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Sustainable Development Performance for Small and Medium Enterprises Using a Fuzzy Synthetic Method-DEMATEL

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Abstract: Small and medium enterprises (SMEs) are forced to adhere to sustainable development (SD) regulations and standards. However, SMEs encounter difficulty in assessing their performance due to the lack of an efficient and effective approach to deal with the uncertainties in hierarchical relationships and interrelationships. Moreover, interrelations exist among the proposed attributes that increase the difficulty of the assessment. To overcome these issues, exploratory factor analysis is used to screen out the less important attributes and build a hierarchal structure. The fuzzy synthetic method addresses the hierarchical structure and decision-making, and a trial evaluation laboratory assesses the interrelationships among the attributes by providing a visual interrelationship map. The results indicate that strategic and financial management are the major problems for SMEs. SD relies on enhancing sustainable supply chain performance, sustainable human resources and environmental management. This study contributes by not only filling the information gap for SD for SMEs but also providing a guideline for improvement. The theoretical and managerial implications are discussed.

Keywords: sustainable development; exploratory factor analysis; fuzzy synthetic method; decision-making and trial evaluation laboratory; small and medium enterprises

1. Introduction

As a result of the United Nation announcing the 2030 sustainable development (SD) goals, an increasing number of countries are striving to accomplish these goals. Thus, the Chinese government declared the "Thirteenth Five-Year Plan" to lead enterprises in developing sustainability [1]. Although large-scale enterprises have abundant resources for adhering to the sustainability policies, small and medium enterprises (SMEs) encounter difficulty in pursuing such policies due to resource constraints. In addition, the market consists of 80% SMEs, affecting the overall economic growth of China. However, launching SD possesses complexity and uncertainties; thus, SMEs lack an effective and efficient approach to assess performance. This study proposes a hybrid method to offer guidelines for these SMEs to improve SD by generating unexpected dynamics to expedite the realization of 2030 SD goals.

In the literature, SD refers to an organizational principle for meeting human development goals by sustaining natural systems to balance natural resources and ecosystems. Elkington [2] proposed the triple bottom line concept to address SD in terms of people, land and profit. Carter and Rogers [3]

extended the concept to balance economic, environmental and social aspects. Wu et al. [4] argued that SD cannot take only economy, environment and society into account but also must consider operations, resilience, the long term and stakeholders. Witjes [5] found that enterprises are impacted by diverse SD aspects, and these impacts are not limited to only environmental or social aspects. Launching SD not only promotes the reputation of an enterprise and fulfills the expectations of the public but also becomes a core competence in competing with rivals. Although prior studies have extensively discussed SD, a discussion from the perspective of SMEs and a guideline for improvement is lacking.

SMEs exist in diverse industries and often face resource constraints in developing SD. Thus, 70% of all industrial pollutants are generated by SMEs [6]. A previous study has demonstrated that approaches to launching SD must be formulated with SME features rather than simply shifting SD practices from large enterprises to SMEs, as the latter approach has been indicated to be unsuitable [7]. Although large enterprises and governments have attempted to increase SME engagement in sustainability initiatives, a framework allowing SMEs to clarify and launch the requested SD arrangements is lacking [8–10]. In addition, ways to assess performance and expressively engage SMEs in real SD management and practices are absent in previous studies [11].

Prior studies have not proposed valid and reliable hierarchical structures or dealt with the interrelationships among the attributes. For instance, Udo and Jansson [12] noted that SD is a multidimensional, multidisciplinary, and interdisciplinary problem of significant complexity and uncertainty. To deal with SD assessment, exploratory factor analysis (EFA) is employed to screen the attributes for validity and reliability. Moreover, the structural aspects are identified by EFA, providing a significant basis for reinforcing SD attributes. Then, the fuzzy synthetic method (FSM) enables the transfer of the uncertainty feature from linguistic preferences into comparable values. In addition, hybridizing FSM and a decision-making and trial evaluation laboratory (DEMATEL) offers a visual analysis by considering the hierarchy and interrelations of the proposed attributes in guiding improvements under resource constraints.

Hence, the objective of this study is to assess SD performance for SMEs using a hybrid method. This study makes three contributions: (1) it provides a theoretical basis for bridging the gap between SD and SMEs; (2) it proposes a hybrid method through integrating EFA, FSM and DEMATEL to assess SD performance; and (3) it offers a guideline for SMEs to improve their SD performance under resource constraints. The rest of the content is structured as follows. An extensive literature review and theoretical background are provided in section 2. Detailed processes of the hybrid method and the proposed analytical procedure are discussed in section 3. Section 4 contains case information and analytical results. Section 5 presents the theoretical and managerial implications. Conclusions and research limitations are discussed in the final section.

2. Literature Review

This section discusses the literature review for SD, SMEs, the proposed method and the proposed attributes.

2.1. Sustainable Development

After Elkington [2] proposed people, plants and profits as an approach to SD issues, Dyllic and Hockerts [13] noted that an SD approach must satisfy the needs of direct and indirect stakeholders as well as the demands of future stakeholders. Lozano [14] adopted the extended concept from Carter and Rogers [3] to incorporate SD into the management of enterprises to promote the success of sustainability. With SD becoming more important in strategy formulation, enterprises must incorporate economic, environmental and social indicators of SD into their internal organizational structure to generate more benefits [15]. Thus, Shields and Shelleman [16] emphasized that many enterprises encounter a critical challenge, regardless of whether they are large or small, in that they lack a framework to integrate sustainable practices into business decisions.

To address this issue, Chalmeta and Palomero [17] pointed out that some useful tools might assist in developing sustainability standards, indicators and guidelines, but integrating these tools

for enhancing the success of SD is an arduous challenge. Prior studies have adopted a single method approach. For instance, Lee [18] employed data envelopment analysis to evaluate SD performance. Prior studies have also attempted to address SD from the perspective of enterprise sustainable management process change or enterprise sustainable management system integration, yet a valid model to guide enterprises in these improvements is still lacking [19,20]. Moreover, the real-life situation of enterprises has been neglected, generating a gap between theoretical applications and practice.

Prior studies have often omitted investigations of the Asian background and emerging economies. These studies have concentrated on qualitative, conceptual and theoretical discussions based on specific industries [21,22]. In addition, Joshi and Li [23] demonstrated that conflicts and uncertainties exist between SD theory and performance; thus, when enterprises want to achieve sustainability, they must aggressively shift SD into actual practice. However, few studies have considered SMEs when exploring specific frameworks for improving sustainability. Accordingly, Shi et al. [24] attempted to adopt a closed-loop hierarchical structure by considering interdependent relations for SD. Nevertheless, a gap still exists between theory and how SMEs deploy their SD attributes under resource constraints [11].

2.2. Small and Medium Enterprises

The Chinese Ministry of Industry and Commerce reported that approximately 16,500 SMEs are registered daily, but their average life span is 2.9 years due to the difficulty in balancing economic, environmental and social aspects. Many studies have discussed applying innovation and SD in benchmarking enterprises (in terms of large firms), but SMEs have rarely been considered in these discussions. In addition, SMEs seem to have strong economic growth potential if they can address their financial constraints, lack of innovation drivers, vague organizational culture, and so on. There is a need to identify key performance attributes. Usually, SMEs are measured by quantitative standards, which are largely based on economic elements that significantly contribute to gross domestic profit, employment and taxation. In contrast to large enterprises, it is harder for SMEs to launch SD, as they commonly suffer from a scarcity of resources. Once SMEs strive to launch SD, they must consider their own features to effectively and efficiently utilize resources [11,25]. Most previous studies have focused on discussing the current conditions, business models and other attributes of SMEs. Moreover, SMEs must develop SD with diverse attributes to sustain their performance. The interrelationships among these attributes have also been neglected in previous studies. This study assumes that these attributes are interrelated and that criteria should be established to reflect the actual situation. This study proposes to assess the SD performance of SMEs using a hybrid method.

2.3. Proposed Method

EFA is usually used in studies to explain a large number of measurement variables with a small number of potential attributes [26]. EFA can generally be used to assess the validity of measurements and provide theoretical assurance for further research [27]. This method not only generates a model to find the main attributes but also can assess the overall performance of the model. In addition, this method plays an important role in clustering large numbers of criteria into a limited set of aspects based on the correlation between criteria [28]. Sunil and Kumar [29] utilized EFA to classify the challenges of industry 4.0 in facilitating targeted solutions. Schrippe and Ribeiro [30] attempted to identify the main criteria for benchmarking corporate sustainability using EFA and revealed the inefficiency of the social dimension.

FSM adopts fuzzy mathematics to convert and measure unclear data and enables a general assessment of the related criteria to identify those needed for the overall assessment [31]. As a branch of fuzzy set theory, FSM is used to solve problems with nondeterministic features. It is considered a tool for identifying improved criteria and developing a nonlinear integer-programming model for making effective comparisons [28]. Tseng et al. [32] adopted a five-point linguistic scale to evaluate performance by transferring qualitative scales to quantitative values. Wu et al. [33] integrated FSM

and analytical network processes to create an interdependent hierarchical structure for enhancing corporate knowledge management and SD.

