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USING THE SUSTAINABILITY-BALANCED SCORECARD FOR ASSESSING SUSTAINABILITY ISSUES OF THE GREEN ENERGY COMPANIES

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Abstract. Assessing the sustainability issues of the green energy companies is a multiple criterion decision that includes both quantitative and qualitative elements. The sustainability-balanced scorecard (SBSC) for sustainability evaluation is more difficult than an internal evaluation and it requires more serious investigation in the green energy companies. This paper objectives to mix this sustainability evaluation and use fuzzy information with the SBSC. The study presents a fuzzy DEMATEL (decision-making trial and evaluation laboratory) method to develop an assessment model that integrates triangular fuzzy numbers, and DEMATEL to develop a fuzzy assessment, which prioritizes the relative influence of SBSC for green energy companies' elements. First, this paper conducts a literature review on SBSC regarding sustainability issues to generate 15 elements with five aspects, which are used to measure the sustainability assessment. Next, fuzzy DEMATEL is employed to manage the uncertain linguistic terms, then to set up an influential network relationship map (INRM). This suggested model provides a structure for the related green energy companies to select the evaluation method and could arrange the sustainability approach according to future competitive pressure. The result shows that environmental aspect is the most direct effect and social aspect is the most important effect aspect to the other aspects.

Keywords: sustainability, sustainability-balanced scorecard (SBSC), green energy companies, influential network relationship map.

JEL Classification: C02, C60, D22, D81, O21, Q40.

Introduction

Within the past decade, numerous energy companies have been paying more attention to environmental issues because of deteriorating environmental pollution. In the meantime, increasing the demands of customer for eco-friendly products demonstrates the positive

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attitude to green energy products or brands (Guo et al., 2017). In recent years, owing to environmental pollution issues, the renewable electricity in Taiwan was getting more and more. Taiwan to boost renewable energy to 20% by 2025. While Taiwan is still far from a sustainable electricity supply, relying heavily on nuclear (12.7%), natural-gas (21.4%) and coal (43.3%) (Chung, 2021), so far, Taiwan has developing in growing novel capacity, particularly in the wind power sector. The total capacity of wind energy in Taiwan amounted to approximately 854 megawatts in 2020, an increase from around 845 megawatts in the previous year. However, the sustainability for the green energy is a critical issue.

Assessment of the green energy companies are also a complicated issue and there are various ways to approach the sustainability problem in the green energy companies. As the market has developed, it has reformed its sustainability policies, and its sustainability assessment has transformed the rapid enlargement of the green energy industry (Prashar, 2019). The international competition in green services has become more intense, and numerous countries have enthusiastically invested in efforts to maintain their competitiveness in the green energy companies. In order to adjust to the global competition, the managers of firms must enhance the value of its green energy companies. Sustainability assessment and administration have become the focus in the recent decade, and examples include the overview of methods, for example, the sustainability-balanced scorecard (SBSC), to enhance these competitiveness of business (Lu et al., 2018; Tsai et al., 2020; Chang et al., 2021b). The green energy companies should learn from other business in these regards. There is a requirement to have a series of sustainability management tools to build green standards and objectives, and to increase the competitiveness of green energy companies in globalized surroundings (Lu et al., 2020). These are the pressing imperatives for green energy companies, especially in Taiwan.

There have few studies to the enhancement of the SBSC in assessment of the green energy companies' activities. However, involving the subjects of SBSC to estimate sustainability in green energy companies have not been addressed via previous investigations. The SBSC context is useful to determine the initial estimation elements for the green energy industries' sustainability in the research. This includes many aspects, such as "social", "growth and learning", "environmental", "internal process", and financial", aspects. Therefore, the initial elements followed the SBSC is able to largely plan and enhance the green energy companies' sustainability performances.

Furthermore, this integrated multiple criteria decision-making (MCDM) method is this approach used to consider assessment elements over a set of detailed inspections with governable observation views. The integrated technique is able to conquer questions of ambiguity this issue of symmetry, and ambiguity in professionals' yield and replies the most consistent agreement comments regarding the assessment elements (Chang et al., 2021a). Obviously, the execution of sustainability assessments for green energy companies consist of various factors, thus implying an issue of MCDM. Lately, numerous studies have been presented to solve these issues of many industries, for example, balanced scorecard method, lean energy-saving and emission-reduction (LESER), DEA (data envelopment analysis), DANP (DEMATEL-based ANP), and KPI (key performance indicator) (Dinçer et al., 2017; Cai et al., 2019; Olfat et al., 2016; Gupta et al., 2016; Rezaei et al., 2017; Wang et al., 2020; Pandey, 2016).

Hence, this paper aims at understanding the drivers and dynamics behind this assessment for sustainability, according to the concepts of the SBSC, and uses fuzzy mathematics, the concept of symmetry, and fuzzy DEMATEL, which is a verified method for collecting the opinions of specialists and determining reliable outcomes. And, this study applied the integrated fuzzy theory and DEMATEL method to study the feedback and interdependent issues among various aspects/elements of sustainability, and to propose the best improvement strategies for administrators to attain value in the green energy companies. Applying the fuzzy DEMATEL method can measure the approaches of sustainability, which is more reliable than measuring according to perception. When specialists fill out questionnaires, their preferences and opinions are difficult to quantify; hence, this study used fuzzy set theory to settle actual life fuzzy issues, and quantified human language based on these triangular fuzzy numbers, which is able to efficiently handle the fuzziness of expressing/thinking the preferences of decision makers (Zadeh, 1965). Next, the DEMATEL of fuzzy method is practical to create a fuzzy influence network relations map (FINRM) that is used to explain the elements of network influence related to sustainability (Lu et al., 2018, 2020).

