Environmental Impact Assessment Review 85 (2020) 106459

Contents lists available at ScienceDirect

Environmental Impact Assessment Review

journal homepage: www.elsevier.com/locate/eiar

Promoting corporate sustainability through sustainable resource management: A hybrid decision-making approach incorporating social media data

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ARTICLE INFO

Keywords:
Sustainable resource management
Corporate sustainability
Vague set
TOPSIS

ABSTRACT

Previous studies revealed triple bottom line cannot entirely cover the concept of corporate sustainability. This study thus uses sustainable resource management (SRM) to improve corporate sustainability (CS) performance considering the socio-environmental, socio-economical, and eco-efficiency aspects. In this study, the vague set (VS) theory and the technique for order preference by similarity to ideal solution (TOPSIS) method are integrated as a hybrid decision-making tool by which social media data can be transformed into entropy weights. The results indicate eco-efficiency and society should be prioritized to improve the corporate sustainability performance. Specifically, the aspects should be promoted through encouraging environmental innovation, redesigning consumers' offer, raising support of the institutions and policy measures, and organizing synergetic involvement. The contributions of this study are three-fold: (i) establishing a comprehensive framework for guiding firms make effective improvements; (ii) developing a hybrid VS-TOPSIS method to process the assessment data and social media information and address the interrelationships; (3) identifying the decisive SRM criteria to precisely guide the Chinese automobile industry towards CS under severe resource constraints.

1. Introduction

The Chinese automobile industry has witnessed a surge growth since the 21st century. In 2007, the amount of China's automobile production had reached 8.88 million, which resulted in a net increase of 16.6 million over the previous year. In the meanwhile, automobile sales reached 8.79 million. Under the 2030 sustainable development goals agenda, the Chinese automobile industry is striving for sustainable development (Wu et al., 2019a). The industry is seeking appropriate managerial paths to balance the economic performance, environmental benefits and social reputation under limited resources. SRM is considered as a key instrument in assisting industrial sector to achieve the CS goal when developing sustainable resource strategies (Wu et al., 2018; Tseng et al., 2019a). Lozano (2012) defined CS as "*corporate activity seeking to achieve sustainability equilibrium, which consists of the economic, environmental, and social dimensions (i.e. triple bottom line, TBL), for today as well as throughout the time dimension while addressing the firm's systems and its stakeholders*". However, it is argued that these three pillars of TBL can neither cover the entire concept of sustainability, nor sufficiently address CS issues (Bordass, 2000; Jeurissen, 2000; Wu et al., 2018). Consequently, these studies presented difficulties in precisely identifying the CS problems merely from economic, environmental and social perspectives (Wu et al., 2019b; Wu et al., 2019d). Furthermore, TBL was found that it existed conflicts and overlapped field among themselves (Tseng et al., 2019b). Therefore, the socio-economic, socio-environmental and eco-efficiency aspects are added as a supplementary of TBL to enrich the CS literature (Wu et al., 2019a). Therefore, this study attempts to adopt SRM practice based on the TBL dimensions with the socio-economic, socio-environmental and eco-efficiency aspects to provide precise guidelines for Chinese automobile industry.

The Chinese automobile industry also requires a valid tool to be adopted to process types of data for decision making. Previous studies mainly considered qualitative data or quantitative data to inform decision-making processes when they discussed SRM issues (Mak et al., 2019; Ng et al., 2019; Wu et al., 2019b). However, these studies ignored the critical type of data which stemmed from social media. Song et al. (2019) pointed out social media data can assist firms to avoid blind

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https://doi.org/10.1016/j.eiar.2020.106459
Received 28 December 2019; Received in revised form 12 May 2020; Accepted 29 July 2020
Available online 18 August 2020

decision-making and provide more support and guarantees for developing SRM. Thus, this study designs a scrapping tool to collect the frequencies of keywords from social media and transfer them into corresponding entropy weights. Moreover, SRM is characterized with nonlinear, systematic feature (Song et al., 2019). Wu et al. (2019b) stated SRM possesses multiple criteria and includes several qualitative perspectives. Therefore, this study integrates VS and TOPSIS to address these problems. The novel VS-TOPSIS tool enables the transformation of experts' linguistic preference to vague set assessment matrix, as well as arranges all the obtained individual profit ratio matrix into the decision matrix. The ranking order can be computed to offer a specific direction for firms to utilize SRM practice to effectively and efficiently improve their CS performance.

Therefore, the objective of this study is to explore the inter-relationship between SRM and CS and identify the decisive measures towards CS. This study provides three contributions: (i) establishing a comprehensive framework for guiding firms make effective improvements; (ii) developing a hybrid VS-TOPSIS method to process the assessment data and social media information and address the inter-relationships; (3) identifying the decisive SRM practice to precisely guide the Chinese automobile industry towards CS under severe resource constraints.

2. Literature review

2.1. CS and SRM

The concept of CS originated from the sustainable development concept (Engert and Baumgartner, 2015; Tseng, 2017). Elkington (1997) proposed planet, people and profits to provide the operational understanding for CS within a business context. Then, Cater and Rogers (2008) formally developed the TBL structure. Afterwards, many CS studies emerged with concentration on the discussion of the economic, social and environmental aspects (Shi et al., 2017). However, the three traditional components of TBL enable insufficiently the coverage of the overall concept of CS (Esquer-Peralta, 2007; Wu et al., 2018). Wu et al. (2019b) also argued there are overlaps among the TBL dimensions, and some operational practices have encountered dilemmas when classifying the operations and actions into TBL aspects as well. Hence, socio-environmental, socio-economical and eco-efficiency aspects have been supplemented to TBL to assist decision makers in precisely distinguishing the practices (Esquer-Peralta, 2007; Wu et al., 2018). More studies these years started to discuss about these newly developed aspects. For example, Heikkurinen et al. (2019) stated companies launching extended eco-efficiency actions can move towards a more sustainable economy. Qiao et al. (2019) found disregarding the socio-environmental losses might lead to failure in the decision process for developing sustainability. Wu et al. (2019a) supposed socio-economical aspect needed to consider social and economic perspectives simultaneously.

Bringezu and Bleischwitz (2017) defined SRM as "utilizing the natural resources in rational ways and maximizing human well-being without impeding the supporting of the living eco-system." In previous literature, several studies have noticed the importance of considering socio-economic, socio-environmental dimensions into SRM towards CS. Dong et al. (2017) noted socio-economic played a critical role in developing urban sustainability for SRM based on literature analysis. In addition, Meng and Han (2018) explored the nexus among transport infrastructure sustainability, socio-economic and socio-environmental factors, and investigated the causal relationships between the variables. Additionally, eco-efficiency is proposed as a win-win operational strategy by means of consuming fewer natural resources and reducing financial costs for companies (Wu et al., 2018; Heikkurinen et al., 2019), while the discussion of the eco-efficiency was ignored in previous SRM studies.

2.2. Proposed hybrid method

Previous studies adopt qualitative data or quantitative data when they address the topic under SRM. For example, Ng et al. (2019) resented a systematic framework of SRM through gathering the quantitative data from the waste and resources action program and Tesco firm. However, the qualitative data need to transform with the purpose of performing valid quantitative computation following the appropriate way. Tseng and Bui (2017) noted that some mistakes may occur during the process of translating qualitative information to quantitative forms. Furthermore, these qualitative experts' respondence always contained ambiguous and uncertain information (Tseng, 2017). Thus, vague set theory was applied in this study to transform qualitative information into quantitative data.

Although existed SRM studies aim at systematically addressing the inter-relationship among SRM attributes, these studies mainly rely on statistical models to examine the relationship based on the independence, linearity and correlation (Liu et al., 2019). Accordingly, the interdependent and exerted feedback effects cannot acquire better demonstration. Therefore, Tseng et al. (2019a) proposed a hybrid fuzzy synthetic method to assess CS performance. However, fuzzy set theory only considered positive evidence by obtaining the single membership function (Gau and Buehrer, 1993). Moreover, TOPSIS was proposed by Hwang and Yoon (1981) aiming at addressing interrelationship inside selected attributes, and it is established by the thought that the selected ideal alternatives should have a minimum geometric distance from the positive ideal consequences and maximum from the negative ideal outcomes. It is commonly recognized as an easier and fast decision-making approach on firm's level (Huang et al., 2011; Behzadian et al., 2012). Therefore, this study combines the VS theory and TOPSIS technique to overcome the drawbacks of fuzzy sets and provide a handy tool for corporate decision-making, as well as fully considering the interdependent and systematic feature of SRM and CS (Tseng et al., 2019a).