DEMATEL enables the simplification of the complex interrelations into cause-and-effect groups by structuring a system model [34]. The model presents a cause-and-effect group through mapping the criteria into a diagram to express each criterion's degree of effectiveness [35]. Lin et al. [36] employed DEMATEL to analyze causal relationships and interactions to offer a guideline for stakeholders for improving the sustainability of a supply chain. Ren [37] applied DEMATEL to explore the attributes of success and strategic implications. However, DEMATEL is unable to address a hierarchical model. Thus, the hybrid method is proposed to overcome these issues.

2.4. Proposed Attributes

Sustainable leadership (C1) and the adoption of SD concepts in business management (C17) play critical roles in developing sustainability for enterprises [38]. If leaders and daily operations managers possess the significant attitudes and practices of SD, they can develop the awareness of employees and even consumers. In addition, accurate service strategy positioning (C7) provides a foundation for leading enterprises to pursue sustainability [39]. Government certification (C9) can provide the core competence for SMEs to acquire competitive advantages in the market. Offering information transparency for stakeholders (C8) enables enterprises to maintain the stability of their overall market condition and has a beneficial effect on the establishment of corporate social sustainability [30,40].

SMEs should also pay close attention to taking care of employees by guaranteeing safe working conditions and should provide reliable products and services. Waldman and Kerr [41] noted that enterprises are responsible for ensuring the health and safety (21) of their customers and employees in their business processes. Therefore, taking human resources efficiency (18), employee incentives (19) and staff service values into account can enable enterprises to enhance the productivity of employees. These concepts can also be applied to strengthening the awareness of SD in maintaining corporate health and stability, solving many employment issues, increasing enterprise growth and promoting the sustainability of society [42,43].

Wu et al. [26] emphasized that most enterprises sacrifice environmental and social investments to maintain economic growth. Adopting an organization management system (C2), exploring green marketing (C5), and increasing research and development investments (C6) may assist SMEs in addressing this issue [40,44,45]. Moreover, employing solid waste reduction (C10), adopting an environmental management system (C11) and decreasing natural resource consumption (C12) can also add value to the production process by eliminating negative environmental impacts and promoting sustainable environmental practices [46–48].

Financial constraints are the bottleneck for SMEs in launching SD; thus, capital optimization and configuration (C13) and diversifying financial channels (C14) enable them to follow different paths [49,50]. Margin improvement (C15) can act as a buffer and assist SMEs in launching SD, as the buffer can absorb a loss to maintain the operation (Wu et al., 2017). To achieve sustainability requires cooperation along the supply chain through complying with supply chain partners (C3), engaging stakeholders (C4) and providing high-quality service with rewards (C20) for fulfilling diverse stakeholders' needs [48,51,52]. Satisfying the demands of customers (C23) is the basic function of SMEs; otherwise, they may encounter difficulty in launching SD. Accepting customer advice (C16) and considering personal feedback (C24) are important attributes after sales. These criteria can promote the understanding of customers' needs, avoid shortages of current products and enhance the satisfaction and repurchasing rate of customers [28,53,54]. A detailed explanation of each criterion is shown in Table 1.

Table 1. Proposed Attributes.

Criteria		Explanation	References
C1	Sustainable Leadership	Sustainable leadership includes building relationships with communities, working with stakeholders and promoting long-term sustainable value.	[55]
C2	Organization Management System	The organization management system complies with applicable environmental laws and regulations.	[40]
C3	Compliance with Supply Chain Partners	Supply chain partner commitment refers to the establishment of legal, effective, and win-win contracts between the company and its partners in the supply chain.	[48]
C4	Stakeholder Engagement	Stakeholder engagement is a process of organizational involvement of people who may be influenced by the decisions the organization makes or influence the execution of its decisions.	[52]
C5	Green Marketing	Green marketing not only requires enterprises to provide green products but also requires them to achieve green services in the development of e-commerce activities, build a green industry, meet demand, and fully consider consumer privacy and information security.	[44]
C6	Research and Development Investments	Research and development investments refer to the depreciation of the assets used in the research and development process, the raw materials consumed, the wages and welfare expenses directly involved in the development, the rents incurred during the development process, and the borrowing costs.	[45]
C7	Service Strategy Positioning	Accurate service strategy positioning facilitates centralized resource input, provides better service to customers and easily realizes resource limitations in developing sustainability.	[38]
C8	Information Transparency for Stakeholders	Information transparency should be offered to stakeholders in terms of the details of the enterprise's products and services.	[30]
C9	Government Certification	Refers to conformity assessment by a certification body accredited by the government to prove that an organization's products, services, and management systems comply with the relevant standards, technical specifications, or mandatory requirements.	[40]
C10	Solid Waste Reduction	Generally, refers to reducing the amount or harmfulness of solid waste, including reduction in the quantity and the environmental damage hazards of solid waste.	[48]

C11	Environmental Management System	Refers to developing and implementing an environmental policy and managing the environmental attributes of SD, including the organizational structure, program activities, etc. required to develop, implement, implement, assess and maintain environmental policies.	[47]
C12	Decreasing Natural Resources Consumption	Refers to the company's efforts to reduce its consumption of natural resources, such as water, electricity and natural gas, and improve its energy efficiency in the process of manufacturing and selling goods and services.	[46]
C13	Capital Optimization and Configuration	For SD, it is necessary to make the asset structure of the enterprise match technology upgrades and the long-term development strategy.	[50]
C14	Diversifying Financial Channels	Diversification of financing for SMEs occurs through leasing, mortgage loans, discounting, and mortgage bonds.	[49]
C15	Margin Improvement	The gross profit margin reflects the management efficiency of the company in the formulation of product prices and the control of product costs. The more efficient the management, the more favorable it is to maintain SD and avoid the waste of funds and personnel.	[48]
C16	Accepting Customer Advice	Customer suggestions express customer needs to a certain extent, so the acceptance of customer advice by a service industry enterprise can promote the SD of the company and stabilize the market.	[28]
C17	Adopting the SD Concept in Business Management	In the process of management and operation, develop an SD strategy, closely link the enterprise with SD, and regard SD as one of the key objectives that the enterprise needs to achieve so that the concept of SD penetrates the daily work of each employee.	[56]
C18	Human Resources Efficiency	The organizational life cycle and individual career cycle are coordinated in the perspective of economic rationality and social rationality.	[42]
C19	Employee Incentives	Employee incentives refer to promoting employee potential and professional development and enables employees to passively obey and actively invest.	[43]
C20	Providing High-Quality Service with Rewards	Refers to the enterprise providing high-quality customer service, satisfying customer service demands efficiently, and stimulating customer desire to continue to seek the enterprise product and services through some form of incentive.	[51]

C21	Health and Safety	Refers to the products or services provided by the enterprise being safe and reliable and generating no negative impacts on customers. Simultaneously, employees should be trusted to share source information to promote belief in the quality of the products or services.	[41]
C22	Staff Service Value	To create a first-class service-oriented enterprise, an enterprise must first work hard to ensure the quality of its employees. The employees should have a strong sense of service, professional skills and good communication skills.	[57]
C23	Satisfying Customer Demands	Customer demands include real and potential demand. Technology, goods or services have great demand-guided capabilities, so by guiding market demand, companies can open new markets.	[53]
C24	Considering Personal Feedback	After using a product or service, the customer will provide feedback about his/her unique, personal and pure experience to the enterprise without being affected by external attributes.	[54]

3. Methods

This section provides relative equations to enhance the understanding of the hybrid method. The proposed analytical procedures are described in the last section.

3.1. Exploratory Factor Analysis

EFA is used to identify the relationships among the criteria that are reflected by the correlation matrix or the covariance matrix. The proposed criteria are extracted based on the effect among others; therefore, the criterion with a greater effect is extracted and given a higher weight. This process is repeated until the criteria are reduced to a few aspects that reflect the intrinsic relationship between the proposed criteria and aspects. If the proposed criteria are independent of each other or the information overlap is too small, then EFA will be invalid. Thus, the correlations of the criteria must be tested before the analysis begins. This study proposed adopting the Kaiser–Meyer–Olkin measure and the Bartlett test of sphericity to examine the correlations of the proposed criteria. Once these examinations prove that a high degree of correlation exists among the proposed criteria, the following analysis can be carried out.

