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Research Article

Financial Performance Assessment by a Type-2 Fuzzy Logic Approach

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Any company must constantly innovate if they want to maintain its market share in the present cutthroat and unstable industry. Innovation has a big influence on consumer behavior, yet it goes against the principles of sustainability. The issue of sustainability has become crucial to their company's growth. In order to evaluate a business firm's sustainability performance statistically, a new and effective fuzzy logic tool is created. Evolution and assessment are performed by a novel interval type-2 fuzzy logic inference system. The judgment of the inference system is carried out on the basis of type-2 fuzzy logic (T2FL), principal component analysis (PCA), and statistical data analysis. The main input variables include corporate environmental performance (CEP) and corporate financial performance (CFP). The suggested approach can effectively examine a corporation's sustainable performance, according to experimental findings. A unique approach that makes use of language variables and if-then logic to assist quantitative business sustainability events is the link between CEP and CFP. The recommended test will provide senior administrative leaders with useful information to supervise natural concerns correctly and gauge their commitment to company success.

1. Introduction

The nature of CSP is generally enormously nonlinear, partially inconsistent and multidimensional, vague, and uncertain [1, 2]. A large number of operators, each competent to forecast the extent of business responses to environmental challenges, define the CSP. The main purpose of the CSP is to present an imprecise or uncertain model to evaluate a CEP and CFP. Many studies have recently documented and produced sustainable performance based on two dimensions, which comprise a number of significant affecting factors. There are two dimensions: CEP and CFP. They took some relevant measurements of the financial and environmental markers in order to analyze the two aspects.

The performance assessment has been widely studied. For example in [3], a fuzzy system is suggested to develop the conventional method based on complex proportional assessment approach. A fuzzy model is designed in [4] to construct a model for budget management. In the study of [5], a decision-making system is designed by fuzzy systems, and it is shown that the amusement accuracy of fuzzy approach is better than conventional step-wise weight assessment approach. A fuzzy assessing approach is suggested in [6], for the assessment and selection of fuel vehicles, and it is shown that the fuzzy approach leads to the vehicles with least decreasing carbon emissions. A risk assessment approach is studied in [7], and the risk awareness is classified. In the study of [8], an empirical approach is proposed to analyze the financial scheme of private enterprises in China. The structural equation modeling approach is developed in [9], and the effect if COVID-19 is analyzed.

Creativity is the only way to solve any complex, multilevel problems [10] in every sector or in every domain [11]. Human development is dependent on the psychology of creativity. The employment of creative practices supports the efficacy of a continuous scientific literacy to assist society, and creative thinking influences the growth of cognitive capabilities [11]. Creativity is not synonymous with innovation since it may express in a variety of ways that are unrelated to commercial activity [12]. Although both are required to solve complicated technical, managerial, or social problems [10]. When innovative ideas are applied successfully, they are regarded as the germ of innovation inside a business [13]. A crucial component of innovation is change, as well as novelty. How do companies maintain a competitive edge in environments and markets that change quickly while still promoting long-term growth? One increasingly important way for organizations to achieve this is through sustainability-driven innovation strategies [14, 15].

The literature on the connection between creativity and sustainability has a knowledge gap. This limited understanding of the relationship is caused by the ideas' ambiguous perception [16]. Moldavska et al. [17] have introduced a special CSA technique for manufacturing industries where corporate sustainability is viewed as a situation and is connected to development goals, modeling the industrial firm utilizing systems representation estimates the evaluation tool, and corporate sustainability is seen as a procedure of constant innovation. Besne et al. [18] Utilize fuzzy logic with LCA to provide effective analytical methodologies. His work includes doing LCAs and cost analyses, normalizing the results of various financial and environmental influencing factors, implementing fuzzy logic by integrating the results, and then computing the fuzzy eco-efficiency index.

The fuzzy systems are extensively employed in different problems such as forecasting [19], controller designing [20], assessing systems [21], sentence representation technique [22], modeling problems [23], mapping problems [24], synchronization systems [25], and many others. However, it is rarely used for sustainability. In this study, a T2FS is developed for attaining corporate sustainability. An IT2FLC is an extensive version of T1-FLS, and it is more accurate and sensitive as reported in literature [26, 27]. Comparative reviews are tabulated in Table 1.

2. Principal Components Analysis

Principle components analysis (PCA) produces an orthogonal transformation from a set of observations of various variables. The order of the principle components is set up such that the first component explains the biggest proportion of variation in data, and the remaining in a decreasing order, explain the remaining proportions of variance. The principle component analysis (PCA) is a statistical method that converts a series of observations of variables that are presumably linked into a set of new values of variables that are linearly uncorrelated, or principal components. The PCA is used to create a low-dimensional representation of a set of data. The most varied linear combinations of variables that are unrelated to one another were presented. In addition to giving extracted parameters for supervised machine learning problems, the PCA may be used to visualize data. The first principal component of a set of features $y_1, y_2, \ldots, y_n$ is the normalized linear combination of the features as

$$Z_1 = \phi_{11} y_1 + = \phi_{21} y_2 + \cdots + \phi_{n1} y_n. \tag{1}$$

It takes the largest variance and it can be calculated by

$$\sum_i^n \alpha_{i1}^2 = 1. \tag{2}$$

Let us considered first principal component elements $\phi_{11}, \phi_{21}, \ldots, \phi_{n1}$ which are the loading of the first principal component and there exists some the principal component loading vectors $\phi_1 = (\phi_{21}, \phi_{21}, \ldots, \phi_{n1})^T$. The loadings are set up in such a way that the total of their squares equals one. Otherwise, arbitrarily large absolute values for these components may result in an arbitrarily bulky variance.