2.3. Proposed measures/practices

Extending products' life span (C1) was stated as a highly effective strategy for reducing the use of economic resource loop (Bocken et al., 2016). Meanwhile, through utilizing optimal capability (C2), firms can achieve greater efficient performance in generating and managing economic resource (Lin and Tseng, 2016). Additionally, applying quality management mechanism (C3) is essential to allow the industrial sector to meet satisfaction, and enable the generation of profit (Lim et al., 2017). With respect to the logistics, optimizing horizontal logistics (C4) is increasingly considered to be a viable approach to lower cost and increase service levels, which significantly promotes the profit margin for firm (Defryn et al., 2019; Tseng et al., 2019b).

As for management strategies for environmental resource, adopting eco-design approach (C5) aims at minimizing environmental life cycle impacts, and thereby maximizing firms' limited environmental resource (Eksi and Karaosmanoglu, 2018). Besides, developing cleaner technology (C6) helps organizations to more effectively access natural resource, and produce products and services with less negative impacts (Büyüközkan and Çifçi, 2013). Considering that the sustainability reports can disclose the utilization of environmental resource, thus improving the transparency of sustainability reports (C7) plays a crucial role in increasing the environmental agility of firms (Roca and Searcy, 2012). Moreover, enhancing decision making resilience (C8) enables the dynamic decision while encountering the environmental pressure from internal and external stakeholders (Galpin et al., 2015; Islam et al., 2019).

Social resource always includes the issue of engagement and relationship which involves diverse and various stakeholders (Wu et al., 2019b; Singh et al., 2019). Therefore, organizing synergetic involvement (C9) can be applied to obtain social resource through aligning stakeholders" engagement with a firm's tactics Wu et al., 2019b). Also, increasing employees' and customers' awareness (C10) will be of benefit to enhancing the efficiency of resource utilization through acquiring positive social resources (Shi et al., 2017). Moreover, raising institution's support and policy measures (C11) is capable of establishing social collaboration and participation among key stakeholders' in society such as producers, consumers and government (Singh et al., 2019). Finally, advocating corporate culture (C12) is involved in the sustainable resource beliefs of a firm, which are embedding in arranging the social resource (Bonn and Fisher, 2011; Tseng et al., 2019b).

Industrial sector needs to take social and economic concepts into account simultaneously in order to address the SRM issue with regard to current product policies, market dynamics and competitive advantages (Singh et al., 2019). Thus, improving stakeholder interactions (C13) should be adopted as a core practice to achieve resource management goals, which is a manifestation of power embedded in the relationship between stakeholders' and the SRM target (Frooman, 1999; Lin et al., 2019). After the stakeholders' employ firms' resource to create value, it is beneficial for building value proposition (C14), which includes social value proposition and economic value proposition (Kristensen and Renmmen, 2019). Additionally, building eco-friendly rewarding systems for employees (C15) should be applied to integrate firms' economic development goal with performance evaluation system (Lozano, 2015).

On the macro level, there is a conflict between the quality and quantity of economic activities, the former is too inefficient, while the latter is stated to be too extensive, which leads to large-scale environmental problems (Daly, 1992; IPCC, 2014). To address this issue, eco-efficiency is proposed as a win-win strategy for firms to target a less harmful use of natural resources, and reduces cost for the company (Heikkurinen et al., 2019). Accordingly, encouraging environmental innovation (C16) can deliver a win-win situation for the economic and environment resource (Liao et al., 2018). Then, pushing the sustainability agenda into government policy (C17) has been argued that mostly in the sphere of eco-efficiency, which is an effective means to address sustainability issue and the financial bottom line of firm (DeSimone and Popoff, 1999; Dauvergne and Lister, 2012; Heikkurinen et al., 2019). In addition, redesigning consumers' offer (C18) enables reduction of the environmental load of the use phase (Baines et al., 2007; Heikkurinen et al., 2019).

Socio-environmental practices reflect various facets for solving internal and external sustainability issues, and reconcile company orientation with stakeholders" needs (Spiller, 2000; Kassinis and Vafeas, 2006). Thus, pursuing eco-resource efficiency orientation (C19) can be expressed that maximize output while minimizing resources utilization without degrading social and environmental aspects (Horton et al., 2016; Von Geibler et al., 2016). Moreover, a potential effective way of managing a company's environmental policy is by socially linking it with purchasing function activities (Humphreys et al., 2004), for instance, selecting and collaborating with green supplier (C20) focuses on the buyer-supplier relationship where close relationship is necessary and capabilities are required (Sarkis and Talluri, 2002). At the same time, enhancing environmental awareness (C21) can be used to prevent negative impacts on the environment, as well as affecting the strategic development and their corporate reputation (Matos and Hall, 2007; Eltayeb et al., 2011; Wu et al., 2019a).

3. Method

3.1. Fuzzy cluster method

This study applies FCM to categorize the proposed SRM criteria into several corresponding CS aspects.

Supposing the raw cluster matrix is $R = [r_{ij}]_{n\times n}$, where r_{ij} denotes the degree of experts' judgement, which can be stated as the following equation.

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{pmatrix} \tag{1}$$

Subsequently, the raw cluster matrix R must be normalized through adopting the standard deviation transformation method, which is delineated in Eq. (2).

$$\tilde{r}_{ik} = \frac{r_{ik} - \bar{r}_k}{\theta_k},\ i = 1, 2, 3, \ldots, n;\ k = 1, 2, 3, \ldots, n \tag{2}$$

Where $\bar{r}_k = \frac{1}{n}\sum_{i=1}^{n} r_{ik}$, $\theta_k = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (r_{ik} - \bar{r}_k)^{2.}}$

Then, the following equation is used to compress the initial data scale into the interval $[0, 1]$.

$$\tilde{r}'_{ik} = \frac{\tilde{r}_{ik} - \min\limits_{1\le i\ge n}(\tilde{r}_{ik})}{\max\limits_{1\le i\ge n}(\tilde{r}_{ik}) - \min\limits_{1\le i\ge n}(\tilde{r}_{ik})},\ k = 1, 2, 3, \ldots, n. \tag{3}$$

Once finalizing the normalization process, similarity coefficient between $\tilde{t}'_{ik}$ and can be obtained with the purpose of further establishing fuzzy similarity matrix $U = [u_{ij}]$ according to maximum-minimum method, which is depicted in Eq. (4)

$$u_{ij} = \frac{\sum_{k=1}^{m} (\tilde{t}_{ik} \wedge \tilde{t}_{jk})}{\sum_{k=1}^{m} (\tilde{t}_{ik} \vee \tilde{t}_{jk})} \tag{4}$$

Subsequently, this study employs self-composition square method to compute the transitive closure of fuzzy similarity matrix in order to obtain fuzzy equivalence matrix $T(U)$. Thereinto, the self-composition square method can be expressed as $U \to U^2 \to U^4 \to \cdots \to U^{2k}$ until the equation $U^k = U^{2k}$ occurred firstly, then $T(U) = U^{2k}$ and U^{2k} is called the transitive closure matrix of U. At last, the clustering results can be generated by utilizing an appropriate threshold, namely, λ, consequently, the λ-cutest matrix is obtained.