Principle components analysis is used to standardize these relations and identify irrelevant variables by changing the coordinates. Subsequently, employing the following equations generates the factor loading matrix F by computing the eigen values ε_x $(\varepsilon_x > 0, x = 1,2,\cdots,a)$ of the irrelevant variables and the corresponding standard orthogonal eigen vectors, e_x.

$$f_{xy} = \sqrt{\varepsilon_x} v_{xy}, x = 1,2,\cdots a, y = 1,2,\cdots b, \tag{1}$$

$$F = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1b} \\ f_{21} & f_{22} & \cdots & f_{2b} \\ \vdots & \vdots & \ddots & \vdots \\ f_{a1} & f_{a2} & \cdots & f_{ab} \end{bmatrix} = \begin{bmatrix} \sqrt{\varepsilon_1} e_{11} & \sqrt{\varepsilon_2} e_{12} & \cdots & \sqrt{\varepsilon_a} e_{1b} \\ \sqrt{\varepsilon_1} e_{21} & \sqrt{\varepsilon_2} e_{22} & \cdots & \sqrt{\varepsilon_a} e_{2b} \\ \vdots & \vdots & \ddots & \vdots \\ \sqrt{\varepsilon_1} e_{a1} & \sqrt{\varepsilon_2} e_{a2} & \cdots & \sqrt{\varepsilon_a} e_{ab} \end{bmatrix}, \tag{2}$$

The variance of criterion f_{xy} can be denoted as

$$v_{xy}^2 = \sum_{x=1}^{a} f_{xy}^2, y = 1,2,\cdots b, \tag{3}$$

$$V(F) = \sum_{y=1}^{b} V_y = \sum_{y=1}^{b} \sum_{x=1}^{a} \left(h_{xy}^2 - \tilde{h}_y\right)^2, \tag{4}$$

where $h_{xy} = \frac{f_{xy}}{v_x}, \tilde{h}_y = \frac{1}{a}\sum_{x=1}^{a} h_{xy}^2, y = 1,2,\cdots b$.

When the absolute factor loading value of each criterion (referring to each row in A) approaches 0 or 1, the value of $\mathrm{V}(F)$ will become larger; at this moment, a simple structure exists. This study adopts the maximum variance method for the original rotation; in other words, choosing an original rotation matrix, δ, facilitates the maximization of the value of $\mathrm{V}(F\delta)$. Once $b = 2$, the original rotation matrix δ can be presented as follows.

$$\delta = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix}, \tag{5}$$

If the proper angle, θ, is chosen for the rotation, then the total variance, $F\delta$, can be maximized. When $b > 2$, the successive rotation of two criterion can be achieved. Thus, there are b numbers of criteria, and the rotation times are C_b^2. Once all the criteria have been rotated, a cycle has been completed. This cycle is repeated until the total variance reaches convergence.

3.2. Employing FSM-DEMATEL Categories Criteria

FSM is used to transfer linguistic preferences into comparable crisp values by employing membership grade theory [58]. Assuming EFA has been structured in c aspects by considering the interrelations of b number of criteria, and then these criteria are assessed by d experts. These assessments can be denoted as $\left(r_{ij}\right)_{bd}^{c}$. Therefore, r_{ij} represents the experts' linguistic preferences,

rated as extremely good (E), better (B), medium (M), lower (L), and poor (P). These linguistic preferences can be expressed as the following equation:

$$\left(r_{ij}\right)_{bd}^{c} = \left(P_{ij}, L_{ij}, M_{ij}, B_{ij}, E_{ij}\right)_{bd}^{c}, \tag{6}$$

where $P_{ij}, L_{ij}, M_{ij}, B_{ij}$, and E_{ij} represent the individual accumulating frequencies for each preference.

These accumulating frequencies need to be transferred into weights and acquire crisp values $\left(\mu_{ij}\right)_{b}^{c}$ by employing the equations below.

$$\left(r_{ij}\right)_{bd}^{c} = \left(P_{ij}, L_{ij}, M_{ij}, B_{ij}, E_{ij}\right)_{bd}^{c}, \tag{7}$$

$$\left(\mu_{ij}\right)_{b}^{c} = \left(1 \times \frac{P_{ij}}{d} + 2 \times \frac{L_{ij}}{d} + 3 \times \frac{M_{ij}}{d} + 4 \times \frac{B_{ij}}{d} + 5 \times \frac{E_{ij}}{d}\right)_{b}^{c}, \tag{8}$$

These crisp values must be arranged into the self-matrix S^{c} for each aspect using the following equation.

$$S^{c} = \begin{bmatrix} \mu_{11} & \mu_{12} & \cdots & \mu_{1b} \\ \mu_{21} & \mu_{22} & \cdots & \mu_{2b} \\ \vdots & \vdots & \ddots & \vdots \\ \mu_{b1} & \mu_{b2} & \cdots & \mu_{bb} \end{bmatrix}^{c} = \left[\mu_{ij}\right]_{b\times b}^{c}, \tag{9}$$

These self-matrices are integrated into a direct relation matrix, T, by adopting the geometric mean as shown in the equation below.

$$T = \sqrt[c]{\prod_{i=1}^{b}\left(\mu_{ij}\right)^{c}} = \left[t_{ij}\right]_{b\times b}, j = 1,2,\cdots,b, \tag{10}$$

The direct relation matrix still needs to be normalized to attain the normalized direct relation matrix, H', by adopting the following equation.

$$T' = \frac{t_{ij}}{\max\limits_{1\le i\le b}\sum_{i=1}^{b} t_i}, \tag{11}$$

Once the normalized direct relation matrix is obtained, the following equation generates the total relation matrix.

$$\tilde{T} = T'\left(\Gamma - T'\right)^{-1} = \left[\tilde{t}_{ij}\right]_{b\times b}, \tag{12}$$

where Γ is the unit matrix.

Using the equations below facilitates gathering the driving x and dependent y power.

$$t^{dr} = \left[\sum_{i=1}^{b}\tilde{t}_{ij}\right]_{b\times 1} = \left[\tilde{t}_{i}\right]_{b\times 1}, \tag{13}$$

$$t^{dp} = \left[\sum_{j=1}^{b}\tilde{t}_{ij}\right]_{1\times b} = \left[\tilde{t}_{j}\right]_{1\times b}, \tag{14}$$

Subsequently, a cause-and-effect diagram is generated by mapping the criteria based on the coordinates $(t^{dr} + t^{dp}, t^{dr} - t^{dp})$. Therefore, $(t^{dr} + t^{dp})$ presents the degree of importance; the higher the value is, the higher the importance. The formula $(t^{dr} - t^{dp})$ is used to categorize the criteria into cause $(t^{dr} - t^{dp} > 0)$ or effect $(t^{dr} - t^{dp} < 0)$ groups. Moreover, $(t^{dr} + t^{dp}, t^{dr} - t^{dp})$ separates the diagram into four sections: the first quadrant, with higher importance and causal influence, is called the driving section; the second quadrant is the voluntary section, with lower importance and causal influence; the third quadrant, with lower importance and effect influence, is the independent section; and the fourth quadrant is the problem section, with higher importance and effect influence.

3.4. Adopting FSM-DEMATEL Identifies the Effects among the Aspects

Calculating the measurement criticality, Q_{cb}, through the following equation shows how each criterion relates to the structured aspects.

$$Q_{cb} = \sqrt[c]{\prod_{i=1}^{b}\left(\mu_{ij}\right)_{b}^{c}} = \left[q_{ji}\right]_{c\times b}, \tag{15}$$

These measurement criticalities must be converted to factor weights to aggregate the influences of the criteria into structured aspects by adopting the equation below.

$$\widetilde{Q}_{cb} = \frac{m_j}{\sum_{j=1}^{\omega} m_j} = \left[\tilde{q}_{ji}\right]_{c\times\omega}, \tag{16}$$

where ω expresses the groups that are structured by the EFA.

Before generating the membership function, the following equation must be applied to aggregate the frequencies based on the ω groups to structure the aspects in advance.

$$R_{bk} = \left(\sqrt[b]{\sum_{i=1}^{b} P_{ij}}, \sqrt[b]{\sum_{i=1}^{b} L_{ij}}, \sqrt[b]{\sum_{i=1}^{b} M_{ij}}, \sqrt[b]{\sum_{i=1}^{b} B_{ij}}, \sqrt[b]{\sum_{i=1}^{b} E_{ij}}\right)_{\omega\times k} = \left[\tilde{r}_{io}\right]_{\omega\times k}, \tag{17}$$

Then, the membership function of the aspects must be associates with the factor weights and aggregated frequencies via the equation below.

$$Z_{bk} = \widetilde{Q}_{cb} \times R_{bk} = \left[\tilde{q}_{ji}\right]_{c\times\omega} \times \left[\tilde{r}_{io}\right]_{\omega\times k} = \left[\tilde{q}_{ji} \times \tilde{r}_{io}\right]_{c\times k} = \left[z_{jo}\right]_{\omega\times k}, \tag{18}$$

where $\left[z_{jo}\right]_{\omega\times k}$ can be rewritten as $\left[z_{jo}^{P}, z_{jo}^{L}, z_{jo}^{M}, z_{jo}^{B}, z_{jo}^{E}\right]_{\omega\times k}$.

However, these membership values functions are still not comparable. The aspects must be transferred to crisp values to generate the total relation matrix by employing the equations below.

$$T^{''} = \left[1 \times z_{jo}^{P} + 2 \times z_{jo}^{L} + 3 \times z_{jo}^{M} + 4 \times z_{jo}^{B} + 5 \times z_{jo}^{E}\right]_{\omega\times k} = \left[t_{jo}^{''}\right]_{c\times c}, \tag{19}$$

$$\tilde{T}^{''} = \frac{t_{jo}^{''}}{\max\limits_{1\le j\le c}\sum_{j=1}^{c} t_{j}^{''}}, \tag{20}$$

$$\tilde{T}^{''} = \tilde{T}^{''}\left(\Gamma - \tilde{T}^{''}\right)^{-1} = \left[\tilde{t}_{jo}^{''}\right]_{c\times c}, \tag{21}$$

Repeating Equations (13) and (14) generates the diagram of the aspects. Then, the threshold value for identifying the effects between two aspects is computed via the following equation.

$$\delta = \frac{\sum_{j=1}^{c} \tilde{t}_{jo}^{''}}{c^2}, o = 1,2,\cdots,c, \tag{22}$$

If $\tilde{t}_{jo}^{''} > \delta$, then there is an interrelation between these two criteria; otherwise, there are no effects.