3. Motivation and Model Formulation

A T2-FLS is proposed to estimated the values of corporate environmental performance (CEP) and CEF. The designed T2-FLS is used to assess the sustainability of corporate. The general scheme is shown Figure 1. The developed model features a multi-variable, nonlinear structure that takes many economic factors into account. CEP and CFP are the two primary inputs of T2-FLS. The T2-FLS rules are optimized in a way that the input variables are used to model the corporate sustainability determinant (CORSUS). A novel method for quantifying CORSUS is produced by the developed rules based on linguistic characteristics. The following is a description of the key variables:

(i) WaC: it determines the influence of the company on water resource. Every industry has a limit to use minimum amount of water for product manufacture so that remaining are available for humans and other biotic source.

(ii) SS & TM: it measures the pollutant before they are exposed to ecosystem. Lower the discharge higher the sustainable value.

(iii) GHG: it comprises of release of GHG like carbon dioxide from various operation. It is essential to minimise the rate of discharge in atmosphere.

(iv) VOC: it measures the emission in atmosphere when the body work is painted i.e., body assembly plant.

(v) (SO_2 and NO_2): it measures the emission in atmosphere due to the burning of fossil fuel and from transport.

(vi) OIW: it is the solid waste obtain from industry which is landfill. It is essential for a company/industry to minimise the amount of waste landfill rather to reuse or recycle.

TABLE 1: Comparative review on sustainability performance assessment.

Authors, years	No. of inputs	Uncertainty/fuzzy	Statistical analysis
Wicher et al. 2019, [28]	3	Type-1	ANP
Pislaru et al. 2019, [29]	2	Type-1	PCA
Proposed model	2	Type-2	Statistical parameter

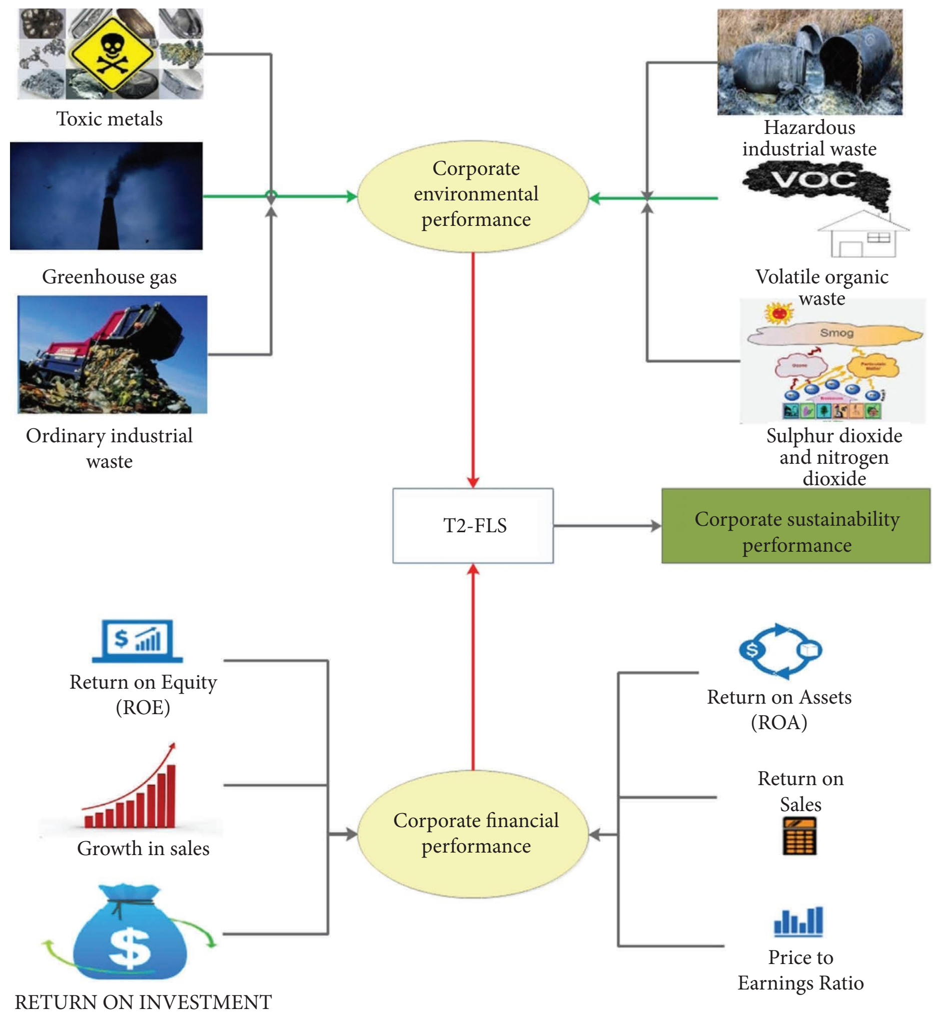

FIGURE 1: Systematic diagram for CSP model.