These contributions of the research are threefold, as follows. Primary, fewer significant aspects are positively measured in a sustainability assessment with the SBSC framework in the green energy companies. Second, the sustainability approach with SBSC is applied to assess the significance values, which are transformed into the final priority according to the influence network. Third, the mixture method is formulated to determine the relationships of interdependence, and yield a hierarchic structure according to the aspects and elements of SBSC. Moreover, this pattern could be used in numerous areas of life with different results, and the conclusions could assistance in developing actual SBSC events tailored to objective issues. Another option to extend the proposed method would be to standardize pairs or groups of SBSC options to build patterns that are more advantageous, and such an approach can enhance growth.

The remainder of this study is organized as next: we identify the sustainability aspects/elements in Section 1, and describe the detailed methodologies, including the fuzzy theory; Fuzzy DEMATEL are applied in Section 2; it illustrates a case study in Section 3; conclusions are presented in the last Section.

1. Literature review

Sustainability assessments are applied to analytically evaluate the actions of the green energy companies, and are intended to attain a certain objective. As sustainability assessments are developed as part of the management and control system of the green companies, they could efficiently estimate the sustainability performances and practices of capital connected to their intention (Lu et al., 2020). The BSC (balanced scorecard), which is intended to improve the commercial performance assessment structure, was initially presented by Kaplan and Norton (2005). The approach was presented due to the weaknesses of the traditional performance assessment, which over emphasized the existing structure parameters of finance, while other viewpoints were ignored, and neither are holistic or valid for comprehensive assessment procedures (Lu et al., 2018).

The issues of sustainability include all economic, environmental, and social aspects. Numerous researchers discuss the difficulty in aligning problems of sustainability through financial performances (Hansen & Schaltegger, 2016; Hristov et al., 2019) and the lacking consideration for the nonfinancial and leading factors (Hristov et al., 2019; Duman et al., 2018). In addition, the insufficiency of combination between firm strategy and sustainability challenges does not agree sufficient attention of the fields in the firm's objectives. The enormous diversity and variety of social dimensions and this deficiency of a general foundation, it is very hard to reach a complete arrangement of social dimensions. For adapting the BSC by value conception of sustainability, it needs to classify ways to manage and overcome the serious dimensions. Hence, in the SBSC, the configuration of sustainability subjects through the performances of finance is merely involved. This SBSC could be a valuable method for the adoption of corporate plans where industries search to leverage and identify the potential of social and environmental administration that pays off finance (Gao & Bansal, 2013; Lu et al., 2018). Furthermore, SBSC does not deem the challenges of sustainability which don't meet by a corporations' strategic, the acuteness of these sustainability challenges or irrespective of ethical thoughts. The monitoring, choice, and usage of the qualitative/quantitative factors on the SBSC aspects are not premeditated effectively to mix the challenges of sustainability into the firm plan.

Therefore, some authors which using the SBSC were determined to solve the shortcomings of the original BSC, as it incorporates sustainability, social, and environmental frameworks, which is imitative since this traditional BSC (Tsai et al., 2020). As an approach to assess and judge the performance of business, the BSC method draws up a hierarchic structure of strategic objectives according to four key aspects: internal process, financial, growth and learning, and customers. While the holistic evaluation model mixes intangible and physical resources to build a relationship among dissimilar elements, sustainability, environmental, and social aspects tend to be neglected. Therefore, the SBSC approach is proposed to evaluate the strategy of the green energy companies after integrating the parameters associated with sustainability. In addition, SBSC can discover the strategic environment and social objects of an enterprise and enhance the value and performance through social and environmental viewpoints (Lu et al., 2018). Some studies have proposed SBSC as a method to improve the strategies of managerial and corporate responsibility (Tsalis et al., 2013; Tsai et al., 2020). Others had applied this SBSC framework to determine useful strategy which integrate economic, social, and environmental viewpoints into an amalgamated architecture for assessment of sustainable development (Lu et al., 2020).

Due to the sustainable development and competitiveness of the green energy companies, it is suitable to apply the SBSC to inspect performance according to sustainability perspectives. By integrating the theory of sustainability, the primary elements for the SBSC performance assessment of the green energy companies involve social, growth and learning, environmental issues, internal processes, and financial aspects. This study conducted literature review and interviews with specialists to determine the elements of sustainability to apply in the assessment process, and 15 elements affecting sustainability were determined, which are assembled into 5 SBSC aspects: social, growth and learning, environmental, internal business processes, and financial (see Table 1). Then, this study classified the assessment elements into a hierarchical structure for the sustainability assessment via the green energy companies. Due to its inclusive technique for creating and investigating a basic pattern relating causal associations between multiple viewpoints (Liou et al., 2019; Wang et al., 2020), this research implements the fuzzy DEMATEL approach to explain the associations among the numerous evaluation aspects, and builds the connections between the elements and aspects to construct a fuzzy influence network relations map (Lu et al., 2020). This method has been effectively used in numerous studies, such as RFID adoption, business-to-business m-commerce, and electronic health record adoption (Lu et al., 2013, 2015; Liou et al., 2017).

The elements for assessing sustainability are designated according to the literature review of the sustainability balanced scorecard (Lu et al., 2018; Na et al., 2020), brain storming, expert opinions, and interviews with managers in the green energy companies, as illustrated in Table 1.