3.3. Proposed Analytical Procedures

1. The proposed criteria were selected from the literature, and experts were consulted to ensure their validity. A total of 72 experts, including policy makers, industrial practitioners and academic researchers, were asked to assess the proposed criteria based on their experience and knowledge. The returned assessments had to adopt Equations (1)–(5) to structure the aspects.
2. Once the structured aspects were obtained, the experts were asked to make a second-round assessment to evaluating their performance by employing their linguistic preferences. These linguistic preferences had to be converted to crisp values for further analysis by applying Equations (6)–(8). Then, Equations (9) and (10) were utilized to generate the direct relation matrix for the criteria. Equations (11) and (12) facilitated the development of the total relation matrix.
3. Equations (13) and (14) enabled the computation of the driving and dependence power to create the cause-and-effect diagram. The measurement criticalities provided a continuous quantitative basis to identify the relations between the criteria and aspects through Equation (15). Equation (16) converted these measurement criticalities into factor weights.

4. Equations (17) and (18) generated the membership functions of the aspects. However, the membership function still needed to be converted to crisp values by exploiting Equation (19). Subsequently, Equations (20) and (21) were used to acquire the total relation matrix. Finally, the effects among the aspects were presented by identifying the threshold in Equation (22).

4. Results

This section presents the case information and analytical results. The analytical results follow the proposed analytical procedures for the numerical computations, thus enabling the application of the proposed hybrid method.

4.1. Case Information

The Chinese government is making a great effort to promote the economic revitalization of northeast China as part of the nation's economic transition. Northeast China is composed of Liaoning, Jilin and Heilongjiang Provinces. Liaoning Province has a better economic performance than the other two provinces. Because SMEs in Liaoning Province make up 99% of the entire number of enterprises, they generated 65% of the output value, 60% of the government taxation income and 70% of employment opportunities. These SMEs can be divided into online, offline and a combination of these types of services. After 135 projects and the 19th Communist Party of China National Congress, these SMEs were forced to adhere to the regulations and policies newly established by the Chinese government to pursue sustainability. For the online service type, these enterprises must optimize their delivery path to reduce CO_2 emissions and enhance packaging materials reuse. For the offline service type, several enterprises have attempted to seek substitute materials to eliminate the use of harmful materials and continue to reduce their energy consumption.

However, these SMEs have encountered difficulty in balancing the economic, environmental and social aspects of SD. Most enterprises are constrained by limited resources and lack an effective approach to assess SD performance and to provide guidelines for improvements. SME decision-makers might make inaccurate decisions that cause resource waste. Furthermore, complex interrelations might exist among the proposed criteria that make it difficult for SMEs to assess how to apply them. This study adopts EFA to simplify these complex interrelations by providing a structure and then proposes a hybrid method to transfer these interrelations into a visual diagram to provide effective and efficient guidelines.

4.2. Analytical Results

1. The qualification of the experts required at least seven years in the related industries. The proposed attributes were assessed based on their expertise and opinions. Once the assessments were returned, EFA was used to structure the aspects through adopting the principle components. Applying Equations (1)–(5) obtains the results presented in Table A1, which shows that criteria C11, C23 and C24 must be deleted from the proposed attributes to ensure that the factor loading is all above 0.6 with a significance level of 0.004 [58]. Sustainable supply chain management A1 is composed of C1 to C4; marketing management A2 consists of C5; C6 to C9 construct A3, strategic management; environmental management A4 is structured through C10 and C12; financial management A5 contains C13 to C15; and finally, A6, sustainable human resources management, is composed of C16 to C22.
2. When the second-round assessments were collected from the experts, these assessments were expressed in the linguistic preferences presented in Table A2. These linguistic preferences need to be converted to crisp values through Equations (6)–(8), as illustrated by Table A3. The crisp value of C1, marked in gray, is computed as $1 \times \frac{P_{ij}}{d} + 2 \times \frac{L_{ij}}{d} + 3 \times \frac{M_{ij}}{d} + 4 \times \frac{B_{ij}}{d} + 5 \times \frac{E_{ij}}{d} = 1 \times 0.091 + 2 \times 0.273 + 3 \times 0.242 + 4 \times 0.212 + 5 \times 0.182 = 3.121$. Table A4 displays the aggregating self-matrix associated with Equation (9). Equation (10) integrates all the self-

matrices of each aspect to attain the direct relation matrix. The value in gray in Table A5 shows the computation as $\sqrt[c]{\prod_{i=1}^{b}(\mu_{ij})^{c}} = \sqrt[6]{3.121 \times 3.242 \times 2.758 \times 2.545 \times 3.091 \times 2.788} = 2.914$.

3. Equations (11) and (12) normalize the direct relation matrix to generate the total relation matrix. Table A6 presents the driving and dependence power by utilizing Equations (13) and (14) to compute the causal degree $(t^{dr} - t^{dp})$ and importance level $(t^{dr} + t^{dp})$. Figure 1 shows that C1, C3, C12 and C21 fall into the driving section; then, C8, C13 and C14 are located in the problem section.

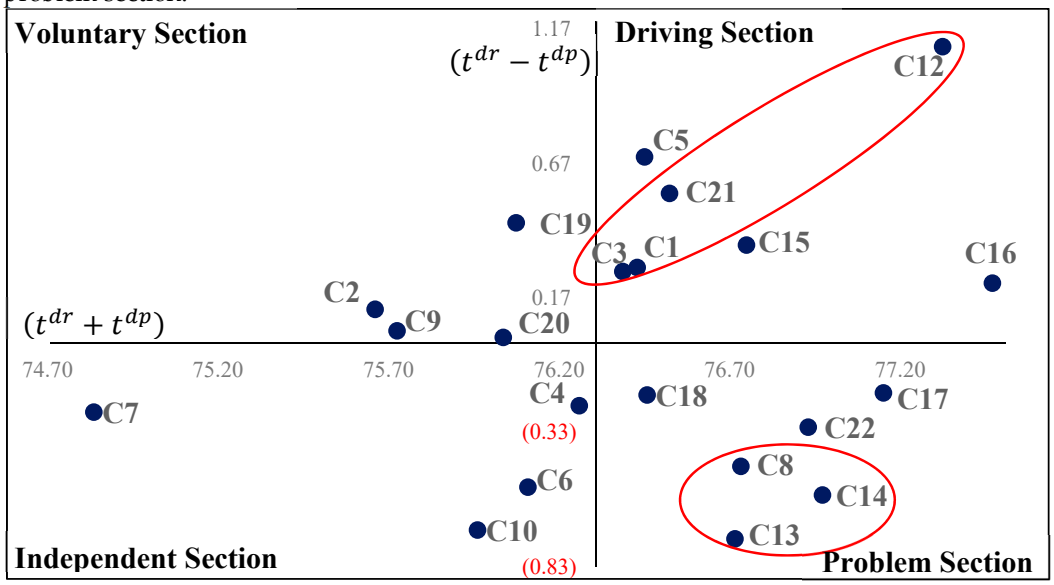

Figure 1. Cause-and-Effect Diagram for Criteria.

4. Table A7 provides the measurement criticalities and converting factor weights of the aspects. The measurement criticality for A1 under C1, marked in gray, is Q_{A1C1}, and the computation is stated as $\sqrt[21]{\begin{matrix}3.121 \times 3.273 \times 2.909 \times 2.576 \times 3.061 \times 3.152 \times 2.727 \times 3.212 \times \\ 2.879 \times 3.091 \times 2.697 \times 2.727 \times 3.212 \times 2.667 \times 3.545 \times 3.030 \times = 2.987 \\ 2.576 \times 3.303 \times 2.879 \times 3.030 \times 3.303\end{matrix}}$ by adopting Equation (15). Subsequently, Equation (16) attains the factor weight as $\tilde{Q}_{A1C1} = \frac{2.987}{(2.987+2.965+2.982+2.991)} = \frac{2.987}{11.925} = 0.250$.

5. Through Equations (17) and (18), the membership function of aspects Z_{A1A1} is calculated as $[0.250 \quad 0.249 \quad 0.250 \quad 0.251] \times \begin{bmatrix}0.190 & 0.202 & 0.176 & 0.167 & 0.198 \\ 0.212 & 0.185 & 0.171 & 0.178 & 0.193 \\ 0.218 & 0.164 & 0.168 & 0.210 & 0.185 \\ 0.194 & 0.198 & 0.164 & 0.174 & 0.203\end{bmatrix} =$ $[0.203 \quad 0.187 \quad 0.170 \quad 0.182 \quad 0.195]$, as marked in gray in Table A8. Equation (19) transfers the membership function into crisp value as $[1 \times 0.203 + 2 \times 0.187 + 3 \times 0.170 + 4 \times 0.182 + 5 \times 0.195] = 2.789$. Table A9 arranges these crisp values in a direct relation matrix to generate the total relation matrix by applying Equations (20) and (21).