3.2. Entropy weight method

This study selected four benchmark Chinese automobile manufacturers: Geely Automobile Group, Great Wall Company Limited, Chery Automobile Co., Ltd. and China First Automobile Group Co., Ltd. Tseng (2017) stated that firm's official website can be adopted as a social media platform that facilitates customers acquiring enormous information about development status and performance of the company. Thus, this study programmed a Web scraping project with Python in order to accumulate the frequency of occurrence of proposed criteria and aspect from these firms' website. Nonetheless, these information contains highly grey and uncertainty feature, which need to be transformed into entropy weight for further computation (Delgado and Romero, 2016). Additionally, Wu et al. (2016) also stated that the degree of system disorder could be well demonstrated by entropy weight. Hence, the entropy weight method was employed to address the ambiguous characteristic of information hidden in firms' official websites, as well as provide an objective weighted approach for VS-TOPSIS.

In accordance with Wu et al. (2019c) and Tseng (2017), this study assumes that there are φ alternatives, and χ_r denotes the scrapped frequencies stemming from social media. Additionally, $r = 1, 2, \cdots, \varphi$. These frequencies χ_r need to be normalized through the following equation:

$$\overline{\chi}_r = \frac{\chi_r}{\sum_{r=1}^{\varphi}\chi_r} \tag{5}$$

Subsequently, entropy associated with each item can be calculated by means of the following equation.

$$\chi_r^E = -(ln\,\varphi)^{-1} \times \left[\sum_{r=1}^{\varphi} \overline{\chi}_r\, ln(\overline{\chi}_r)\right] \tag{6}$$

Where $\overline{\chi}_r$ represents the entropy for each indicator. If an indicator has smaller $\overline{\chi}_r$, it has higher weight (Ding et al., 2017) .

Table 1
the linguistic preference and corresponding vague value.

Linguistic preference	Corresponding vague value	μ	ν
Very low (VL)	$[0.1 - \mu \times \tau_{\alpha\beta}{}^{t}, 0.1 + \nu \times \tau_{\alpha\beta}{}^{t}]$	0	1
Low (VL)	$[0.3 - \mu \times \tau_{\alpha\beta}{}^{t}, 0.3 + \nu \times \tau_{\alpha\beta}{}^{t}]$	0.5	0.5
Medium (M)	$[0.5 - \mu \times \tau_{\alpha\beta}{}^{t}, 0.5 + \nu \times \tau_{\alpha\beta}{}^{t}]$	0.5	0.5
High (H)	$[0.7 - \mu \times \tau_{\alpha\beta}{}^{t}, 0.7 + \nu \times \tau_{\alpha\beta}{}^{t}]$	0.5	0.5
Very high (VH)	$[0.9 - \mu \times \tau_{\alpha\beta}{}^{t}, 0.9 + \nu \times \tau_{\alpha\beta}{}^{t}]$	1	0

Next, the degree of discriminability can be attained through applying the following equation:

$$d_r^E = 1 - \chi_r^E \tag{7}$$

Where $1 - \chi_r{}^E$ represents the degree of divergence.

After obtaining the entropy and the degree of discriminability, the following equation can be used to determine the entropy weight $\widetilde{\omega}_r^E$ for each alternative.

$$\widetilde{\omega}_r^E = \frac{d_r^E}{\sum_{r=1}^{\varphi} d_r^E} \tag{8}$$

3.3. Vague set

Given that there are a set of criteria $c = \{c_1, c_2, \ldots, c_\gamma\}$, and the group of experts can be expressed as $\{d_t | 1 \le t \le n\}$, thereinto, n refers to the number of experts inside group. Initially, the original assessment information was present in the form of linguistic preference, such as very high (VH), high (H), medium (M), low (L) and very low (VL). Then the qualitative information must be transferred into corresponding vague value, as shown in Table 1. After obtaining the vague assessment matrix, $p_{ij}{}^t$ was adopted to represent the transferred vague assessment result of expert d_t on criterion c_i of c_j, meanwhile, $p_{ij}{}^t$ was present with vague set, i.e. $p_{ij}{}^t = [E_{\alpha\beta}{}^t, F_{\alpha\beta}{}^t]_{\gamma\times\gamma}$, where $0 \le E_{\alpha\beta}{}^t \le F_{\alpha\beta}{}^t \le 1$. Detailly, $p_{ij}{}^t$ could be demonstrated in the following equation.

$$p_{ij}^t = \begin{bmatrix} [E_{11}^t, F_{11}^t] & \cdots & [E_{1\beta}^t, F_{1\beta}^t] \\ \vdots & \ddots & \vdots \\ [E_{\alpha 1}^t, F_{\alpha 1}^t] & \cdots & [E_{\alpha\beta}^t, F_{\alpha\beta}^t] \end{bmatrix} \tag{9}$$

Additionally, $\tau_{\alpha\beta}{}^t$ denotes the hesitant degree of expert d_t, which stems from hesitancy matrix $H_{\alpha\beta}{}^t$, as well as being stated in Eq. (10).

$$H_{\alpha\beta}^t = \begin{bmatrix} \tau_{11}^t & \cdots & \tau_{1\beta}^t \\ \vdots & \ddots & \vdots \\ \tau_{\alpha 1}^t & \cdots & \tau_{\alpha\beta}^t \end{bmatrix} \tag{10}$$

Subsequently, the following equations can be applied to compute the benefit b^t and cost c^t scores from the vague assessment matrix

$$b^t = max\, p_{ij}^t = max\, [E_{\alpha\beta}^t, F_{\alpha\beta}^t] \tag{11}$$

$$c^t = min\, p_{ij}^t = min\, [E_{\alpha\beta}^t, F_{\alpha\beta}^t] \tag{12}$$

Afterwards, the Group Utility ($G_U{}^t$) and the Individual Regret ($I_R{}^t$) can be obtained through employing these equations below.

$$(\overleftrightarrow{b^t, \sigma}) = |F_{\alpha\beta}^t - max\, F_{\alpha\beta}^t| + |E_{\alpha\beta}^t - max\, E_{\alpha\beta}^t| + |\sigma - \pi| \tag{13}$$

$$(\overleftrightarrow{b^t, c^t}) = |max\, F_{\alpha\beta}^t - min\, F_{\alpha\beta}^t| + |max\, E_{\alpha\beta}^t - min\, E_{\alpha\beta}^t| + |\pi - \varepsilon| \tag{14}$$

$$G_U^t = \varphi^t \times \frac{(\overleftrightarrow{b^t, \sigma})}{(\overleftrightarrow{b^t, c^t})} \tag{15}$$

$$I_R^t = max\, F_{\alpha\beta}^t \times \frac{(\overleftrightarrow{b^t, \sigma})}{(\overleftrightarrow{b^t, c^t})} \tag{16}$$

where $\sigma = E_{\alpha\beta}{}^t + E_{\alpha\beta}{}^t \times (1 - E_{\alpha\beta}{}^t - F_{\alpha\beta}{}^t)$, $\pi = 1 - max\, E_{\alpha\beta}{}^t - max F_{\alpha\beta}{}^t$, $\varepsilon = 1 - min\, E_{\alpha\beta}{}^t - min\, F_{\alpha\beta}{}^t$, and φ^t denote the important weight of expert d_t, additionally, $\Sigma_{t=1}{}^n \varphi^t = 1$.

Once obtaining all the parameters above, the profit ratio matrix $\forall_{pr}{}^t$ can be generated by means of the following equation.

$$\forall_{pr}^t = (\forall_{pr}^t)_{ij} = \varnothing \times \frac{max\, G_U^t - G_U^t}{max\, G_U^t - min\, G_U^t} + (1 - \varnothing) \times \frac{max\, I_R^t - I_R^t}{max\, I_R^t - min I_R^t} \tag{17}$$

It is utilized to maximize the group utility, and it has been generally set as 0.5 to reflect the real situation.