Table 1. Clarification of aspects and elements

Aspects / Elements	Descriptions
Social aspect (A_1)	
Customer relationship management (e_1)	Managing the relations with customer to enhance customer satisfaction and loyalty
Job security for employees (e_2)	Creating a friendly and safe work environment for employees
Society impact (e_3)	Reducing the degree of public health influences, and providing assistance for community development or educational institutions plans
Growth and Learning aspect (A_2)	
Enhancing the employee skills (e_4)	Employee professional ability knowledge, and skills in operating a green energy companies
Employee education (e_5)	Carry out employee education and training to improve their quality
Research & development (e_6)	A number of scientific works and patents for research & development in the green energy companies
Environmental aspect (A_3)	
Preventing and monitoring noise (e_7)	Monitoring and preventing noise in green energy companies
Carbon emission reduction and energy conservation (e_8)	Energy conservation and carbon emission reduction and with using green supply chains in the green energy companies
Environmental policy (e_9)	To strengthen natural resources and environmental protection activities, or appropriate environmental certifications
Internal process aspect (A_4)	
Improved efficiency (e_{10})	Provide products or services to customers in a timely and efficient manner in green energy companies
Employee productivity (e_{11})	Service or product produced by each employee
Risk management (e_{12})	Number of identified risks to number of managed risks
Financial aspect (A_5)	
Net profit ratio (e_{13})	Current period net profit/Revenue income
Return on investment (e_{14})	Current period net income or loss/investment amount
Transparency of finance (e_{15})	Reliable disclosures that are meaningful and timely regarding the finances and performances of green energy companies

2. Methods

To deal with uncertainty/fuzzy of human assessment, the fuzzy approach is combined by DEMATEL. 5 linguistic terms are applied to assign a number to the influence of an unambiguous element on the relevant feature, as listed in Table 2. Linguistic information is understood into a fuzzy linguistic scale. These fuzzy assessments are defuzzified and aggregated as a crisp number via using linguistic info to varied fuzzy numbers so that the crisp number might be measured (Lu et al., 2020).

Table 2. Values incorporated to the fuzzy triangle linguistic terms

Linguistic terms	Fuzzy triangle numbers	Corresponding numbers
No influence (No)	(0.00, 0.00, 0.25)	0
Very low influence (VL)	(0.00, 0.25, 0.50)	1
Low influence (L)	(0.25, 0.50, 0.75)	2
High influence (H)	(0.50, 0.75, 1.00)	3
Very high influence (VH)	(0.75, 1.00, 1.00)	4

The development of fuzzy theory is aimed at studying uncertain, incomplete, or ambiguous information, usually via applying the linguistic variables to convert the crisp values into corresponding fuzzy membership functions (e.g. triangular fuzzy numbers, which have minimum, intermediate and maximum values). Each specialist's view thus has a set of corresponding assessment fuzzy numbers (Yucesan & Gul, 2020; Lu et al., 2020). Grey theory also measures uncertainty which generates a set of interval type values, with upper and lower bounds. The grey interval describes the range covered by the expressed information (Parkouhi et al., 2019). However, the grey numbers only consider the possible upper and lower bounds of the information, unlike the fuzzy numbers, which have a "intermediate value" parameter. In addition, the rough number technique is applied to integrate the opinions of many experts. Experts evaluating an object or concept, will not usually assign it the same value. Hence, numerous researches use rough number technique to convert the judgments of a group of specialists into a set of rough numbers (with rough upper and lower bounds). The rough number is thus an aggregation of individual observations and preferences which overcomes the shortcomings of using the arithmetic mean technique in the decision-making procedure. Nevertheless, the rough number technique is not to explore the problem of information uncertainty (Qi et al., 2020; Liou et al., 2019). Therefore, in this study, we used the fuzzy theory combined the DEMATEL technique as our research's approach.

The fuzzy DEMATEL technique is recognized as an appropriate method for investigating the problems related to sustainability for the green energy companies, and can be used as an orientation method for managers to improve the sustainability of individually elements. Fuzzy DEMATEL is a systematic method that is able to resolve multifaceted problems associated the theories of mathematics and exploits a matrix to investigate the effect and cause of individual elements. Combined with the fuzzy theory, and DEMATEL, which is able to be used to explain the relationships between elements by assigning numbers to the linguistic terms of natural language (Lu et al., 2020; Hu et al., 2015). This technique is applied to create a matrix of total influence relationsships and to probe the cause and effect of the interrelations among parameters, as derived by dissimilar aspects and elements. This development in existing modeling is a shift through ranking and choice to improve sustainability according to the fuzzy INRM (Hu et al., 2015; Lu et al., 2020; Petrovic & Kankaras, 2020). The information of the fuzzy DEMATEL steps is shown, as next.

Step 1. Express direct influence matrix with fuzzy numbers.

Following these alternated fuzzy numbers of experts' perspective via linguistics from natural language, then, the direct influence of element i on element j is able to be indicated as fuzzy scores $\tilde{B}_{ij} = (w_{ij}, y_{ij}, z_{ij})$. The direct relations matrix $\tilde{\boldsymbol{B}} = [\tilde{B}_{ij}]_{n\times n} = \left[(w_{ij}, y_{ij}, z_{ij})\right]_{n\times n}$ can be obtained (Lu et al., 2020; Hu et al., 2015).

$$\tilde{\boldsymbol{B}} = \begin{pmatrix} \tilde{B}_{11} & \cdots & \tilde{B}_{1j} & \cdots & \tilde{B}_{1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{B}_{i1} & \cdots & \tilde{B}_{ij} & \cdots & \tilde{B}_{in} \\ \vdots & & \vdots & & \vdots \\ \tilde{B}_{n1} & \cdots & \tilde{B}_{nj} & \cdots & \tilde{B}_{nn} \end{pmatrix}_{m\times m} \tag{1}$$

where the fuzzy members of diagonal triangular are considered as $\tilde{B}_{11} = \ldots = \tilde{B}_{ii} = \ldots = \tilde{B}_{nn} =$ (0,0,0); $\tilde{B}_{ij} = (w_{ij}, y_{ij}, z_{ij})$ are fuzzy numbers of triangular, ($i \neq j$) and $i, j \in \{1,2,\ldots,n\}$.

Step 2. Direct influence matrix via normalizing.

As this direct influence matrix $\tilde{\boldsymbol{B}}$, the normalized matrix $\tilde{\boldsymbol{C}}$ of direct relations is acquired via using Eqs. (1)–(2).

$$\tilde{\boldsymbol{C}} = h \otimes \tilde{\boldsymbol{B}} \tag{2}$$

where $h = \min\left\{1/\max_i \sum_{j=1}^{n} r_{ij}, 1/\max_j \sum_{i=1}^{n} r_{ij}\right\}$, $i, j \in \{1,2,\ldots,n\}$.

