sustainability strategy, business strategy, technology used, and also social factors. Decision-makers should appropriately modify the contents and aims of environmental practices to match changes in business development. Many companies have just begun exploring environmental concerns and implemented environmentally-friendly activities, so they have not yet identified many environmentally-related factors. Therefore, rethinking the relationships between each factor of environmental practices is necessary. This research uses hybrid MCDM aproach in this study to select the best sustainability strategy for a SME's as a guideline to aid company decisions.

Multi-Attribute Decision Making is the most well known branch of decision making. It is a branch of a general class of Operations Research (or OR) models which deal with decision problems under the presence of a number of decision criteria. This super class of models is very often called multi-criteria decision making (or MCDM) (Triantaphyllou, et.al, 1998). An MCDM methods as a compromise solution for a problem with conflicting criteria can help the decision makers to reach a final decision.

In MCDM context, the alternative selection is obtained using the evaluation of the alternatives where each alternative is described by its performance on each of a number of criteria. The Multi-criteria Decision Making aims to provide support to the decision maker in the process of making the choice among the available alternatives. Moreover, the MCDM method may include the generation of a proposed "compromise" solution and/or some form of preference ranking.

The SME sustainable strategies selection is modelled in accordance with the criteria set by the company. Multi Criteria Decision Making (MCDM) is used in this research to solve the problem. Among numerous methods of MCDM, outranking methods have a rapid progress because of their flexibility to the most real decision situations. In addition, outranking methods using Vikor algorithm which was proposed by Opricovic (1998) is applied. The proposed research methodology consists of several steps and it is shown as in Figure 1.

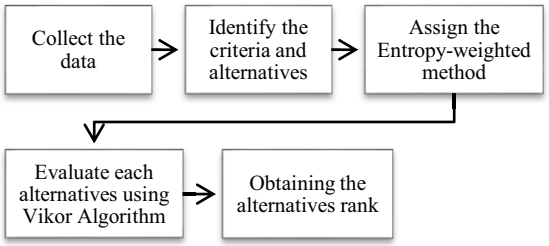

Figure-1. Proposed Research Methodology in Sustainable Strategies Selection

The first step in the proposed research methodology is collecting the data, then identifying the criteria and alternatives. Afterwards, assigning the Entropy-weighted method is needed to each criterion before applying the Vikor algorithm to evaluate each alternative. The weighting data used on this study is obtained from the decision maker score for each alternative. Finally, the last step is obtaining the alternatives of sustainable strategy's rank.

Entropy-weighted method

Entropy was originally a thermodynamic concept. Shannon (2001) is first introduced the entropy application into information theory. Since then, it has been widely

used in the engineering, socioeconomic and other fields. This research utilized entropy method to obtain W_j, weight for each criterion (C_j). There are three steps to acquire the weight using entropy-based weighting method.

First of all is normalizing the value of each criterion using Eqn. (1) with r_{ij} is the normalized value of each x_{ij}

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (1)$$

Then, calculate entropy values of each criterion using Eqn. (2).

$$e_j = -K \sum_{i=1}^{m} r_{ij} * \log\ r_{ij} \quad (2)$$

where

- e_j indicate entropi value of C_j
- $K = \frac{1}{\log m}$ is a constant value to make the entropi (e_j) value remains between $0 \leq e_j \leq 1$

And, the last step is calculating W_j, a weight of C_j criteria using Eqn. (3).

$$W_j = \frac{1-e_j}{\sum_{i=1}^{n}(1-e_j)} \quad (3)$$

The obtained W_j reveals the weight of each C_j criteria. Afterwards, the weight of each criteria is used to calculate the ranking method.

Vikor algorithm method

After performing Entropy weighting method, the next step is to apply Vikor algorithm method to get the rank of sustainable strategies option. Regarding on Opricovic (1998), Vikor algorithm is one of multi-criteria decision methods based on ideal point method to solve a complex system. The basic view of VIKOR is determining positive-ideal solution and negative-ideal solution. The positive-ideal solution is the best value of alternative for each criterion, while the negative-ideal solution is the worst value of alternative for each criterion. Below are the calculation steps of Vikor algorithm.