After acquiring the profit ratio matrix $\forall_{pr}{}^t$, eq. (18) can be adopted to aggregate all individual assessments into an aggregated matrix S.

$$S = \sum_{i=j=1}^{i=\alpha, j=\beta} (\forall_{pr}^t)_{ij} \tag{18}$$

3.4. VS-TOPSIS for criteria

The decision matrix $\hat{S}$ in TOPSIS can be generated based on the obtained aggregated matrix S , then it has to be normalized for attaining the normalized decision matrix $\widetilde{S}$:

$$\hat{S} = [(\forall_{pr}^t)_{ij}]_{n\times n} = \begin{bmatrix} (\forall_{pr}^t)_{1j} & \cdots & (\forall_{pr}^t)_{1n} \\ \vdots & \ddots & \vdots \\ (\forall_{pr}^t)_{n1} & \cdots & (\forall_{pr}^t)_{nn} \end{bmatrix} \tag{19}$$

$$\widetilde{S} = \frac{(\forall_{pr}^t)_{ij}}{\sqrt{\sum_{i=j=1}^{i=j=n} (\forall_{pr}^t)_{ij}^2}},\ i = j = 1,\ 2,\ 3 \ldots n \tag{20}$$

Subsequently, this study applies the calculated entropy weight in Section 3.2 to calculate the weighted normalized decision matrix Z, which can be stated as the following equation:

$$Z = [z_{ij}] = \widetilde{\omega}_r^E \times \widetilde{S} \tag{21}$$

After acquiring the weighted normalized decision matrix, the positive ideal solution $\mathscr{E}^+$ and the negative ideal solution $\mathscr{E}^-$ are determined by Eq. (22) and Eq. (23), respectively.

$$\mathscr{E}^+ = \{z_1^+, \ldots, z_j^+, \ldots, z_n^+\} = [\max_{1 \le i \ge n} z_i{}^+] \tag{22}$$

$$\mathscr{E}^- = \{z_1^-, \ldots, z_j^-, \ldots, z_n^-\} = [\max_{1 \le i \ge n} z_i{}^-] \tag{23}$$

Next, using n-dimensional Euclidean distance to compute the geometric distance of a criterion s_i from the positive ideal solution $\mathscr{E}^+$ is given as

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (z_{ij} - z_j^+)^2},\ i = 1,\ 2,\ 3 \ldots, m \tag{24}$$

Similarly, the Euclidean distance of a criterion s_i from the negative ideal solution $\mathscr{E}^-$ is presented as below.

$$D_i^- = \sqrt{\sum_{j=1}^{n} (z_{ij} - z_j^-)^2},\ i = 1,\ 2,\ 3 \ldots, m. \tag{25}$$

Ultimately, the overall performance score, namely, the relative closeness of the criterion s_i is compared with positive ideal solution $\mathscr{E}^+$, which can be defined as follow:

$$RC_i = \frac{D_i^-}{D_i^- + D_i^+},\ i = 1,\ 2, \ldots, m. \tag{26}$$

Where $0 \le RC_i \le 1$, and the obtained value RC_i provide the ranking of each criterion, and the criteria acquires higher ranking are those that have higher overall performance score RC_i.

Table 2
Proposed measures.

Clustered aspect			SRM criteria	Reference
A1	Economics	C1	extending product's life span	Bocken et al., 2016
		C2	utilizing optimal capability	Lin and Tseng, 2016
		C3	applying quality management mechanism	Lim et al., 2017
		C4	optimizing horizontal logistics	Defryn et al., 2019; Tseng et al., 2019b
A2	Environment	C5	adopting eco-design approach	Eksi and Karaosmanoglu, 2018
		C6	developing cleaner technology	Büyüközkan and Çifçi, 2013
		C7	improving the transparency of sustainability reports	Roca and Searcy, 2012
		C8	enhancing decision making resilience	Galpin et al., 2015; Islam et al., 2019
A3	Society	C9	organizing synergetic involvement	Tseng et al., 2018; Wu et al., 2019b
		C10	increasing employee and customer awareness	Shi et al., 2017
		C11	raising institution's support and policy measures	Singh et al., 2019
		C12	advocating corporate culture	Bonn and Fisher, 2011; Tseng et al., 2019a
A4	Socio-economics	C13	improving stakeholder interactions	Frooman, 1999; Lin et al., 2019
		C14	building value proposition	Kristensen and Renmmen, 2019
		C15	building eco-friendly rewarding systems for employees	Lozano, 2015
A5	Eco-efficiency	C16	encouraging environmental innovation	Liao et al., 2018
		C17	pushing the sustainability agenda into government policy	Dauvergne and Lister, 2012; Heikkurinen et al., 2019
		C18	redesigning the consumer's offer	Baines et al., 2007; Heikkurinen et al., 2019
A6	Socio-environment	C19	pursuing eco-resource efficiency orientation	Von Geibler et al., 2016; Horton et al., 2016
		C20	selecting and collaborating with green supplier	Sarkis and Talluri, 2002
		C21	enhancing environmental awareness	Matos and Hall, 2007; Eltayeb et al., 2011; Wu et al., 2019a

4. Results

In this section, the computational results of FCM, Entropy weight and VS-TOPSIS is present as below, respectively.

1. The cluster matrix in FCM was built on the survey data from experts. Then Eq. (1)-Eq. (4) can be used to compute the transitive closure matrix. In this study, the frequency of self-composition square was eight, and $\lambda = 0.858$ was adopted in this study for acquiring a proper clustering result. Accordingly, Table 2 reveals that these 21 SRM criteria was clustered into six categories, thereinto, C1-C4 was clustered into the aspect of economic, C5-C8 fall into the aspect of environment, C9-C12 belongs to the aspect of society, C13-C15 was included in the aspect of socio-economic, C16-C18 was considered in the aspect of eco-efficiency, C19-C21 was covered in the aspect of socio-environment.
2. After scraping the social media data based on Python software, these accumulated frequencies must be transferred into the corresponding entropy weight by means of Eq. (5)–(8). Specifically, Appendix A shows the calculated entropy weight of 21 criteria and 6 aspects.
3. The expert group was consisted of 5 professors, 10 senior managers and 10 senior engineers who had more than 5 years of work or research experience in Chinese automobile industry. Each expert was required to fill out two questionnaires so as to generate the qualitative assessment matrix and the hesitant matrix, respectively. Additionally, all the linguistic preference must be integrated with the corresponding hesitancy index in order to convert them into unified vague value in contrast with Table 1 in using Eq. (9). Table 3 presents the transferred vague set assessment matrix, taking the interrelationship from C3 to C1 as an example, the detailed transformation process is $[0.7 - 0.7 * 0.3, 0.7 + 0.7 * 0.5] = [0.550, 0.850]$.
4. Utilizing Eqs. (10)–(17) to compute the profit ratio matrix. Then, the aggregated matrix S can be obtained through aggregating all the individual proration matrix in using Eq. (18), as shown in Table 4.
5. Once the aggregated profit ratio matrix is obtained, the decision matrix can be derived and normalized by adopting Eq. (19) and Eq. (20), respectively. The entropy weight is integrated to weight the normalized decision matrix in employing Eq. (21). Subsequently, using Eq. (22)–(26) to determine the positive ideal solution $\mathscr{E}^+$ and the negative ideal solution $\mathscr{E}^-$ to attain the overall performance score of criteria and aspects, which can be found in Appendix B.
6. Consequently, the ranking results of 21 criteria can be described as C16 > C11 > C4 > C9 > C18 > C21 > C8 > C20 > C1 > C5 > C14 > C12 > C6 > C7 > C2 > C3 > C13 > C19 > C10 > C17 > C15, similarly, the ranking order of 6 aspects can be expressed as A5 > A3 > A2 > A6 > A1 > A4. In addition, Fig. 1 depicts the results of sensitivity analysis while considering if includes the entropy weight calculated from social media data into the proposed hybrid method. The result indicated that there are four gaps existing in the criterion of C19, C17, C15, C10 which is consistent with the evaluation result. Thus, this study suggests that social media information can reveal the real situation of performing SRM practice, as well as present a more balanced CS development phenomenon among SRM criteria.