6. Repeating Equations (13) and (14) generates the effect diagram of the aspects, as shown in Figure 2. Equation (22) is used to identify the threshold value as $\delta = \frac{\sum_{j=1}^{c} \tilde{t}''_{jo}}{c^2} = \frac{\left(\begin{matrix}15.417+15.755+15.409+15.485+15.573+15.588+15.509+15.843+15.494+15.581+15.663+15.685 \\ +15.067+15.404+15.063+15.141+15.225+15.244+15.341+15.679+15.336+15.401+15.496+15.513 \\ +15.185+15.518+15.165+15.254+15.336+15.355+15.526+15.862+15.514+15.595+15.684+15.700\end{matrix}\right)}{(6)^2} = \frac{556.608}{36} = 15.461$.
Table A10 presents the pairwise relations among the aspects; the value in gray is gathered as $\tilde{t}''_{A1A2} > \delta = 15.755 > 15.461$. Thus, an effect exists between A1 and A2. All the effects are drawn in the effect diagram of the aspects, as shown in Figure 2.

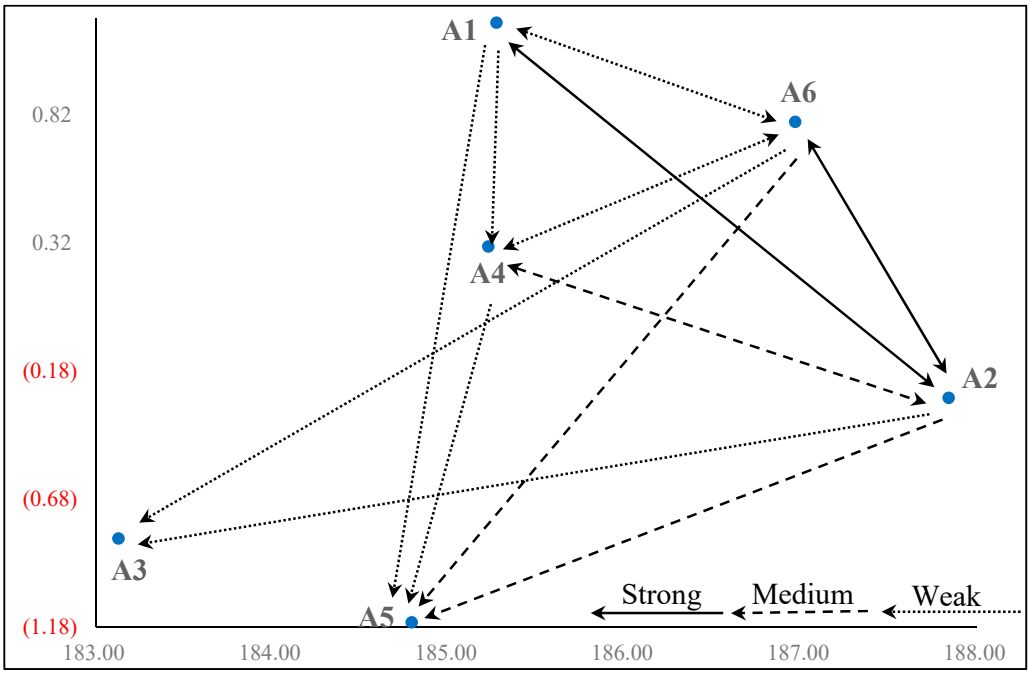

Figure 2. Effect Diagram of Aspects.

5. Implications

This section provides the significant implications of the analytical results. These implications can bed separate into theoretical and managerial implications to enhance the understanding of the theory, reinforce the theoretical basis and bridge the gap between theory and practice.

5.1. Theoretical Implications

Prior studies have attempted to investigate SD from diverse perspectives [59,60]. Few studies have considered the interrelations between SDs and SMEs by employing an enterprise decision-making model. To reflect the real-life situation, this study addresses this gap and provides guidelines for SMEs to improve their SD. The structured aspects came from internal business management, which enables internal activities to be efficiently and effectively improved. The analytical results show that sustainable supply chain management (A1), environmental management (A4) and sustainable resource management (A6) are the causal aspects that affect other aspects. In addition, strategic management (A3) and financial management (A5) are critical problems for SMEs in service industry.

Sustainable supply chain management refers to collaborating with supply chain partners through the voluntary integration of economic, environmental and social considerations and through efficient and effective internal business management to supply the products or services that fulfill the needs of customers and improve the profitability, competitiveness and resilience of the organization over the short and long term [4,61]. This finding confirmed that sustainable leadership (C1) and compliance with supply chain partners (C3) play important roles in sustainable supply chain management to implement SD. Sustainable supply chain management involves large-scale SD; however, this study reveals that sustainable supply chain management has a strong interrelation only with marketing management. Although it can affect sustainable human resources and environmental and financial management directly, these effects are weak and may be insufficient to generate the dynamic needed to effectively achieve the improvement. In fact, it relies on marketing management to generate the dynamic to achieve financial management improvement.

Sustainable human resources management has a weak interrelation with sustainable supply chain management and environmental management and interacts strongly with marketing management. In addition, it enables SMEs to improve SD by considering a direct relationship with strategic and financial management. The analytical results confirmed the argument of Chams and García-Blandón [62] that sustainable human resources management and SD are interconnected through the general element of the human factor because attitudes, behaviors and resource consumption generate an immediate effect on society and ecology. This argument clearly states that the purpose of sustainable human resource management is to align with the organizational strategies for balancing the growth of business and SD. Thus, the results show that SMEs must ensure the health and safety (C21) of their customers and employees to achieve sustainable human resources management.

Environmental management has separate weak and medium interrelations with sustainable human resources and marketing management. It also has a weak direct effect on financial management. In other words, decreasing natural resource consumption (C12) can reinforce environmental management and generate the necessary dynamics for SMEs to pursue SD by improving financial management. If SMEs enable efficient and effective environmental management, they may be able to achieve financial benefits as a buffer to absorb the risk of launching SD. Most enterprises prefer to invest in financial management rather than in environmental management [58], as it is difficult to see the return on investment in environmental management in the short term. SD is a long-term campaign, particularly for SMEs, and requires decision-makers to consider long-term instead of short-term benefits.

Currently, SMEs encounter difficulties in strategic and financial management caused by insufficient information transparency for stakeholders (C8), a lack of capital optimization and configuration (C13) and insufficient diversity in financial channels (C14). However, these aspects fall into the effect section, which means that the SD improvements cannot be made by investing directly in these aspects. Improvement in these areas requires strengthening SD performance by investing in causal aspects (including sustainable supply chain management, environmental management and sustainable resource management) to carry out the improvements. Moreover, the analytical results provide evidence that SMEs should launch SD by considering internal business management. Internal business management enables SMEs to facilitate their search for a competitive advantage while taking SD into account.

5.2. Managerial Implications

In Liaoning Province, most SMEs are family businesses or businesses with friendly relationships that enable them to promote awareness and comply easily with the related regulations and standards. Therefore, top managers play a critical role in delivering SD information to employees, stakeholders and customers, which requires sustainable leadership in developing these relations. To enhance sustainable leadership, local governments attempt to reinforce environmental awareness by holding conferences or meetings to spread the relevant SD information. Some owners who possess sustainable leadership skills have paid considerable attention to searching for optimal ways to mix reused materials with raw materials in their production processes while ensuring quality and safety. In addition, they provide training courses to their employees to increase their success in practicing SD.

As Wu et al. [26] noted, Chinese enterprises consider establishing a rigid relation the first priority. This was confirmed in this study through the finding that supply chain management is located in the causal section with both higher causal effect and importance. To strengthen compliance with supply chain partners, several procedures facilitate such compliance, such as enhancing confidence through collaboration, careful selection of supply chain partners, repeating cooperation through games to attain co-benefits, establishing a fair benefit sharing mechanism and motivating group learning among supply chain partners. Liaoning SMEs believe that a rigid relation enables an increase in the transparency of information and shares the risk through an efficient communication platform in launching SD.

Decreasing natural resource consumption is an effective practice of responsible consumption and production in achieving SD. Chavez and Sharma [63] mentioned that a closed-loop supply chain enables a decrease in natural resource consumption through remanufacturing, reusing, recycling and repairing in the process of providing products or services. Liaoning SMEs strive to search for technology to reduce the utilization of natural resources by enhancing production efficiency. However, this approach is a double-edged sword because once an enterprise enables the use of reused materials in production, quality and safety become major concerns. SMEs must find the optimal combination of reused materials and raw materials while guaranteeing the safety of their products. For example, for a pipe manufacturer to produce the pipe that is used to deliver gas, petroleum and other products that require a high level of safety, the production process must use 100% raw materials to ensure quality and safety. Thus, decreasing natural resource consumption depends on the situation of the SME in practicing SD.