Step 3. Measure the total influential matrix.

As this direct influence matrix $\tilde{\boldsymbol{C}}$ of normalization is attained, the matrix $\tilde{\boldsymbol{P}} = (\boldsymbol{P}^l, \boldsymbol{P}^m, \boldsymbol{P}^r)$ of FINRM can be acquired by applying Eq. (3), that indicates this identity matrix $\tilde{\boldsymbol{E}}$.

$$\tilde{\boldsymbol{P}} = \tilde{\boldsymbol{C}} + \tilde{\boldsymbol{C}}^2 + \tilde{\boldsymbol{C}}^3 + \ldots + \tilde{\boldsymbol{C}}^h = \tilde{\boldsymbol{C}}(\boldsymbol{F} + \tilde{\boldsymbol{C}} + \tilde{\boldsymbol{C}}^2 + \ldots + \tilde{\boldsymbol{C}}^{u-1})\ [(\boldsymbol{E} - \tilde{\boldsymbol{C}})(\boldsymbol{E} - \tilde{\boldsymbol{C}})^{-1}] =$$
$$\tilde{\boldsymbol{C}}(\boldsymbol{E} - \tilde{\boldsymbol{C}}^u)(\boldsymbol{E} - \tilde{\boldsymbol{C}})^{-1}.$$

Then, $\tilde{\boldsymbol{P}} = \tilde{\boldsymbol{C}}(\boldsymbol{E} - \tilde{\boldsymbol{C}})^{-1}$, when $u \to \infty$, we can guarantee $\tilde{\boldsymbol{C}}^u = [0]_{n\times n}$. (3)

where $\tilde{\boldsymbol{C}} = [\tilde{c}_{ij}]_{n\times n} = [(c_{ij}^w, c_{ij}^y, c_{ij}^z)]_{n\times n}$, $0 \le c_{ij}^w, c_{ij}^y, c_{ij}^z < 1$, $0 < \sum_{j=1}^{n} c_{ij}^z \le 1$, $0 < \sum_{i=1}^{n} c_{ij}^z \le 1$. If at smallest a column or row of summation in $\sum_{j=1}^{n} c_{ij}^z$ and $\sum_{i=1}^{n} c_{ij}^z$ is equal to 1, we are able to agreement $\lim_{u\to\infty}([c_{ij}^z]_{n\times n})^u = \lim_{u\to\infty}(\boldsymbol{C}^z)^u = [0]_{n\times n}$. Likewise, we approve that, too; $\lim_{u\to\infty}([c_{ij}^y]_{n\times n})^u = \lim_{u\to\infty}(\boldsymbol{C}^y)^u = [0]_{n\times n}$ and $\lim_{u\to\infty}([c_{ij}^w]_{n\times n})^u = \lim_{u\to\infty}(\boldsymbol{C}^w)^u = [0]_{n\times n}$. Then $\tilde{\boldsymbol{P}} = [\tilde{p}_{ij}]$ can be reached.

Step 4. Exploring the outcomes.

These sums of rows $\sum_{j=1}^{n}\tilde{p}_{ij}=\tilde{p}_{i\cdot}=\tilde{d}_i$ and columns $\sum_{i=1}^{n}\tilde{p}_{ij}=\tilde{p}_{\cdot j}=\tilde{v}_j$ are individually stated as vector $\tilde{\boldsymbol{v}}=(\tilde{\boldsymbol{v}}_1,\ldots,\tilde{\boldsymbol{v}}_j,\ldots,\tilde{\boldsymbol{v}}_n)'$ and vector $\tilde{\boldsymbol{d}}=(\tilde{\boldsymbol{d}}_1,\ldots,\tilde{\boldsymbol{d}}_i,\ldots,\tilde{\boldsymbol{d}}_n)'$ via applying Eqs (4) to Eqs (6). Let $i,j\in\{1,2,\ldots,n\}$ and $i=j$; the axis vector of horizontal $(\tilde{\boldsymbol{d}}+\tilde{\boldsymbol{v}})$ is then made through enhancing $\tilde{\boldsymbol{d}}$ to $\tilde{\boldsymbol{v}}$, that determines the significance of the element. Individually, the vertical axis vector $(\tilde{\boldsymbol{d}}-\tilde{\boldsymbol{v}})$ is created through deducting $\tilde{\boldsymbol{d}}$ from $\tilde{\boldsymbol{v}}$, that divides these elements into an effect group and a cause group. Normally, as $(\tilde{\boldsymbol{d}}-\tilde{\boldsymbol{v}})$ is positive, the element is amount of the cause group. On the contrary, as vector $(\tilde{\boldsymbol{d}}-\tilde{\boldsymbol{v}})$ is negative, this element is part of the influence cluster. Thus, the causal map is able to be understood through drafting the data of vectors $(\tilde{\boldsymbol{d}}+\tilde{\boldsymbol{v}},\ \tilde{\boldsymbol{d}}-\tilde{\boldsymbol{v}})$, which offers a valued technique for management.

$$\tilde{\boldsymbol{P}}=[\tilde{p}_{ij}]_{n\times n},\ i,j=1,2,\ldots,n; \tag{4}$$

$$\tilde{\boldsymbol{d}}=\left[\sum_{j=1}^{n}\tilde{t}_{ij}\right]_{n\times 1}=\left[\tilde{t}_{i\cdot}\right]_{n\times 1}=(\tilde{\boldsymbol{d}}_1,\ldots,\tilde{\boldsymbol{d}}_i,\ldots,\tilde{\boldsymbol{d}}_n)'; \tag{5}$$

$$\tilde{\boldsymbol{v}}=\left[\sum_{i=1}^{n}\tilde{t}_{ij}\right]'_{1\times n}=[\tilde{t}_{\cdot j}]_{n\times 1}=(\tilde{\boldsymbol{v}}_1,\ldots,\tilde{\boldsymbol{v}}_j,\ldots,\tilde{\boldsymbol{v}}_n)', \tag{6}$$

where $\tilde{\boldsymbol{d}}$ & $\tilde{\boldsymbol{v}}$ vectors individually definite the sum of the columns and rows through the matrix $\tilde{\boldsymbol{P}}=[\tilde{p}_{ij}]_{n\times n}$ of total influence, and the application of the superscript denotes transpose.