5. Implications

5.1. Theoretical implications

There is an obvious conflict between the economic growth and environmental protection in the industry when developing CS, because firms often assume substitutability between economic and environmental resources, and focus on relative efficiency gains, whereas largely ignores the rebound effect (Heikkurinen and Bonnedahl, 2013; Fuchs et al., 2015). The results show eco-efficiency can provide a trade-off towards an overall improvement. The aspect of eco-efficiency (A5) ranks first among all the aspects, referring that to reduce the consumption on natural resources needs to depend on encouraging environmental innovation (C16) and redesigning the consumers' offer (C18). Encouraging environmental innovation is important to achieving highly efficient production technology and methods to improve CS performance. Moreover, through encouraging environmental innovation, the industry can have the capacity to address preservation of natural resources, industrial efficiency and finally achieve the profit improvement. Therefore, eco-efficiency can provide both environmental and economic benefits through production efficiency.

Although social resource is argued as an inessential part in SRM (Sanginga et al., 2003), this study supports Bouwen and Taillieu (2004) that the social aspect presents great benefits to pursue CS through SRM practice. Therein, organizing synergetic involvement (C9) entails the alignment of multiple stakeholders" engagement with firms' CS strategy, and long-term cooperative relationships between themselves and investors in capital markets. Without organizing synergetic

Table 3
Transferred vague set assessment under expert d_1

	C1	C2	C3	⋯	C19	C20	C21
C1	[1.000 1.000]	[0.500 0.500]	[0.150 0.450]	⋯	[0.900 0.900]	[0.450 0.950]	[0.500 0.900]
C2	[0.700 0.900]	[1.000 1.000]	[0.250 0.750]	⋯	[0.500 0.500]	[0.250 0.750]	[0.250 0.350]
C3	[0.550 0.850]	[0.100 0.200]	[1.000 1.000]	⋯	[0.250 0.750]	[0.100 0.100]	[0.100 0.600]
C4	[0.200 0.400]	[0.350 0.650]	[0.500 0.900]	⋯	[0.700 0.700]	[0.050 0.550]	[0.250 0.350]
C5	[0.250 0.750]	[0.300 0.300]	[0.450 0.550]	⋯	[0.550 0.850]	[0.550 0.850]	[0.500 0.900]
C6	[0.300 0.300]	[0.700 0.900]	[0.800 0.900]	⋯	[0.150 0.450]	[0.450 0.950]	[0.400 0.900]
C7	[0.200 0.400]	[0.050 0.550]	[0.500 0.500]	⋯	[0.400 0.900]	[0.600 0.900]	[0.900 0.900]
C8	[0.100 0.300]	[0.400 0.900]	[0.800 0.900]	⋯	[0.200 0.400]	[0.150 0.450]	[0.600 0.900]
C9	[0.100 0.500]	[0.550 0.850]	[0.250 0.350]	⋯	[0.500 0.500]	[0.400 0.900]	[0.100 0.100]
C10	[0.900 0.900]	[0.500 0.900]	[0.650 0.750]	⋯	[0.100 0.500]	[0.250 0.750]	[0.800 0.900]
C11	[0.900 0.900]	[0.050 0.550]	[0.500 0.900]	⋯	[0.250 0.350]	[0.250 0.750]	[0.650 0.750]
C12	[0.450 0.950]	[0.100 0.400]	[0.400 0.600]	⋯	[0.400 0.900]	[0.400 0.600]	[0.500 0.900]
C13	[0.500 0.900]	[0.400 0.900]	[0.100 0.500]	⋯	[0.500 0.500]	[0.500 0.900]	[0.400 0.900]
C14	[0.700 0.900]	[0.550 0.850]	[0.500 0.500]	⋯	[0.300 0.700]	[0.400 0.900]	[0.700 0.700]
C15	[0.300 0.300]	[0.600 0.900]	[0.900 0.900]	⋯	[0.550 0.850]	[0.250 0.350]	[0.900 0.900]
C16	[0.450 0.950]	[0.200 0.400]	[0.100 0.600]	⋯	[0.800 0.900]	[0.100 0.600]	[0.700 0.900]
C17	[0.900 0.900]	[0.100 0.400]	[0.700 0.900]	⋯	[0.200 0.400]	[0.500 0.900]	[0.500 0.900]
C18	[0.500 0.500]	[0.700 0.900]	[0.100 0.400]	⋯	[0.450 0.550]	[0.100 0.500]	[0.700 0.900]
C19	[0.300 0.300]	[0.100 0.100]	[0.900 0.900]	⋯	[1.000 1.000]	[0.100 0.300]	[0.300 0.300]
C20	[0.800 0.900]	[0.550 0.850]	[0.150 0.450]	⋯	[0.450 0.950]	[1.000 1.000]	[0.200 0.400]
C21	[0.450 0.950]	[0.450 0.950]	[0.500 0.900]	⋯	[0.900 0.900]	[0.100 0.100]	[1.000 1.000]

involvement to obtain social resource in SRM, the common interests among stakeholders cannot reach a balanced situation, neither towards a common CS goal. In addition, social collaboration and participation among key stakeholders' can be established according to raising institutions' support and policy measures (C11). Institutional and political support is the guarantee for the industry to utilize SRM towards CS. In other words, firms' political resources and top managers' orientation will significantly impact on firms' CS performance.

5.2. Practical implications

Encouraging environmental innovation (C16) reveals that firms should make endeavor to develop more eco-friendly technologies. Although many firms started to take the environmental innovation into consideration of short-term business strategy, they neglected the long-term benefit according to encouraging environmental innovation. However, to achieve CS goal, firms need to transfer their business strategy and product designed concept into corresponding SRM practice. Geely Automobile Group performed a shift from "low cost and high quality" to "more safe, eco-friendly and energy-saving cars". Also, Geely Automobile Group invested efforts in research and development process in terms of alternative fuels and fuel cells. The focal firm witnessed all have a decent CS performance after the implementation of the SRM practice of encouraging environmental innovation.

Redesigning the consumers' offer (C18) depends on firms to adopt the dynamic strategy to grasp the trend in change of consumers' preferences according to the dynamic market change. During the infancy stage, the Chinese automobile industry put more attention on lowing the cost and acquiring maximum profit under limited resources, yet it is currently transiting to strategies with customer-orientation for obtaining more precise decision. For instance, the Great Wall decided to redesign the customers' offer and begun to launch a fashion and sports