Recently, an increasing number of scandals have emerged in terms of food, vaccines, medicines, etc., destroying the trust of the public in those enterprises. Ensuring health and safety in providing products or services is a basic principle for enterprises, and SMEs in particular must take this principle as a core value in fulfilling customer demands. However, health and safety do not just mean considering customers; SMEs also need to provide health and safety in the working conditions of their employees. As Maslow's hierarchy of needs demonstrated, health and safety belong to the second demand after the physiological demand. The bottom line of health and safety relies on the local government to establish the relative regulations and policies in guiding SMEs.

Furthermore, Liaoning SMEs encounter difficulty in capital optimization and configuration, offering information transparency for stakeholders and diversifying financial channels, which show the problems of financial management. However, these criteria are located in the effect section; therefore, SD improvements cannot be made by investing directly in these criteria. Accordingly, the core problem criteria must be addressed by decreasing natural resource consumption, improving health and safety, practicing sustainable leadership and complying with supply chain partners to generate the dynamic to improve SD.

6. Conclusions

SMEs are forced to launch SD to adhere to regulations and meet public expectations based on higher public environmental awareness. Approximately 70% of industrial pollution is generated by SMEs due to the lack of an efficient and effective approach to assess the performance in conditions of complexity and uncertainty. Although SMEs understand that pursuing sustainability enables them to conquer these issues, they still experience resource constraints, in contrast to large enterprises. If SD practices are simply shifted from large enterprises to SMEs, then the features of SMEs have not been examined for suitability. Therefore, this study structures the aspect of internal business management by employing EFA to reduce complexity and ensure context validity. Subsequently, FSM-DEMATEL is used as a hybrid method to overcome the uncertainties and enable the shift of the interrelations into hierarchical relations by providing a visual analysis to guide the improvement.

This study contains three types of contributions. For the theoretical contribution, the analytical results provide evidence to strengthen the understanding of SD from the perspective of internal business management. In terms of method, the proposed hybrid method simplifies the complex interrelations in a hierarchical structure and then provides a visual analysis by identifying the causal and effect influences. Furthermore, the assessments are stated in linguistic preferences that enable them to be converted to comparable values to present the performance. Liaoning SMEs can attain guidelines from the diagram to make effective and efficient improvements under resource constraints. The results reveal that strategic and financial management are the current major problems. If Liaoning SMEs want to improve these two problems, their resources need to be invested in sustainable human resources, sustainable supply chain management and environmental management to attain the maximum improvement.

The analytical results indicate that SD is needed to formulate six types of internal business management to provide a specific direction for SMEs. In addition, the proposed criteria and structural

aspects reflect the current performance of Liaoning SMEs. Therefore, capital optimization and configuration, diversifying financial channels and offering information transparency for stakeholders are the core problems that cause poor performance in financial and strategic management. Because these factors are located in the effect section, SEMs must rely on investing in the driving attributes, including decreasing natural resource consumption, improving health and safety, practicing sustainable leadership and complying with supply chain partners to improve SD. Without these analytical results, SMEs encounter difficulty in investing their resources in the right areas to generate the most effective impact under resource constraints.

This study has several limitations. Although it strives to select the attributes that reflect the real-life situation of Liaoning SMEs, several considerations are still omitted. Therefore, future studies can include as many more criteria as possible for a comprehensive discussion. Liaoning Province is the focal region that this study proposes to investigate, which might indicate insufficient generalizability. To address this issue, further discussions can follow the proposed analytical procedures to compare different industries, provinces or nations. The assessment is based on experts' opinions and knowledge, which may be highly subjective. To overcome this limitation, a combination of quantitative data, qualitative information and social media data should be considered to eliminate the subjective nature of such an assessment.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Exploratory Factor Analysis.

Aspects		Cronbach's Alpha	Criteria		Factor Loading
A1	Sustainable Supply Chain Management	0.733	C1	Sustainable Leadership	0.871
			C2	Organization Management System	0.623
			C3	Compliance with Supply Chain Partners	0.814
A2	Marketing Management	0.662	C4	Stakeholder Engagement	0.830
			C5	Green Marketing	0.662
A3	Strategic Management	0.858	C6	Research and Development Investments	0.720
			C7	Service Strategy Positioning	0.798
			C8	Offering Information Transparency for Stakeholders	0.831
			C9	Government Certification	0.864
A4	Environmental Management	0.718	C10	Solid Waste Reduction	0.867
			C12	Decreasing Natural Resources Consumption	0.782
A5	Financial Management	0.885	C13	Capital Optimization and Configuration	0.616
			C14	Diversifying Financial Channels	0.666
			C15	Margin Improvement	0.860
A6	Sustainable Human Resources Management	0.806	C16	Accepting Customer Advice	0.802
			C17	Adopting the SD Concept in Business Management	0.583
			C18	Human Resources Efficiency	0.799

	C19	Employee Incentives	0.803
	C20	Providing High-Quality Service with Rewards	0.796
	C21	Health and Safety	0.667
	C22	Staff Service Values	0.770

Table A2. Sample Assessment for Criteria under A1.

	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**	**E16**	**E17**	**E18**	**E19**	**E20**	**E21**	**E22**	**E23**	**E24**	**E25**	**E26**	**E27**	**E28**	**E29**	**E30**	⋯	**E72**
C1	B	E	M	E	P	L	B	P	B	L	P	B	P	L	E	L	E	E	B	E	E	P	B	M	B	E	M	P	B	E	⋯	P
C2	M	P	B	E	L	B	L	M	E	M	B	P	M	B	B	M	P	B	M	B	B	M	E	L	E	E	L	E	L	E	⋯	M
C3	E	L	M	E	M	P	B	E	L	P	B	P	E	E	M	L	B	P	L	B	P	E	L	P	L	E	B	L	E	L	⋯	L
C4	B	M	E	B	E	P	E	B	M	L	E	E	M	M	M	P	M	L	P	E	P	M	E	B	L	P	P	M	E	E	⋯	P
C5	L	L	E	L	B	E	M	L	B	E	P	P	P	E	E	E	M	B	B	P	L	L	B	M	B	P	M	B	E	E	⋯	P
C6	P	B	M	B	P	M	P	E	P	E	E	P	M	B	M	L	M	L	P	P	E	E	L	L	P	B	L	B	E	L	⋯	P
C7	P	M	E	L	P	L	L	L	L	L	L	M	M	E	L	B	L	P	L	E	E	E	E	P	B	M	B	B	E	M	⋯	E
C8	B	M	E	M	P	M	B	E	P	E	P	M	P	P	L	L	P	L	L	E	E	E	M	L	M	E	B	E	M	E	⋯	M
C9	B	B	M	P	L	M	P	P	L	B	E	B	E	M	P	M	B	E	L	P	M	E	M	E	P	L	B	B	M	E	⋯	E
C10	L	E	M	E	M	P	E	M	M	B	B	B	L	P	M	B	B	P	M	P	E	P	M	B	E	B	L	P	L	M	⋯	B
C12	L	B	E	L	E	E	L	P	L	P	B	E	P	P	M	L	E	M	M	E	L	E	E	M	M	E	M	P	L	M	⋯	M
C13	E	L	P	M	B	M	B	E	M	P	L	B	E	P	M	B	B	L	P	L	E	M	L	B	M	P	P	M	P	B	⋯	L
C14	M	P	P	P	M	E	L	B	M	B	L	B	B	M	B	E	E	P	P	E	L	E	P	B	P	E	E	M	P	B	⋯	E
C15	L	M	M	E	P	E	P	B	B	P	E	B	P	B	B	M	E	E	P	L	L	P	L	B	E	L	P	M	M	E	⋯	M
C16	E	B	P	M	B	P	B	L	P	B	B	B	M	P	M	E	P	P	B	P	E	P	B	E	M	P	P	M	B	L	⋯	M
C17	L	E	E	E	E	E	E	P	L	L	B	B	L	M	B	P	P	E	M	E	E	M	E	E	L	P	M	E	E	P	⋯	B
C18	P	E	E	L	M	M	M	E	M	P	L	B	L	P	B	P	P	E	B	E	L	P	P	B	E	P	M	M	B	E	⋯	P
C19	M	B	E	P	P	P	P	L	M	M	P	L	L	P	E	E	P	L	B	L	M	E	M	B	E	P	P	L	B	B	⋯	E
C20	E	E	P	L	B	P	P	M	M	E	P	M	E	L	E	M	M	E	B	B	B	E	E	M	P	E	E	B	M	P	⋯	B
C21	L	M	B	E	L	M	M	L	B	M	B	M	P	E	P	E	L	M	P	E	E	B	L	B	P	M	P	B	B	M	⋯	E
C22	B	E	M	E	P	L	B	P	B	L	P	B	P	L	E	L	E	E	B	E	E	P	B	M	B	E	M	P	B	E	⋯	P

1

Table A3. Crisp Values of Criterion C1 under A1.