3. Empirical case analysis

The case study of this study focused on the green energy companies in Taiwan to determine this application of the proposed fuzzy DEMATEL typical by objectively assessing and selecting the best methods. This technique facilitates the efforts of managers to better deal with sustainability topics and to understand values extracted for dissimilar aspects and elements.

3.1. Data collection

These statistics were compiled via 12 experts regarding the issues of sustainability in green energy companies and per one has at least fifteen years of working experience. These background info of the specialists is showed as Table 3. This consensus of statistical significance confidence is 95.280%, which is greater than 95%, thus, this gap error is 4.720%, which is less than 5%. The observations of the specialists regarding all aspects were collected via individual interviews and a survey, which were executed in the end of 2020, and required 40–50 minutes per topic.

Table 3. These specialists' background info

Category	Number of specialists
Working Level Top managers in green energy companies Investigators in related companies	 9 3
Education Level Bachelor Master Ph.D.	 4 5 3
Working experiences Between 15 and 19 years More than 20 years	 5 7

3.2. Creating the FINRM via the fuzzy DEMATEL technique

The investigation recognized the fuzzy DEMATEL estimation structure and investigated the sustainability strategies in the green energy companies, as according to 15 elements and five aspects. The elements and aspects for the total influence matrix, as showed in Table 4 to Table 5, was acquired using expert surveys. Specialists' opinions of the five aspects were composed, and the relations between the ranges of effect were identified as related to the other aspects. It presented in Table 6. According to net influence $\tilde{\boldsymbol{d}} - \tilde{\boldsymbol{v}}$, the environmental aspect (A_3) is the most direct effect the other aspects, and financial aspect (A_5) is the most vulnerable to influence. And the total influence prominence $\tilde{\boldsymbol{d}} + \tilde{\boldsymbol{v}}$, the financial aspect ($A_5$) has the smallest effect; by contrast, the social aspect (A_1) has the most important influence on the strength of the relations.

Table 7 lists the relationships among the degree of the indirect or direct assessments, as well as the influences relative to other factors. Employee education (e_5) is the most important element for management consideration; transparency of finance (e_{15}) has the smallest influence on the other elements. Table 7 also displays which environmental policy (e_9) has the strongest influence on other elements, and the transparency of finance (e_{15}) is the most influenced by other elements.

Table 4. The sum of effects on aspects with fuzzy number and defuzzication

Aspects	(A_1)	(A_2)	(A_3)	(A_4)	(A_5)
Social aspect (A_1)	0.29 (0.15, 0.22, 0.49)	0.30 (0.17, 0.24, 0.51)	0.29 (0.16, 0.23, 0.49)	0.29 (0.16, 0.23, 0.49)	0.32 (0.19, 0.26, 0.52)
Growth and Learning aspect (A_2)	0.30 (0.16, 0.24, 0.50)	0.28 (0.15, 0.22, 0.47)	0.28 (0.15, 0.22, 0.50)	0.29 (0.16, 0.23, 0.48)	0.32 (0.19, 0.26, 0.51)
Environmental aspect (A_3)	0.32 (0.18, 0.25, 0.52)	0.31 (0.18, 0.25, 0.51)	0.28 (0.15, 0.22, 0.52)	0.30 (0.18, 0.24, 0.49)	0.33 (0.20, 0.27, 0.53)
Internal process aspect (A_4)	0.31 (0.17, 0.24, 0.50)	0.30 (0.17, 0.24, 0.50)	0.29 (0.16, 0.23, 0.50)	0.27 (0.15, 0.21, 0.46)	0.31 (0.18, 0.25, 0.51)
Financial aspect (A_5)	0.15 (0.03, 0.10, 0.30)	0.14 (0.03, 0.09, 0.30)	0.14 (0.03, 0.09, 0.30)	0.13 (0.03, 0.08, 0.28)	0.14 (0.04, 0.10, 0.30)

Table 5. The total effect matrix for elements with defuzzication

Elements	(e_1)	(e_2)	(e_3)	(e_4)	(e_5)	(e_6)	(e_7)	(e_8)	(e_9)	(e_{10})	(e_{11})	(e_{12})	(e_{13})	(e_{14})	(e_{15})
(e_1)	0.262	0.318	0.325	0.315	0.315	0.327	0.303	0.326	0.287	0.294	0.295	0.316	0.341	0.331	0.338
(e_2)	0.316	0.247	0.313	0.303	0.305	0.318	0.284	0.314	0.285	0.294	0.292	0.307	0.328	0.324	0.331
(e_3)	0.307	0.293	0.238	0.270	0.291	0.288	0.273	0.294	0.263	0.281	0.267	0.292	0.310	0.301	0.310
(e_4)	0.322	0.317	0.320	0.254	0.317	0.327	0.314	0.317	0.283	0.302	0.311	0.327	0.343	0.333	0.340
(e_5)	0.334	0.336	0.342	0.334	0.264	0.344	0.326	0.341	0.302	0.319	0.317	0.328	0.356	0.346	0.355
(e_6)	0.245	0.236	0.248	0.237	0.238	0.200	0.228	0.238	0.213	0.223	0.224	0.252	0.268	0.261	0.251
(e_7)	0.333	0.326	0.330	0.325	0.317	0.331	0.254	0.340	0.299	0.317	0.307	0.323	0.349	0.339	0.349
(e_8)	0.316	0.303	0.308	0.304	0.300	0.306	0.298	0.250	0.261	0.292	0.289	0.304	0.324	0.315	0.321
(e_9)	0.320	0.310	0.313	0.308	0.304	0.319	0.300	0.324	0.222	0.298	0.297	0.307	0.328	0.318	0.324
(e_{10})	0.327	0.323	0.333	0.325	0.314	0.321	0.321	0.337	0.294	0.245	0.310	0.331	0.334	0.325	0.332
(e_{11})	0.320	0.312	0.326	0.318	0.308	0.329	0.303	0.318	0.276	0.293	0.236	0.320	0.336	0.326	0.339
(e_{12})	0.271	0.273	0.281	0.280	0.269	0.277	0.268	0.265	0.230	0.249	0.247	0.216	0.273	0.265	0.274
(e_{13})	0.182	0.166	0.169	0.167	0.172	0.176	0.166	0.183	0.150	0.160	0.147	0.157	0.149	0.176	0.180
(e_{14})	0.160	0.134	0.137	0.133	0.138	0.141	0.132	0.143	0.114	0.122	0.117	0.123	0.165	0.117	0.149
(e_{15})	0.128	0.115	0.120	0.107	0.115	0.124	0.119	0.126	0.099	0.104	0.106	0.108	0.140	0.115	0.102