First, normalize the dimension of each criterion's value. The normalization for benefit-type criteria used Eqn. (4), while for the cost-type criteria used Eqn. (5).

$$v_{ij} = \frac{x_{ij}}{\max_i(x_{ij})} \quad (4)$$

$$v_{ij} = \frac{\min_i(x_{ij})}{x_{ij}} \quad (5)$$

Second, calculate each criteria's positive-ideal solution value f_1^* and negative-ideal solution's value f_1^-, $i = 1,2, \dots, n$ using Eqn. (6) and Eqn. (7), respectively.

$$f_i^* = \max_j f_{ij} \quad (6)$$

$$f_i^- = \min_j f_{ij} \quad (7)$$

Third, Obtain the optimal solution (S_i) and the most inferior solution(R_i), $i = 1,2, \dots, n$ using Eqn. (8) and Eqn. (9). At this point, each criteria's weight (w_i) will be used to determine entropy-weighting method as explained in the previous subsection.

$$S_i = \sum_i^n \frac{w_i(f_i^* - f_{ij})}{(f_i^* - f_i^-)} \quad (8)$$

$$R_i = max\left[w_i(f_i^* - f_{ij})/(f_i^* - f_i^-)\right] \quad (9)$$

Fourth, Obtain the value of interest ratio (Q_j) using Eqn. (10).

$$Q_j = \frac{v(S_i - S^*)}{(S^- - S^*)} + \frac{(1-v)\,(R_j - R^*)}{(R^- - R^*)} \quad (10)$$

where

- $S^* = \min_i S_j$
- $S^- = \max_i S_j$,
- $R^* = \min_i R_j$,
- $R^- = \max_i R_j$,

v is introduced as a weight for the strategy of maximum group utility, whereas 1 - v is the weight of the individual regret.

Fifth, rank the alternatives sorting by values S, R and Q in an ascending order. The minimum value is the best rank regarding the value S, R, and Q.

Sixth, check whether these two conditions are satisfied:

C1: Acceptable Advantage

$$Q\left(a^{(2)}\right) - Q\left(a^{(1)}\right) \geq 1/(m-1) \quad (11)$$

Where

- $a^{(1)}$ is the alternative with best rank regarding the minimum value of Q.
- $a^{(2)}$ is the alternative with second position in the ranking list by Q.
- m is the number of alternatives

C2: ***Acceptable acceptable stability in decision-making process***

C2 is the condition where $a^{(1)}$ is also the best rank alternative regarding the value of S or and R. This compromise solution is stable in decision-making process, it may differ as varies:

- when $v > 0.5$, decision-making will be according to majority criteria;
- when $v \approx 0.5$, the selection will consider to overall and individual's evaluation;
- when $v < 0.5$, veto the schemes set.

If one of the above two conditions is not satisfied, then the compromise solution should be obtained, including:

a. If the condition $C2$ is not met, then $a^{(1)}$ and $a^{(2)}$ schemes are both compromise solution.
b. If the condition $C1$ is not met, then the schemes is used: $a^{(1)}, a^{(2)}, \ldots, a^{(r)}$, where $a^{(r)}$ is determined by the relation $Q(a^{(r)}) - Q(a^{(1)}) \geq 1 / (m-1)$ with maximum value.

RESULTS

In this section this study proposes a numerical example to illustrate an application of the proposed method in the previous section. The case study has been conducted in a middle-sized SME of Batik located in Sidoarjo, Indonesia. The SME is in the process of implementing certain sustainable concept to increase awareness and concern over the environmental impact and economic growth of business and trade. This research is then proposed to select the best sustainable strategy. The inputs have been gathered from the decision maker, who is responsible for implementing sustainable strategy in the SME's organisation.

The SME in this case study is still looking at sustainability in terms of cost efficiency rather than as something that can add value to their company. Furthermore, material properties and selection are very important in sustainable manufacturing. Sustainability can also be achieved, if the designers include sustainable development aspects into their design (Kerr, I. R., 2006; Maxwell, D., and Van der Vorst, R., 2003). Innovations are obtained by new production methodologies, so the choice of technology is very important, not only for technical reasons, but also because of the influence of economical, ecological and social factors. Therefore in this case study sustainability orientations are taken as green design, green manufacturing, green purchasing and green methodology, which are designated as (S_1, S_2, S_3, S_4).

There are four sustainable strategies orientation (S_1, S_2, S_3, S_4) selected against five criteria. The evaluation criteria are: facility requirement (C_1), clean technology (C_2), workforce engagement (C_3), profits (C_4) and environmental degradation (C_5). The description and orientation of each criterion is described in Table 1.

Table-1. Criterion with description

Evaluation Criteria	Description	Type
Facility requirement (C1)	Usage of the facilities while using the method	Percent
Adaptability (C2)	Ability to adapt efficiently and fast to changed circumstances	Percent
Workforce engagement (C3)	Measurable degree of an employee's positive or negative emotional attachment to their job	Number of hours
Profits (C4)	Profit obtained by implementing the concepts	Rupiah
Environmental degradation (C5)	The reduction of the capacity of the environment to meet social and ecological objectives, and needs	Percent

After identifying criterion, the decision maker is invited to rate the strategies according to the evaluation criteria. The criteria's values are shown in Table 2.