Table 4
The aggregated profit ratio matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
C1	0.951	0.458	0.463	0.503	0.510	0.470	0.450	0.510	0.493	0.560	0.486	0.468	0.439	0.439	0.486	0.485	0.484	0.492	0.588	0.489	0.526
C2	0.386	0.942	0.411	0.420	0.422	0.562	0.449	0.450	0.442	0.489	0.467	0.523	0.410	0.490	0.460	0.433	0.443	0.426	0.479	0.515	0.432
C3	0.440	0.373	0.938	0.498	0.451	0.432	0.349	0.467	0.423	0.420	0.451	0.434	0.482	0.397	0.436	0.393	0.508	0.424	0.386	0.447	0.459
C4	0.515	0.484	0.468	0.954	0.461	0.521	0.467	0.482	0.502	0.496	0.505	0.479	0.504	0.512	0.434	0.508	0.476	0.460	0.495	0.483	0.474
C5	0.482	0.456	0.453	0.492	0.954	0.461	0.460	0.495	0.443	0.492	0.401	0.522	0.514	0.540	0.473	0.424	0.457	0.472	0.527	0.542	0.482
C6	0.503	0.415	0.543	0.417	0.496	0.945	0.463	0.465	0.451	0.458	0.505	0.457	0.482	0.442	0.454	0.471	0.464	0.584	0.437	0.530	0.478
C7	0.441	0.394	0.452	0.377	0.380	0.422	0.937	0.414	0.396	0.425	0.419	0.416	0.466	0.475	0.388	0.455	0.474	0.438	0.478	0.473	0.490
C8	0.462	0.462	0.549	0.462	0.441	0.474	0.487	0.950	0.452	0.452	0.459	0.422	0.473	0.438	0.464	0.417	0.461	0.554	0.473	0.483	0.540
C9	0.497	0.573	0.539	0.465	0.566	0.527	0.509	0.513	0.963	0.572	0.498	0.514	0.514	0.511	0.466	0.518	0.575	0.537	0.508	0.488	0.477
C10	0.547	0.443	0.496	0.488	0.459	0.497	0.408	0.462	0.421	0.947	0.491	0.421	0.487	0.456	0.459	0.476	0.419	0.459	0.519	0.419	0.462
C11	0.582	0.528	0.513	0.586	0.505	0.565	0.518	0.514	0.552	0.553	0.970	0.543	0.462	0.541	0.526	0.507	0.535	0.494	0.556	0.503	0.565
C12	0.546	0.485	0.495	0.528	0.550	0.513	0.544	0.527	0.513	0.519	0.478	0.963	0.537	0.517	0.510	0.537	0.592	0.515	0.574	0.503	0.539
C13	0.554	0.511	0.487	0.446	0.545	0.522	0.441	0.537	0.573	0.531	0.422	0.503	0.950	0.495	0.525	0.486	0.453	0.503	0.426	0.509	0.530
C14	0.486	0.511	0.480	0.476	0.423	0.501	0.515	0.476	0.499	0.442	0.533	0.448	0.516	0.951	0.499	0.488	0.539	0.449	0.422	0.486	0.516
C15	0.364	0.374	0.419	0.412	0.347	0.419	0.372	0.461	0.401	0.382	0.349	0.402	0.453	0.426	0.927	0.426	0.362	0.423	0.395	0.321	0.462
C16	0.529	0.531	0.546	0.485	0.470	0.497	0.486	0.563	0.496	0.542	0.517	0.519	0.502	0.478	0.518	0.962	0.534	0.463	0.550	0.494	0.547
C17	0.402	0.480	0.459	0.491	0.412	0.474	0.438	0.408	0.465	0.374	0.501	0.453	0.474	0.435	0.495	0.412	0.941	0.416	0.496	0.474	0.424
C18	0.445	0.459	0.493	0.508	0.453	0.475	0.464	0.549	0.536	0.495	0.462	0.455	0.500	0.445	0.469	0.437	0.530	0.949	0.480	0.474	0.471
C19	0.433	0.464	0.444	0.433	0.465	0.464	0.406	0.478	0.358	0.475	0.418	0.375	0.406	0.429	0.536	0.472	0.498	0.399	0.940	0.469	0.398
C20	0.469	0.437	0.387	0.378	0.447	0.409	0.469	0.431	0.454	0.375	0.487	0.407	0.437	0.407	0.475	0.408	0.466	0.383	0.500	0.935	0.353
C21	0.465	0.461	0.499	0.386	0.414	0.501	0.467	0.432	0.415	0.486	0.387	0.482	0.530	0.429	0.496	0.397	0.487	0.462	0.458	0.441	0.946

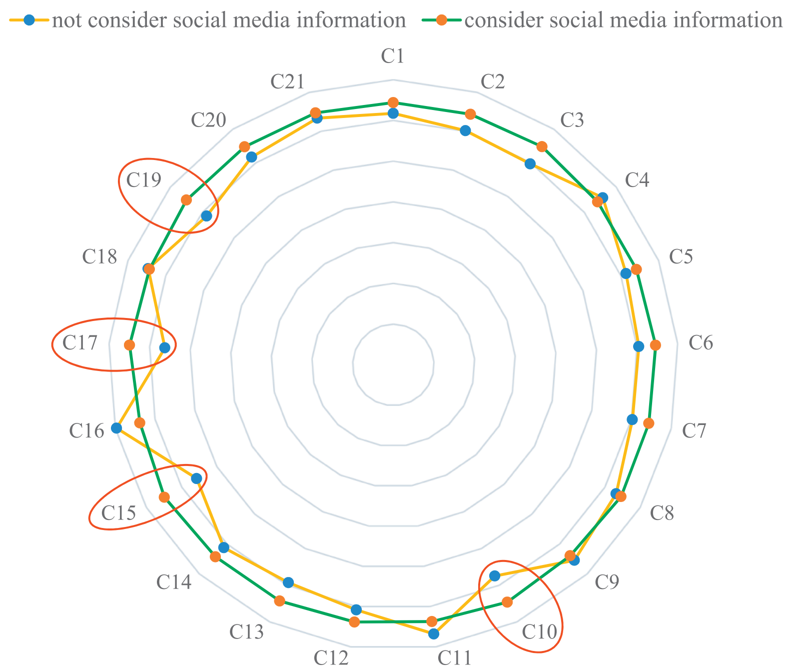

Fig. 1. The result of sensitivity analysis.

car model under SRM concept, resulting in the selling of the new model reaching over 10 thousand in several months. Accordingly, when customers present a desire for sustainable production, firms should adjust and redesign the customers' offer with the purpose of adapting to the new and real market situation.

Raising institution's support and policy measures (11) played a significant role in improving CS performance for Chinese automobile industry. In prior literature, the importance of institutional support and government-support measures in stimulating technological innovation was researched extensively (Veblen, 1915; Nelson, 2008). Lundvall (1992) also emphasized the embedding organizations and institutions can actively advance the role of research and development in each industry. This study has found the similar conclusion in the Chinese automobile industry. For example, in response to the policy of energy-saving and emission-reduction, Chery has undertaken many national key researches and development tasks of new energy technology, and consequently achieved a profit increase of 35.7% in 2017. This evidence prove that the institution's support and policy can push firms towards CS goal.

Moreover, one of the goals of SRM is to promote resource and energy optimization, better infrastructure, and access to basic amenities, green environment through organizing synergetic involvement (C9). Organizing synergetic involvement implies firms should align stakeholders' engagement with a firm's CS target. In the real situation, firms always seek more involvement or alliances among stakeholders' in supply chain networks, for instance, China First Automobile Group (FAW) always aims at protecting and aligning its stakeholders, which has re-established it as the distributor support department to support distributors. Furthermore, existed literature has clearly suggested that synergetic involvement among stakeholders' is essential to improve CS performance (Bocken et al., 2014; Schoenherr and Speier-Pero, 2015). Thus, firms should carefully maintain long term relationships between firms and key stakeholders, and align them with the CS target.

6. Conclusions

The findings reveal that with the integration of eco-efficiency, socio-environmental and socio-economic aspects into the TBL hierarchy, the new framework provides a more comprehensive consideration of CS than previous discussions. Chinese automobile firms that want to acquire the long-term benefit and attain the competitive advantage need to launch the SRM practice of encouraging environmental innovation, which can effectively and efficiently help firms develop a more environment-friendly technology and methods. In addition, the SRM practice of redesigning the consumers' offer can enable firms to meet the dynamic consumers' demand in time. The result also indicates that raising institutions' support and policy measures plays a crucial role in stimulating R&D activities, which can obtain positive performance internally and externally. Finally, firms adopt SRM practice of organizing synergetic involvement with the purpose of aligning stakeholders' engagement with CS goal, and synergetic involvement can function on CS and decision-making process significantly.

This study presents three main contributions as follows: (1) it provides a theoretical contribution through collecting SRM measures/practices from previous literature and establish a comprehensive framework between SRM and CS. Thereinto, eco-efficiency, socio-environmental and socio-economic aspects were proposed to supplement TBL. (2) it provides a methodological contribution by integrating VS theory and TOPSIS method to study the interrelationship between SRM and CS, as well as gathering social media information and transfers them into corresponding entropy weight and make an improvement to efficiently reduce time consumption of decision making. Additionally, the result of sensitivity analysis shows that the integration with social media data can help effectively eliminate the subjective judgement, as well as identify practical gaps in real situation. (3) the obtained analytical results in this study can help decision-makers to select the decisive SRM practice which can be used to provide precise guidelines for Chinese automobile industry towards CS goal.

This study has several limitations that need future studies to overcome. First, the selected 21 SRM practices may not enough to reveal the real situation, thus future study may require taking more proper SRM practices into account. Moreover, this study proposed VS-TOPSIS to measure the geometric interrelationship among alternatives, while the causal relationship cannot be reflected. Hence, future study may need to consider further modifying this method.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This research was funded by the National Natural Science Foundation of China (71828102, 71921001 and 72042008), and the Foundation of President of China National Institute of Standardization (282019Y-6772).