Table 6. Total influence prominence and net influence with fuzzy number and defuzzication

Aspects	$\tilde{d}_x$	$\tilde{v}_x$	$\tilde{d}+\tilde{v}$	$\tilde{d}-\tilde{v}$
Social aspect (A_1)	1.50 (0.83, 1.17, 2.51)	1.36 (0.71, 1.06, 2.32)	2.87 (1.54, 2.23, 4.83)	0.14 (0.12, 0.12, 0.19)
Growth and Learning aspect (A_2)	1.47 (0.81, 1.16, 2.44)	1.34 (0.70, 1.03, 2.29)	2.81 (1.51, 2.19, 4.73)	0.13 (0.12, 0.13, 0.14)
Environmental aspect (A_3)	1.55 (0.89, 1.23, 2.52)	1.29 (0.65, 0.99, 2.22)	2.83 (1.54, 2.22, 4.74)	0.26 (0.24, 0.24, 0.30)
Internal process aspect (A_4)	1.49 (0.83, 1.17, 2.46)	1.29 (0.68, 0.99, 2.19)	2.77 (1.51, 2.15, 4.65)	0.20 (0.15, 0.18, 0.26)
Financial aspect (A_5)	0.69 (0.16, 0.46, 1.46)	1.43 (0.79, 1.13, 2.36)	2.12 (0.95, 1.59, 3.82)	–0.73 (–0.63, –0.67, –0.90)

Table 7. sum of effects of each element with fuzzy number

A/E	$\tilde{d}_x$	$\tilde{v}_x$	$\tilde{d}+\tilde{v}$	$\tilde{d}-\tilde{v}$
Social aspect (A_1)				
(e_1)	4.693 (2.735, 3.757, 7.586)	4.141 (2.170, 3.211, 7.042)	8.834 (4.904, 6.968, 14.629)	0.551 (0.565, 0.545, 0.544)
(e_2)	4.562 (2.512, 3.543, 7.629)	4.012 (2.075, 3.103, 6.856)	8.573 (4.588, 6.647, 14.485)	0.550 (0.437, 0.440, 0.772)
(e_3)	4.278 (2.223, 3.260, 7.352)	4.103 (2.149, 3.193, 6.966)	8.381 (4.372, 6.453, 14.317)	0.175 (0.074, 0.667, 0.386)
Growth and Learning aspect (A_2)				
(e_4)	4.725 (2.738, 3.757, 7.679)	3.979 (2.120, 3.096, 6.720)	8.704 (4.858, 6.854, 14.400)	0.746 (0.618, 0.661, 0.959)
(e_5)	4.944 (3.036, 4.036, 7.760)	3.968 (1.983, 2.986, 6.935)	8.912 (5.018, 7.022, 14.696)	0.976 (1.053, 1.050, 0.825)
(e_6)	3.560 (1.553, 2.638, 6.490)	4.125 (2.187, 3.209, 6.980)	7.686 (3.740, 5.847, 13.470)	–0.565 (–0.634, –0.571, –0.490)
Environmental aspect (A_3)				
(e_7)	4.838 (2.893, 3.901, 7.720)	3.888 (1.922, 2.974, 6.767)	8.726 (4.815, 6.875, 14.400)	0.950 (0.971, 0.927, 0.952)
(e_8)	4.493 (2.409, 3.435, 7.634)	4.114 (2.187, 3.231, 6.925)	8.607 (4.596, 6.666, 14.696)	0.378 (0.222, 0.203, 0.709)
(e_9)	4.592 (2.703, 3.710, 7.362)	3.578 (1.741, 2.700, 6.292)	8.169 (4.444, 6.410, 13.470)	1.014 (0.961, 1.010, 1.070)
Internal process aspect (A_4)				
(e_{10})	4.774 (2.869, 3.856, 7.599)	3.794 (1.942, 2.871, 6.568)	8.568 (4.811, 6.726, 14.167)	0.981 (0.927, 0.985, 1.030)
(e_{11})	4.662 (2.659, 3.688, 7.637)	3.762 (1.964, 2.890, 6.432)	8.424 (4.623, 6.578, 14.070)	0.899 (0.696, 0.797, 1.205)
(e_{12})	3.940 (1.946, 2.980, 6.893)	4.013 (2.179, 3.108, 6.752)	7.953 (4.126, 6.088, 13.645)	–0.073 (–0.233, –0.128, 0.142)
Financial aspect (A_5)				
(e_{13})	2.499 (0.695, 1.769, 5.031)	4.345 (2.415, 3.424, 7.194)	6.843 (3.111, 5.193, 12.226)	–1.846 (–1.720, –1.655, –2.163)
(e_{14})	2.023 (0.396, 1.342, 4.332)	4.194 (2.331, 3.298, 6.952)	6.217 (2.726, 4.640, 11.284)	–2.170 (–1.935, –1.956, –2.620)
(e_{15})	1.729 (0.375, 1.035, 3.778)	4.296 (2.377, 3.411, 7.099)	6.025 (2.752, 4.446, 10.876)	–2.567 (–2.002, –2.376, –3.321)

According to the offered fuzzy DEMATEL model, the research recognizes the interrelations among the various elements and aspects via using the FINRM. Figure 1 shows that environmental aspect (A_3) effects other aspects, specifically, the internal process aspect (A_4), social aspect (A_1), growth and learning aspect (A_2), and financial aspects (A_5); and environmental aspect (A_3) reveals an important representative, and has the strongest effect on the others within the SBSC framework.