Table-2. The criteria's values of each alternative

Evaluation Criteria	Type	Sustainable strategy orientation			
		S1	S2	S3	S4
Facility requirement (C1)	Cost	75	65	70	60
Adaptability (C2)	Benefit	70	85	70	80
Workforce engagement (C3)	Benefit	60	75	75	80
Profits (C4)	Benefit	60	80	75	80
Environmental degradation (C5)	Cost	70	65	70	50

The next step, the entropy-weighted method is applied using Eqn. (1), Eqn. (2) and Eqn. (3). As the result, the weight of each criteria, $w_i = (0.382, 0.031, 0.119, 0.376, 0.041)$. Before applying the weight into Vikor algorithm, the normalization process should be done to normalize each criterion's value using Eqn. (4) for benefit-type criteria and Eqn. (5) for cost-type criteria. The transformation result is shown in Table 3.

Table-3. The transformated criteria's value

Evaluation Criteria	Sustainable strategy orientation			
	S1	S2	S3	S4
Facility requirement (C1)	0,800	0,923	0,857	1,000
Adaptability (C2)	0,824	1,000	0,824	0,941
Workforce engagement (C3)	0,750	0,938	0,938	1,000
Profits (C4)	0,750	1,000	0,938	1,000
Environmental degradation (C5)	0,714	0,769	0,714	1,000

At this point, the positive-ideal solution (f_i^*) and the negative-ideal solution (f_i^-) are obtained, which is presented in Table 4.

Table-4. The f_i^* and f_i^- value

	The positive-ideal solution (f_i^*)	The negative-ideal solution (f_i^-)
C1	1,0000	0,8000
C2	1,0000	0,8235
C3	1,0000	0,7500
C4	1,0000	0,7500
C5	1,0000	0,7143

Calculate each strategy's S, R, Q value according to Eqn. (8), Eqn. (9) and Eqn. (10). In this calculation process, the weight of the decision-making strategy is set as "consensus" ($v = 0.5$). The result is presented in Table 5.

Table-5. S, R, Q values of each strategy orientation

	Sustainable strategy orientation			
	S1	**S2**	**S3**	**S4**
S	1,000	0,379	0,682	0,042
R	0,302	0,244	0,302	0,042
Q	1,000	0,564	0,834	0,000

Rank the S, R, Q value of each strategy orientation in ascending order. The result is shown in Table 6.

Table-6. Rank of S, R, Q value of each strategy orientation

	Sustainable strategy orientation			
	S1	**S2**	**S3**	**S4**
S	4	2	3	1
R	4	2	3	1
Q	4	2	3	1

DISCUSSION

After obtaining the value of S, R, and Q, the next procedure is to check whether this scheme meet the condition of C1. Regarding rank list in Q value, it is found that $a^{(1)}$ is S4 and $a^{(2)}$ is S2. Therefore, according Eqn. (11), it is obtained that:

$$Q(S_2) - Q(S_4) \geq 1/(4-1)$$
$$0.564 - 0 \geq 1/3 \quad \text{(satisfy)}$$

Subsequently, the next step is to check whether this scheme met the condition of C2 using the Eqn. (11) applied to S and R list. To satisfy the C2, then $a^{(1)}$ should also the best rank alternative in S or / and R list.

$$S(S_2) - S(S_4) \geq 1/(4-1)$$
$$0.379 - 0.042 \geq 1/3$$
$$0.337 \geq 0.333 \quad \text{(satisfy)}$$

$$R(S_2) - R(S_4) \geq 1/(4-1)$$
$$0.244 - 0.042 \geq 1/3$$
$$0.202 \geq 0.333 \quad \text{(does not satisfy)}$$

From the computation above, it is found that S4 is the optimal solution which met the condition of C1 and C2. Therefore, the final ranking result using entropy-weighting method and Vikor algorithm is S4 > S2 > S3 > S1.

CONCLUSION

The implementation of green concept in the manufacturing field has been the theme of intense research in recent years. This study utilizes hybrid MCDM to find the best sustainable strategy orientation. It is essential to the required information for the analysis from the case organisation, and detailed procedure of analysis has been carried out. This analysis is carried out using four evaluation criteria. From the discussion, it is concluded that the production methodology is the best strategy orientation to improve the sustainability in the case organisation under the given evaluation criteria. This result implies that there should be a change of production methodology, such as designing the workplaces and production procedure which is continuously reduced or eliminated physical, chemical, biological, and technologies that present hazards to human health or the environment.

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