	P	L	M	B	E	Crisp Value
C1	0.091	0.273	0.242	0.212	0.182	3.121
C2	0.242	0.091	0.182	0.061	0.424	3.333
C3	0.152	0.273	0.030	0.212	0.333	3.303
C4	0.152	0.182	0.152	0.212	0.303	3.333
C5	0.182	0.182	0.212	0.182	0.242	3.121
C6	0.182	0.242	0.242	0.091	0.242	2.970
C7	0.212	0.242	0.182	0.303	0.061	2.758
C8	0.242	0.152	0.152	0.303	0.152	2.970
C9	0.333	0.152	0.182	0.121	0.212	2.727
C10	0.152	0.303	0.303	0.152	0.091	2.727
C12	0.242	0.121	0.212	0.152	0.273	3.091
C13	0.121	0.333	0.273	0.152	0.121	2.818
C14	0.121	0.182	0.394	0.121	0.182	3.061
C15	0.242	0.091	0.212	0.182	0.273	3.152
C16	0.273	0.212	0.121	0.061	0.333	2.970
C17	0.212	0.121	0.121	0.333	0.212	3.212
C18	0.212	0.212	0.121	0.273	0.182	3.000
C19	0.242	0.242	0.152	0.121	0.242	2.879
C20	0.152	0.242	0.152	0.242	0.212	3.121
C21	0.242	0.152	0.212	0.212	0.182	2.939
C22	0.182	0.242	0.242	0.273	0.061	2.788

2

Table A4. Self-matrix of C1 under A1.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22
C1	3.121	3.273	2.909	2.576	3.061	3.152	2.727	3.212	2.879	3.091	2.697	2.727	3.212	2.667	3.545	3.030	2.576	3.303	2.879	3.030	3.303
C2	3.333	2.879	2.909	3.333	2.485	2.879	2.788	2.848	3.000	2.788	3.091	3.030	3.091	2.818	3.061	2.909	2.939	2.576	3.121	3.212	3.364
C3	3.303	2.576	2.818	3.030	3.061	3.000	3.303	3.152	2.879	3.182	2.667	2.909	2.758	2.879	3.242	3.091	3.091	3.152	2.970	2.939	2.758
C4	3.333	2.667	2.939	3.061	3.242	2.909	2.758	2.939	3.061	2.818	3.152	2.727	3.303	2.697	3.364	2.970	2.939	2.909	3.394	2.848	2.939
C5	3.121	2.939	2.970	2.667	3.121	2.606	2.788	2.848	2.758	2.545	3.121	3.273	3.273	3.091	3.061	2.970	2.879	3.242	2.818	3.455	3.091
C6	2.970	2.939	3.030	3.303	3.364	3.061	2.667	3.303	2.788	3.152	3.152	2.758	3.212	2.818	2.667	3.212	3.030	3.030	2.788	2.455	3.030
C7	2.758	2.818	2.515	3.485	2.727	3.394	3.091	3.303	2.939	2.879	3.030	3.030	2.788	3.242	2.758	3.333	2.970	2.455	2.818	3.091	2.848
C8	2.970	2.879	2.758	2.879	2.848	2.758	3.030	3.000	2.909	3.091	3.030	2.909	3.485	2.909	3.333	3.212	2.818	2.909	2.788	2.970	3.182
C9	2.727	3.000	3.030	3.121	3.152	2.879	3.091	3.303	3.000	2.879	2.697	3.273	3.091	2.848	3.242	2.636	2.939	2.970	2.909	2.909	2.879
C10	2.727	2.909	3.030	2.818	2.545	2.727	2.848	2.697	2.424	3.273	3.030	3.030	3.121	3.121	3.000	2.758	2.364	2.848	2.970	3.091	2.788
C12	3.091	3.424	3.061	3.000	3.000	2.909	3.000	3.515	3.061	2.758	3.242	3.364	2.697	3.121	3.182	3.061	3.515	3.061	3.030	3.212	3.182
C13	2.818	3.212	2.636	2.667	2.697	3.212	2.697	3.424	2.939	2.818	2.636	2.970	3.121	2.848	3.242	3.182	3.152	2.939	2.667	3.000	2.788
C14	3.061	3.182	3.242	3.273	3.212	2.758	3.091	3.030	2.879	3.061	2.667	3.061	3.152	2.758	2.545	3.303	3.424	3.030	3.121	3.030	2.758
C15	3.152	3.091	3.182	3.091	3.061	2.697	2.939	3.182	2.939	3.273	3.091	3.364	3.061	2.636	3.121	3.000	3.303	2.515	2.667	3.485	3.182
C16	2.970	2.788	2.848	2.818	2.848	2.848	3.030	3.333	3.091	3.273	3.000	2.909	3.030	3.303	3.121	3.364	2.758	2.818	2.848	3.121	2.758
C17	3.212	3.212	3.091	3.364	2.576	3.000	3.424	3.121	3.000	3.212	2.879	3.152	3.121	3.030	3.273	3.152	3.061	3.182	2.848	3.000	2.909
C18	3.000	3.152	2.939	3.424	2.788	2.788	2.818	2.636	3.121	3.212	3.061	3.061	2.545	2.818	2.879	3.455	3.485	3.091	2.697	2.848	3.030
C19	2.879	2.848	3.212	2.788	2.455	2.606	3.121	3.424	3.333	2.970	2.758	3.303	2.909	3.091	3.212	3.061	2.818	2.667	3.212	2.879	3.152
C20	3.121	3.212	2.848	3.212	2.515	2.515	2.788	2.788	2.667	3.242	3.061	2.970	3.242	3.121	2.970	2.909	3.000	3.061	3.061	2.758	3.455
C21	2.939	2.970	3.303	3.364	3.121	3.394	2.909	3.152	2.848	3.212	2.909	2.909	3.152	3.152	3.000	2.939	3.061	2.970	3.182	3.182	3.333
C22	2.788	3.000	3.212	2.606	2.939	3.364	3.182	2.788	3.576	3.394	2.970	3.091	2.636	3.394	2.758	2.879	3.242	3.030	3.030	3.000	3.242

Table A5. Direct Relation Matrix of Criteria.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22
C1	2.914	2.954	3.007	3.103	3.098	3.091	2.904	3.027	2.883	3.002	2.888	2.925	3.038	2.906	3.362	3.092	2.898	3.197	2.900	2.845	3.152
C2	3.007	2.878	2.811	3.063	2.869	2.959	2.792	3.037	2.919	2.910	3.001	2.973	3.215	2.896	3.040	3.011	2.896	2.709	3.100	3.127	3.211
C3	3.008	3.069	3.134	3.004	3.016	3.050	3.159	2.953	2.876	3.113	2.921	3.021	2.815	2.980	3.133	3.121	2.873	3.031	2.991	2.933	2.947
C4	3.001	2.733	2.960	3.036	3.060	2.886	2.890	3.053	2.976	2.922	3.054	2.844	3.198	2.828	3.153	3.052	3.011	2.963	3.136	2.925	2.936
C5	3.094	2.930	2.999	2.741	3.100	3.016	3.003	2.963	2.955	2.740	3.031	3.146	3.074	3.070	3.064	2.989	3.022	3.201	3.012	3.208	3.178
C6	3.000	2.984	2.922	3.104	3.071	2.945	2.847	3.074	2.749	2.980	3.090	2.849	2.921	2.969	2.914	2.953	3.003	3.100	3.005	2.679	3.090
C7	2.819	2.809	2.852	3.016	2.711	3.056	2.940	3.050	2.924	2.810	3.075	3.062	2.930	3.027	2.776	3.150	2.963	2.584	2.994	2.926	2.963
C8	3.188	2.885	2.831	2.727	3.021	3.044	2.920	2.924	2.877	3.016	3.104	2.855	3.224	2.944	3.281	3.140	3.007	2.997	2.911	2.902	3.022
C9	2.952	2.832	2.980	2.882	3.181	2.954	2.923	2.998	3.102	2.873	2.782	3.326	3.095	2.893	3.001	2.720	2.994	3.008	3.097	2.846	2.982
C10	2.893	3.031	3.087	2.959	2.854	3.089	2.790	2.872	2.884	3.045	3.138	2.952	3.124	3.041	2.957	2.896	2.626	2.919	2.990	3.017	2.832
C12	3.043	3.137	3.159	2.994	3.021	3.058	2.952	3.138	3.036	2.900	3.049	3.432	2.904	3.091	3.056	3.059	3.284	3.012	2.982	3.117	3.180
C13	2.963	2.971	2.840	2.968	2.972	3.147	2.937	3.090	2.949	3.004	2.848	2.953	3.147	2.911	3.096	3.087	3.145	2.989	2.712	2.953	2.915
C14	3.096	2.989	2.927	3.103	3.036	2.859	2.988	2.944	3.036	2.951	2.928	2.971	3.108	2.997	2.800	2.992	3.199	3.060	3.095	2.992	2.871
C15	2.789	2.807	3.141	3.097	2.974	3.012	2.933	3.230	3.103	3.013	3.131	3.276	3.079	2.898	3.175	3.021	3.133	2.622	2.716	3.305	3.063
C16	3.086	3.105	2.905	3.030	3.042	3.052	3.017	3.027	3.008	3.190	3.049	3.027	3.100	3.170	3.080	3.279	2.913	2.948	2.904	3.194	2.875
C17	3.015	3.013	2.975	3.071	2.769	3.084	3.149	3.067	2.989	3.156	2.977	3.161	2.966	3.109	3.047	3.146	2.958	3.151	2.878	2.820	2.912
C18	3.047	2.976	2.989	2.981	2.921	3.039	2.732	2.869	2.987	3.143	2.975	3.069	2.835	2.941	2.894	3.228	3.272	3.169	2.855	2.887	3.015
C19	2.956	3.121	2.915	3.022	2.759	2.972	3.117	3.217	3.022	2.855	2.965	3.045	3.068	3.068	3.108	3.085	2.888	2.715	3.146	2.868	3.129
C20	2.915	2.990	3.105	3.012	2.959	2.854	2.890	2.931	2.920	3.150	3.014	2.926	3.066	3.020	2.953	2.907	2.933	2.987	2.990	2.839	3.292
C21	2.893	3.033	3.077	2.994	3.062	3.077	2.947	3.054	2.945	3.118	2.958	2.873	3.170	2.968	2.987	2.949	2.991	2.964	3.121	3.236	3.080
C22	3.036	2.969	3.090	3.099	2.904	2.890	3.026	3.071	3.197	3.241	2.808	3.115	2.795	3.189	2.756	2.823	3.121	2.957	3.087	2.959	2.995