Appendix A. The entropy weight of focal firms based on 21 criteria and 6 aspects

	Geely Automobile Group	Great Wall Motor Company Limited	Chery Automobile Co., Ltd.	China First Automobile Group Co., Ltd	Total
A1	0.1646	0.1597	0.1729	0.1724	0.1683
A2	0.1768	0.1623	0.1618	0.1652	0.1670
A3	0.1638	0.1629	0.1747	0.1651	0.1643
A4	0.1639	0.1737	0.1628	0.1657	0.1654
A5	0.1668	0.1783	0.1615	0.1649	0.1702
A6	0.1641	0.1631	0.1664	0.1668	0.1648
C1	0.0502	0.0470	0.0473	0.0473	0.0478
C2	0.0467	0.0474	0.0467	0.0466	0.0475
C3	0.0460	0.0465	0.0469	0.0516	0.0476
C4	0.0464	0.0469	0.0480	0.0488	0.0458
C5	0.0507	0.0463	0.0471	0.0466	0.0480
C6	0.0509	0.0469	0.0520	0.0465	0.0477
C7	0.0458	0.0520	0.0468	0.0466	0.0490
C8	0.0475	0.0463	0.0470	0.0525	0.0476
C9	0.0485	0.0463	0.0488	0.0465	0.0473
C10	0.0455	0.0512	0.0471	0.0465	0.0472
C11	0.0457	0.0477	0.0467	0.0471	0.0477
C12	0.0463	0.0463	0.0491	0.0465	0.0473
C13	0.0457	0.0490	0.0470	0.0480	0.0477
C14	0.0459	0.0463	0.0472	0.0474	0.0469
C15	0.0497	0.0463	0.0479	0.0466	0.0480
C16	0.0468	0.0506	0.0467	0.0465	0.0487
C17	0.0457	0.0507	0.0473	0.0467	0.0477
C18	0.0483	0.0464	0.0468	0.0514	0.0475
C19	0.0473	0.0464	0.0471	0.0465	0.0477
C20	0.0486	0.0476	0.0490	0.0473	0.0480
C21	0.0516	0.0463	0.0474	0.0465	0.0474

Appendix B. The overall performance score of 21 criteria and 6 aspects

	$\mathscr{E}^{+}$	$\mathscr{E}^{-}$	RC_i	Ranking
A1	0.389	0.493	0.559	5
A2	0.414	0.528	0.560	3
A3	0.408	0.522	0.561	2
A4	0.411	0.520	0.559	6
A5	0.473	0.606	0.561	1
A6	0.380	0.484	0.560	4
C1	0.220	0.256	0.538	9
C2	0.220	0.240	0.522	15
C3	0.206	0.222	0.518	16
C4	0.188	0.259	0.579	3
C5	0.223	0.256	0.535	10
C6	0.222	0.245	0.525	13
C7	0.209	0.230	0.523	14
C8	0.197	0.244	0.553	7
C9	0.208	0.281	0.575	4
C10	0.245	0.240	0.495	19
C11	0.205	0.293	0.588	2
C12	0.256	0.287	0.528	12
C13	0.250	0.263	0.514	17
C14	0.227	0.258	0.532	11
C15	0.223	0.204	0.478	21
C16	0.173	0.279	0.618	1
C17	0.243	0.227	0.483	20
C18	0.193	0.253	0.567	5
C19	0.217	0.223	0.507	18
C20	0.189	0.220	0.538	8
C21	0.188	0.233	0.554	6

References

Baines, T.S., Lightfoot, H.W., Evans, S., et al., 2007. State-of-the-art in product-service systems. Proc. Inst. Mech. Eng. B J. Eng. Manuf. 221 (10), 1543–1552.

Behzadian, M., Otaghsara, S.K., Yazdani, M., et al., 2012. A state-of the-art survey of TOPSIS applications. Expert Syst. Appl. 39 (17), 13051–13069.

Bocken, N.M., Short, S.W., Rana, P., et al., 2014. A literature and practice review to develop sustainable business model archetypes. J. Clean. Prod. 65, 42–56.

Bocken, N.M.P., De Pauw, I., Bakker, C., et al., 2016. Product design and business model strategies for a circular economy. J. Ind. Prod. Eng. 33 (5), 308–320.

Bonn, I., Fisher, J., 2011. Sustainability: the missing ingredient in strategy. J. Bus. Strateg. 32 (1), 5–14.

Bordass, B., 2000. Cost and value: fact and fiction. Build. Res. Inf. 28 (5–6), 338–352.

Bouwen, R., Taillieu, T., 2004. Multi-party collaboration as social learning for interdependence: developing relational knowing for sustainable natural resource management. J. Community Appl. Soc. Psychol. 14 (3), 137–153.

Bringezu, S., Bleischwitz, R. (Eds.), 2017. Sustainable Resource Management: Global 208 Trends, Visions and Policies. Routledge, UK.

Büyüközkan, G., Çifçi, G., 2013. An integrated QFD framework with multiple formatted and incomplete preferences: a sustainable supply chain application. Appl. Soft Comput. 13 (9), 3931–3941.

Daly, H.E., 1992. Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable. Ecol. Econ. 6 (3), 185–193.

Dauvergne, P., Lister, J., 2012. Big brand sustainability: governance prospects and environmental limits. Glob. Environ. Chang. 22 (1), 36–45.

Defryn, C., Sörensen, K., Dullaert, W., 2019. Integrating partner objectives in horizontal logistics optimisation models. Omega 82, 1–12.

Delgado, A., Romero, I., 2016. Environmental conflict analysis using an integrated grey clustering and entropy-weight method: a case study of a mining project in Peru. Environ. Model Softw. 77, 108–121.

Desimone, L.D., Popoff, F., 1999. Eco-efficiency: the business link to sustainable development. Corp. Environ. Strat. 6 (2), 220–221.

Ding, X.W., Chong, X., Bao, Z.F., et al., 2017. Fuzzy comprehensive assessment method based on the entropy weight method and its application in the water environmental safety evaluation of the Heshangshan drinking water source area, three gorges reservoir area, China. Water 9 (5), 329.

Dong, L., Wang, Y., Scipioni, A., et al., 2017. Recent progress on innovative urban infrastructures system towards sustainable resource management. Resour. Conserv. Recycl. 128, 355–359.

Eksi, G., Karaosmanoglu, F., 2018. Life cycle assessment of combined bioheat and biopower production: an eco-design approach. J. Clean. Prod. 197, 264–279.

Elkington, J., 1997. Cannibals with Forks. The Triple Bottom Line of 21st Century 698. Business. Capstone, Oxford.

Eltayeb, T.K., Zailani, S., Ramayah, T., 2011. Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: investigating the outcomes. Resour. Conserv. Recycl. 55 (5), 495–506.

Engert, S., Baumgartner, R.J., 2015. Corporate sustainability strategy – bridging the gap between formulation and implementation. J. Clean. Prod. 113, 822–834.

Esquer-Peralta, J. (2007). Sustainability Management Systems (SMS): An Integrative Approach to Management Systems towards Sustainable Development, PhD Dissertation, University of Massachusetts Lowell, USA.

Frooman, J., 1999. Stakeholder influence strategies. Acad. Manag. Rev. 24 (2), 191–205.

Fuchs, D., Di Giulio, A., Glaab, K., et al., 2015. Power: the missing element in sustainable consumption and absolute reductions research and action. J. Clean. Prod. 132, 298–307.

Galpin, T., Whitttington, J.L., Bell, G., 2015. Is your sustainability strategy sustainable? Creating a culture of sustainability. Corp. Govern.: Int. J. Bus. Soc. 15 (1), 1–17.

Gau, W.L., Buehrer, D.J., 1993. Vague sets. IEEE Trans. Syst. Man Cybern. 23 (2), 610–614.

Heikkurinen, P., Bonnedahl, K.J., 2013b. Corporate responsibility for sustainable development: a review and conceptual comparison of market- and stakeholder-oriented strategies. J. Clean. Prod. 43, 191–198.