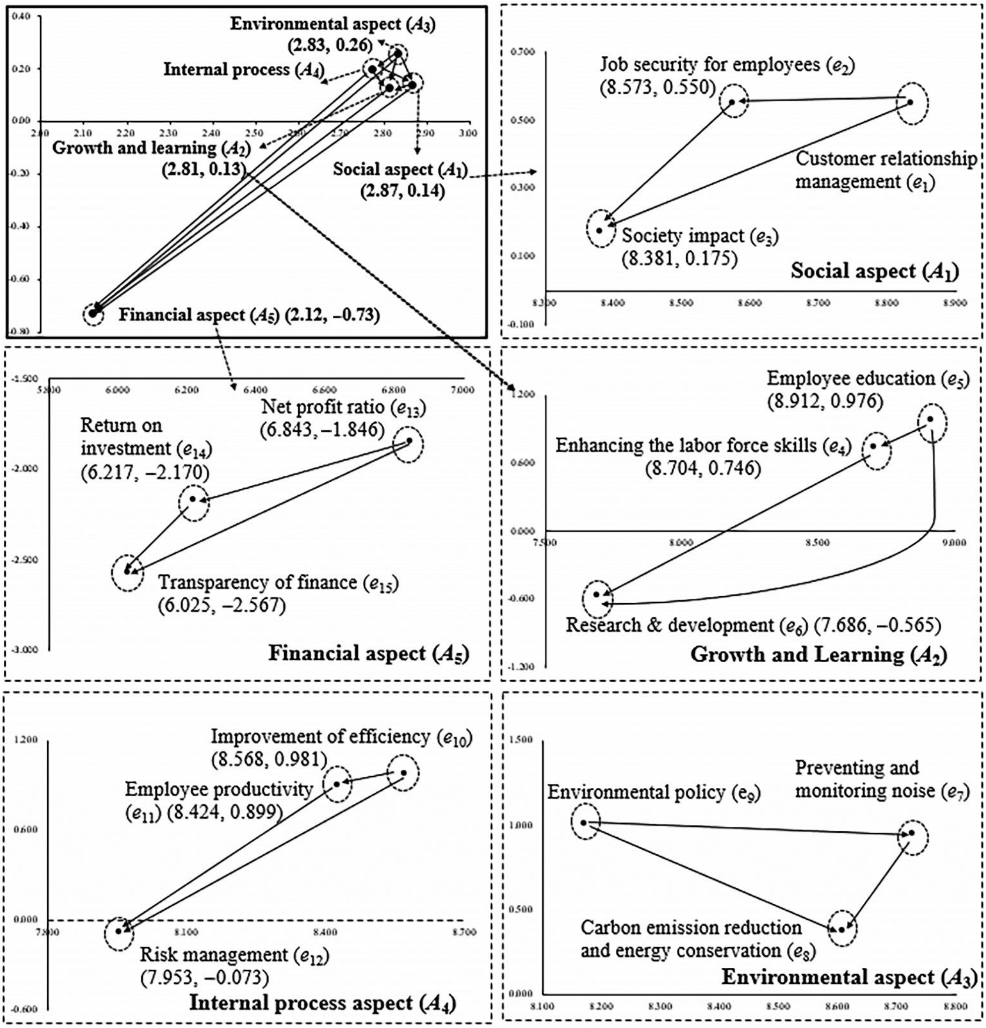

Figure 1. The fuzzy INRM per aspect and element

After exploring dissimilar aspects, this study states the elements considered by separate aspects. According to these results, Figure 1 presents the influence relationship diagram map of the elements. Hence, regarding the influence relationships among the elements: from the social aspect (A_1), customer relationship management (e_1) was the most influenced element and should be enhanced, next by job security for employees (e_2) and society impact (e_3), respectively (see causal relationship A_1 in Figure 1); regarding the growth and learning aspect (A_2) , employee education (e_5) was the most influence element, and must be improved, next by enhancing employee skills (e_4), and research and development (e_6), respectively (see causal relationship A_2 in Figure 1); regarding the environmental aspect (A_3), environmental policy (e_9) was the most influenced element, and should be enhanced, followed by preventing and monitoring noise (e_7), and carbon emission reduction and energy conservation (e_8), respectively; regarding the internal process aspect (A_4), improvement of efficiency (e_{10}) was the most influenced element, and should be improved, next by employee productivity (e_{11}), and personal rights (C_{12}), respectively; regarding the financial aspect (A_5), net profit ratio (e_{13}) was the most influenced element, and must be improved, next via return on investment (e_{14}) and transparency of finance (e_{15}), respectively.

3.3. Results and discussions

Most present approaches cannot capture the multifaceted interrelations among the numerous aspects and elements which are impact sustainability issues in the green energy companies. The research can differentiate the interrelations between each aspects and elements. Based on the matrix of total influence, this environmental aspect (A_3) has the strongest influence on the relations and is the most significant. According to the net influence, this social aspect (A_1) is the most net effect for the other aspects. Environmental aspect is this main worry of the future of people and gets the most consideration through the fields. These managers in the green energy companies need to enhance environmental aspect (A_3) initial, next by internal process aspect (A_4), social aspect (A_1), growth and learning aspect (A_2) and financial aspect (A_5) as improving the sustainability.