1

Table A6. Driving and Dependence Power.

	t^{dr}	t^{dp}	$t^{dr} + t^{dp}$	$t^{dr} - t^{dp}$
C1	38.352	38.068	76.420	0.283
C2	37.890	37.762	75.652	0.128
C3	38.323	38.055	76.378	0.268
C4	38.010	38.241	76.250	(0.231)
C5	38.568	37.874	76.442	0.695
C6	37.783	38.317	76.100	(0.534)
C7	37.286	37.541	74.827	(0.255)
C8	38.134	38.591	76.724	(0.457)
C9	37.882	37.834	75.716	0.047
C10	37.629	38.323	75.952	(0.694)
C12	39.211	38.105	77.316	1.106
C13	37.990	38.717	76.707	(0.728)
C14	38.200	38.764	76.963	(0.564)
C15	38.554	38.187	76.741	0.367
C16	38.844	38.618	77.462	0.225
C17	38.479	38.663	77.142	(0.183)
C18	38.129	38.320	76.449	(0.191)
C19	38.258	37.808	76.065	0.450
C20	38.025	38.002	76.028	0.023
C21	38.537	37.978	76.515	0.559
C22	38.305	38.616	76.921	(0.312)

2

Table A7. Converting Factor Weights of Aspects.

c \ b		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22
A1	Q_{cb}	2.987	2.965	2.982	2.991	2.974	2.978	2.953	2.979	2.975	2.854	3.111	2.927	3.022	3.039	2.988	3.081	2.982	2.975	2.967	3.091	3.043
	$\widetilde{Q}_{cb}$	0.250	0.249	0.250	0.251	1.000	0.251	0.249	0.251	0.250	0.478	0.522	0.326	0.336	0.338	0.141	0.146	0.141	0.141	0.140	0.146	0.144
A2	Q_{cb}	2.928	3.047	3.064	2.995	3.008	3.030	2.918	3.003	3.041	3.059	3.030	3.080	2.962	3.073	3.083	2.965	2.996	2.940	2.966	3.036	2.934
	$\widetilde{Q}_{cb}$	0.243	0.253	0.255	0.249	1.000	0.253	0.243	0.250	0.254	0.502	0.498	0.338	0.325	0.337	0.147	0.142	0.143	0.141	0.142	0.145	0.140
A3	Q_{cb}	3.137	2.908	2.984	3.058	3.014	2.980	2.911	3.033	2.895	3.019	3.038	2.909	2.998	3.014	3.031	2.970	3.019	2.999	2.980	2.962	2.928
	$\widetilde{Q}_{cb}$	0.260	0.241	0.247	0.253	1.000	0.252	0.246	0.257	0.245	0.498	0.502	0.326	0.336	0.338	0.145	0.142	0.145	0.144	0.143	0.142	0.140
A4	Q_{cb}	3.008	3.041	3.012	2.899	3.124	2.943	2.918	2.975	2.981	2.950	3.068	3.032	3.002	2.962	3.130	2.974	2.946	3.035	2.941	3.017	3.031
	$\widetilde{Q}_{cb}$	0.252	0.254	0.252	0.242	1.000	0.249	0.247	0.252	0.252	0.490	0.510	0.337	0.334	0.329	0.149	0.141	0.140	0.144	0.140	0.143	0.144
A5	Q_{cb}	2.977	2.995	3.025	2.990	3.006	2.882	2.912	2.969	2.955	2.947	3.074	2.950	2.994	3.009	3.000	3.054	3.000	3.015	3.110	3.014	3.029
	$\widetilde{Q}_{cb}$	0.248	0.250	0.252	0.249	1.000	0.246	0.248	0.253	0.252	0.489	0.511	0.329	0.334	0.336	0.141	0.144	0.141	0.142	0.147	0.142	0.143
A6	Q_{cb}	3.004	2.866	2.969	2.948	3.016	2.961	2.922	2.972	2.973	2.875	3.095	2.999	2.966	3.051	3.016	3.058	3.021	3.014	2.932	3.023	3.057
	$\widetilde{Q}_{cb}$	0.255	0.243	0.252	0.250	1.000	0.250	0.247	0.251	0.251	0.482	0.518	0.333	0.329	0.338	0.143	0.145	0.143	0.143	0.139	0.143	0.145

Table A8. Membership Function and Crisp Values of Aspects.

	A1						**A2**						**A3**					
	Z_{bk}					t''_{jo}	Z_{bk}					t''_{jo}	Z_{bk}					t''_{jo}
A1	**0.203**	**0.187**	**0.170**	**0.182**	**0.195**	**2.789**	0.183	0.197	0.177	0.189	0.198	2.855	0.188	0.185	0.173	0.202	0.190	2.835
A2	0.192	0.177	0.192	0.187	0.191	2.828	0.209	0.163	0.159	0.210	0.188	2.795	0.191	0.171	0.168	0.191	0.192	2.763
A3	0.185	0.199	0.201	0.131	0.183	2.629	0.186	0.173	0.192	0.190	0.190	2.818	0.199	0.183	0.192	0.177	0.179	2.743
A4	0.191	0.180	0.187	0.185	0.186	2.781	0.171	0.170	0.214	0.185	0.197	2.876	0.184	0.184	0.174	0.188	0.210	2.874
A5	0.130	0.193	0.179	0.191	0.193	2.784	0.186	0.178	0.176	0.196	0.201	2.855	0.191	0.185	0.199	0.128	0.190	2.618
A6	0.182	0.187	0.186	0.192	0.190	2.832	0.189	0.181	0.194	0.182	0.190	2.811	0.191	0.185	0.191	0.185	0.185	2.800
	A4						**A5**						**A6**					
	Z_{bk}					t''_{jo}	Z_{bk}					t''_{jo}	Z_{bk}					t''_{jo}
A1	0.197	0.170	0.191	0.178	0.193	2.784	0.189	0.192	0.178	0.185	0.195	2.823	0.210	0.192	0.175	0.180	0.187	2.774
A2	0.175	0.175	0.161	0.199	0.217	2.887	0.183	0.173	0.195	0.208	0.172	2.808	0.184	0.179	0.186	0.192	0.201	2.876
A3	0.193	0.191	0.185	0.183	0.179	2.755	0.206	0.197	0.179	0.171	0.187	2.757	0.182	0.209	0.198	0.165	0.185	2.780
A4	0.177	0.103	0.180	0.208	0.179	2.650	0.173	0.194	0.184	0.192	0.185	2.804	0.189	0.181	0.186	0.187	0.187	2.791
A5	0.185	0.180	0.194	0.179	0.193	2.809	0.129	0.195	0.182	0.181	0.194	2.756	0.126	0.199	0.179	0.190	0.191	2.776
A6	0.180	0.192	0.185	0.188	0.193	2.833	0.182	0.182	0.188	0.192	0.197	2.865	0.180	0.187	0.185	0.196	0.189	2.835

Table A9. Total Relation Matrix of Aspects.

	A1	A2	A3	A4	A5	A6
A1	15.417	15.755	15.409	15.485	15.573	15.588
A2	15.509	15.843	15.494	15.581	15.663	15.685
A3	15.067	15.404	15.063	15.141	15.225	15.244
A4	15.341	15.679	15.336	15.401	15.496	15.513
A5	15.185	15.518	15.165	15.254	15.336	15.355
A6	15.526	15.862	15.514	15.595	15.684	15.700

Table A10. Relation Identification Matrix of Aspects.

	A1	A2	A3	A4	A5	A6
A1	0.000	15.755	0.000	15.485	15.573	15.588
A2	15.509	15.843	15.494	15.581	15.663	15.685
A3	0.000	0.000	0.000	0.000	0.000	0.000
A4	0.000	15.679	0.000	0.000	15.496	15.513
A5	0.000	15.518	0.000	0.000	0.000	0.000
A6	15.526	15.862	15.514	15.595	15.684	15.700

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