Heikkurinen, P., Young, C.W., Morgan, E., 2019. Business for sustainable change: extending eco-efficiency and eco-sufficiency strategies to consumers. J. Clean. Prod. 218, 656–664.

Horton, P., Koh, L., Guang, V.S., et al., 2016. An integrated theoretical framework to enhance resource efficiency, sustainability and human health in agri-food systems. J. Clean. Prod. 120, 164–169.

Huang, I.B., Keisler, J., Linkov, I., 2011. Multi-criteria decision analysis in environmental sciences: ten years of applications and trends. Sci. Total Environ. 409 (19), 3578–3594.

Humphreys, P.K., et al., 2004. The impact of supplier development on buyer-supplier performance. Omega Int. J. Manag. Sci. 32 (2), 131–143.

Hwang, C.L., Yoon, K., 1981. Multiple Attribute Decision Making: Methods and Applications. Springer-Verlag, New York, United States.

IPCC (2014), "5th Assessment Report. Climate change 2014: Impacts, adaption, and vulnerability", working group II. Geneva: Intergovernmental Panel on Climate Change.

Islam, M.S., Tseng, M.L., Karia, N., 2019. Assessment of corporate culture in sustainability performance using a hierarchical framework and interdependence relations. J. Clean. Prod. 217, 676–690.

Jeurissen, R., 2000. Cannibals with forks: the triple bottom line of 21st century business. J. Bus. Ethics 23 (2), 229–231.

Kassinis, G., Vafeas, N., 2006. Stakeholder pressures and environmental performance. Acad. Manag. J. 49 (1), 145–159.

Kristensen, H.S., Renmmen, A., 2019. A framework for sustainable value propositions in product-service systems. J. Clean. Prod. 233, 25–35.

Liao, Z.J., et al., 2018. What drives environmental innovation? A content analysis of listed companies in China. J. Clean. Prod. 198, 1567–1573.

Lim, M.K., Tseng, M.L., Tan, K.H., et al., 2017. Knowledge management in sustainable supply chain management: improving performance through an interpretive structural modelling approach. J. Clean. Prod. 162, 806–816.

Lin, X., McKenna, B., Ho, C.M.F., et al., 2019. Stakeholders' influence strategies on social responsibility implementation in construction projects. J. Clean. Prod. 235, 348–358.

Lin, Y.H., Tseng, M.L., 2016. Assessing the competitive priorities within sustainable supply chain management under uncertainty. J. Clean. Prod. 112, 2133–2144.

Liu, J.Y., Shiue, W., Chen, F.H., et al., 2019. A multiple attribute decision making approach in evaluating employee care strategies of corporate social responsibility. Manag. Decis. 57 (2), 349–371.

Lozano, R., 2012. Towards better embedding sustainability into companies systems: an analysis of voluntary corporate initiatives. J. Clean. Prod. 25, 14–26.

Lozano, R., 2015. A holistic perspective on corporate sustainability drivers. Corp. Soc. Responsib. Environ. Manag. 22 (1), 32–44.

Lundvall, B.A., 1992. National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Pinter Publishers, London.

Mak, T.M.W., Yu, I.K.M., Wang, L., et al., 2019. Extended theory of planned behaviour for promoting construction waste recycling in Hong Kong. Waste Manag. 83, 161–170.

Matos, S., Hall, J., 2007. Integrating sustainable development in the supply chain: the case of life cycle assessment in oil and gas and agricultural biotechnology. J. Oper. Manag. 25 (6), 1083–1102.

Meng, X., Han, J., 2018. Roads, economy, population density, and co2: a city-scaled causality analysis. Resour. Conserv. Recycl. 128, 508–515.

Nelson, R.R., 2008. Economic development from the perspective of evolutionary economic theory. Oxf. Dev. Stud. 36 (1), 9–21.

Ng, K.S., Yang, A., Yakovleva, N., 2019. Sustainable waste management through synergistic utilisation of commercial and domestic organic waste for efficient resource recovery and valorisation in the Uk. J. Clean. Prod. 227, 248–262.

Qiao, Y.-K., Peng, F.-L., Sabri, S., et al., 2019. Socio-environmental costs of underground space use for urban sustainability. Sustain. Cities Soc. 51, 101757.

Roca, L.C., Searcy, C., 2012. An analysis of indicators disclosed in corporate sustainability reports. J. Clean. Prod. 20, 103–118.

Sanginga, N., Dashiell, K.E., Diels, J., et al., 2003. Sustainable resource management coupled to resilient germplasm to provide new intensive cereal–grain–legume–livestock systems in the dry savanna. Agric. Ecosyst. Environ. 100 (2–3), 305–314.

Sarkis, J., Talluri, S., 2002. A model for strategic supplier selection. J. Supply Chain Manag. 38 (1), 18–28.

Schoenherr, T., Speier-Pero, C., 2015. Data science, predictive analytics, and big data in supply chain management: current state and future potential. J. Bus. Logist. 36 (1), 120–132.

Shi, L., Wu, K.J., Tseng, M.L., 2017. Improving corporate sustainable development by using an interdependent closed-loop hierarchical structure. Resour. Conserv. Recycl. 119, 24–35.

Singh, J., Cooper, T., Cole, C., et al., 2019. Evaluating approaches to resource management in consumer product sectors - an overview of global practices. J. Clean. Prod. 224, 218–237.

Song, M., Fisher, R., Kwoh, Y., 2019. Technological challenges of green innovation and sustainable resource management with large scale data. Technol. Forecast. Soc. Chang. 144, 361–368.

Spiller, R., 2000. Ethical business and investment: a model for business and society. J. Bus. Ethics 27, 149–160.

Tseng, M.L., 2017. Using social media and qualitative and quantitative information scales to benchmark corporate sustainability. J. Clean. Prod. 142, 727–738.

Tseng, M.L., Bui, T.D., 2017. Identifying eco-innovation in industrial symbiosis under linguistic preferences: a novel hierarchical approach. J. Clean. Prod. 140, 1376–1389.

Tseng, M.L., Wu, K.J., Li, M., et al., 2019a. A hierarchical framework for assessing corporate sustainability performance using a hybrid fuzzy synthetic method-DEMATEL. Technol. Forecast. Soc. Chang. 144, 524–533.

Tseng, M.L., Wu, K.J., Lim, M.K., et al., 2019b. Data-driven sustainable supply chain management performance: a hierarchical structure assessment under uncertainties. J. Clean. Prod. 227, 760–771.

Veblen, T., 1915. Imperial Germany and the Industrial Revolution. Macmillan, London.

Von Geibler, J., Cordaro, F., Kennedy, K., et al., 2016. Integrating resource efficiency in business strategies: a mixed-method approach for environmental life cycle assessment in the single-serve coffee value chain. J. Clean. Prod. 115, 62–74.

Wu, K.J., Liao, C.J., Tseng, M.L., et al., 2016. Multi-attribute approach to sustainable supply chain management under uncertainty. Ind. Manag. Data Syst. 116 (4), 777–800.

Wu, K.J., Zhu, Y., Tseng, M.L., et al., 2018. Developing a hierarchical structure of the co-benefits of the triple bottom line under uncertainty. J. Clean. Prod. 195, 908–918.

Wu, K.J., Zhu, Y., Chen, Q., Tseng, M.L., 2019a. Building sustainable tourism hierarchical framework: coordinated triple bottom line approach in linguistic preferences. J.

Clean. Prod. 229, 157–168.
Wu, K.J., Tseng, M.L., Lim, M.K., et al., 2019b. Causal sustainable resource management model using a hierarchical structure and linguistic preferences. J. Clean. Prod. 229, 640–651.
Wu, K.J., Gao, S., Xia, L., et al., 2019c. Enhancing corporate knowledge management and sustainable development: an inter-dependent hierarchical structure under linguistic preferences. Resour. Conserv. Recycl. 146, 560–579.
Wu, K.J., Chen, Q., Qi, Y., et al., 2019d. Sustainable development performance for small and medium enterprises using a fuzzy synthetic method-DEMATEL. Sustainability 11, 4119.