This proposed structure includes social, growth and learning, environmental issues, internal business processes, and financial aspects, as according to the suggestions of specialists to inspect the elements effecting sustainability issues in green energy companies. The descriptions showed in Table 1 do not simultaneously consider the five aspects for evaluating sustainability issues with the SBSC framework. The environmental aspect is not discussed with the BSC aspects in the previous study of green energy companies. Though, these outcomes of the research demonstrate that environmental policy (e_9) appertaining to the environmental aspect is this direct most important element among all elements. Environmental policy is realized as the most serious element for the achievement of lots of environmental events. As predicted, it also plays a significant part in improving sustainability. These green companies should be improved the environmental protection activities and natural resources, or got appropriate environmental certifications in local place towards sustainable development. Such as the development of wind power sector in Taiwan, the green energy companies and the government have been paying more money and resources for the environmental protection activities.

As the suggestions through the specialists in the green energy companies, the suggested structure involves social, growth and learning, environmental issues, internal business processes, and financial aspects to study the elements affecting sustainability issues. The empirical outcomes also address the elements measured within each aspect. This study summarizes the sequence of influence elements within separately aspect in the Table 8. The implications of the 15 elements may vary according to the status, thus, administrators need to examine these sustainability strategies and make sure these gaps before making conclusions. For example, to enhance the priority for sustainability of social aspect, the priorities for improvement are the customer relationship management (e_1), job security for employees (e_2), and society impact (e_3). Nevertheless, managers need to be careful as using the fuzzy MCDM pattern in the green energy companies. The implications of the 15 elements might fluctuate according to the situation, and administrators must to compare the sustainability plans before planning.

For long-term improvement, managers need to manage motives wisely, as stated above. We specify the research outcomes, our results in Table 8, in relation to the objective of this research. This study illustrates the effects of the SBSC model toward the sustainability of the green energy companies. It submits that SBSC can be improved for most green energy companies' managers who use the SBSC model toward sustainability. However, managers should be careful as they use the model. The importance of the 15 elements might change according to the dissimilar consequences, and administrators need to compare this SBSC model toward sustainability of the green energy companies.

Table 8. Sequence of improvement priority for the approach of sustainability

Formula	Sequence of improvement priority
F1: Influence network of system	(A_3), (A_4), (A_1), (A_2), (A_5)
F2: Influence network of elements within each aspect	(A_1): (e_1), (e_2), (e_3)
	(A_2): (e_5), (e_4), (e_6)
	(A_3): (e_9), (e_7), (e_8)
	(A_4): (e_{10}), (e_{11}), (e_{12})
	(A_5): (e_{13}), (e_{14}), (e_{15})

Conclusions

The chief objective of the present study was to assess the interrelations among SBSC over the viewpoint of the most important SBSC in the structure of the green energy companies. Since many companies exist that have limited resources in the green energy companies, the proposed SBSC framework combining the social, growth and learning, environmental, internal process, and financial aspects. To achieve the purpose, the context of research was recognized. The literatures review on SBSC were conducted, and a validation of the significant elements over the multiple context of viewpoint through experts through means of MCDM method was carried out. An integration of DEMATEL, and fuzzy theory approaches was presented for the assessment of SBSC according to different strategic viewpoints. The implication and the interrelationship of separate factors were presented, and divided for separate aspects and in aggregated arrangements overall aspects.

About the implications, the governance of management has a role in assessing SBSC in the green energy companies via categorizing and prioritizing SBSC toward sustainability assessment within a SBSC elements to make sure its practical apply for sustainability. The research offers a comprehensive and simply related MCDM typical which could be used to assist in disentangling evaluation strategies and SBSC design in the green energy companies. To the best of our understanding, in Taiwan, this is the first time this approach has been applied to determine the aspects of SBSC for the green energy companies. The outcomes demonstrate that this environmental aspect which has the highest net effect of 0.26 need to be enhanced primarily. Environmental policy that has the highest influence of 1.014 is the strongest influence element for improving sustainability issue in the green energy companies in Taiwan. Additionally, these outcomes recommend managers to suitable prioritize elements in the enhancement plans for sustainability.

These elements are ordered through the fuzzy DEMATEL approaches. While the model presented is universal, the perceptions of SBSC via specialists in Taiwan could be thought to be a limitation. Nevertheless, SBSC, as well as the development of sustainability and the market, are diverse in different regions around the world. Hence, whether the green energy companies wish to take advantage of systematic models such as these approaches and proposals, regional applications must be established to enhance competitiveness in the broader market. The model can be improved for application in numerous regions of the world, but conclusions will vary. The conclusions can sustenance administrators' proposals for SBSC application actions which are suited to circumstances. A supplementary extension of the study would be a comparison of pairs of SBSC application purposes against those which are more favorable. Such a study can advance the consciousness of the parts most in need of enhancement in SBSC framework through involving different applications.

There are many limitations to this approach, which involve advanced investigation. Principally, this approach used the fuzzy DEMATEL method and the conception of sustainability to propose an assessment model that assists the manager to understand the principles of improvement assessments. Future study can adopt additional fuzzy multiple criteria methods (such as BWM (Best worst method) with fuzzy, or fuzzy integral) to assess the comparative weights of the effects on the sustainability assessment, and such results can then be associated with the results of this study. While this approach conducted relatively professional sample collections, larger samples with better supplementary explanatory ability may have more intricate and certified assessment results for better generalizability. Third, the estimation factors were determined according to the literature review of sustainability estimation, thus, the assessment may exclude some possible impacts on sustainability estimation. Future researches can use dissimilar methods, such as interview, or longitudinal research to determine other measures. Finally, to gain extra agreement with the impartial information regarding the suitability of this recommended sustainability model, future research can apply empirical studies of detailed performance estimations or add the sensitivity analysis, thus, verifying the feasibility of sustainability with the fuzzy DEMATEL estimation procedure, as proposed by this study.

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