(vii) HIW: it includes all the waste which is harmful for biotic and abiotic component. It will be more sustainable for company if the amount of production of waste is less. In case of CFP consist of eight parameters which includes:

1 PE: it is a ratio that is used to compare the stock's current market price. Investors are more prepared to pay a larger share if the ratio is higher.

2 ROI: it is a ratio which is used to measure and compare the efficiency of investment.

3 ROE: it actually measures the net assets. It is use to determine how company use investment profitably.

4 ROA: it is used to measure the efficiency of the company to use asset in future profitably.

5 ROS: it measures the profit obtain by the company in selling the product.

6 OM: *t* measures the profit obtained by considering the cost of product sold and the operating expense.

7 GS: it signifies the difference obtain in previous sales record and current sales which is used to measure customer satisfaction.

8 DP: it measures the time taken by the company to pay the supplier. High ratio indicates company have insufficient cash.

PCA used the beginning factors to get the projection scores for the CEP and CFP magnitudes. CEP and CFP were valued for the two dimensions using the statistical method PCA by taking into account their initial points in the following equations. CEP is modeled as

$$\begin{aligned}\text{CEP} &= \beta_1\text{WaC} + \beta_2 TM + \beta_3 SS + \beta_4\text{GHG} + \beta_5\text{VOC}\\ &\quad+\beta_6 SO_2 + \beta_7 NO_X + \beta_8\text{OIW} + \beta_9\text{HIW},\\ \text{CFP} &= \delta_1 PE + \delta_2\text{ROI} + \delta_3\text{ROE} + \delta_4\text{ROA} + \delta_5\text{ROS} + \delta_6 OM + \delta_7 GS + \delta_8 DP.\end{aligned} \tag{3}$$

To evaluate the number of T2FS must be computing for determining the final indicator in corporate sustainable performance (CORSUS), positive values for μ and ν must be allocated which indicating the importance of the two input parameter in the development of the output parameter, CORSUS. The linguistic values are represented as follows. The value 0 is used for very bad, 1 is used for bad, 2 is used for medium, 3 is used for good, and 4 is for very good. For the weight of CEP and CFP, an index have allocated for corporate sustainable performance (CORSUS) of the overall sustainability. This index for CORSUS can be evaluated with the help of the following equation:

$$\text{CORSUS} = \mu\text{CEP} + \nu\text{CFP}. \tag{4}$$

When $\mu = \nu = 0$, the minimum value of CORSUS is zero and the maximum value is $4\mu + 4\nu$. To strike a balance between the two variables of sustainability's environmental and economical components, we have considered the hypothesis= ν. During this spontaneous process in a corporate sustainability, we have computed a new function pattern for the proposed model which is depicted in Figure 2.

4. Solution Procedure

In this section, the fuzzy approach is illustrated. The input variables are CEP and CFP, and the output is CORSUS. The structure is shown in Figure 3. As it is seen for inputs, we have 4 membership functions MFs. The MFs for CEP are denoted by $\widetilde{A}_i, i = 1, \ldots, 4$, and for CFP are denoted by $\widetilde{B}_i, i = 1, \ldots, 4$. The MFs represent the value of CEP and CFP in various range such as: very-bad ($\widetilde{A}_1$, $\widetilde{B}_1$), bad ($\widetilde{A}_2$, $\widetilde{B}_2$), good ($\widetilde{A}_3$, $\widetilde{B}_3$) and very-good ($\widetilde{A}_4$, $\widetilde{B}_4$) see Figures 4 and 5. Also, for CORSUS, 6 MFs are considered. The MFs of output are denoted by $\widetilde{O}_i, i = 1, \ldots, 6$ (see Figure 6). The MFs of output represent the value of CORSUS in various range such as: very-low$(\widetilde{O}_1)$, low $(\widetilde{O}_2)$, medium-low$(\widetilde{O}_3)$, medium $(\widetilde{O}_4)$, medium-high$(\widetilde{O}_5)$, and high $(\widetilde{O}_6)$ The details of computations are given as follows.

Step 1: get the inputs u_{CEP} and u_{CFP}, that represent CEP and CFP, respectively.

Step 2: compute the upper/lower membership of $\widetilde{A}_i, i = 1, \ldots, 4$ and $\widetilde{B}_i, i = 1, \ldots, 4$ as

$$\begin{aligned}\overline{\mu}_{\widetilde{A}_i}(\text{CEP}) &= \exp\left(-\frac{\left(\text{CEP} - m_{\widetilde{A}_i}\right)^2}{\overline{\sigma}^2_{\widetilde{A}_i}}\right),\\ \underline{\mu}_{\widetilde{A}_i}(\text{CEP}) &= \exp\left(-\frac{\left(\text{CEP} - m_{\widetilde{A}_i}\right)^2}{\underline{\sigma}^2_{\widetilde{A}_i}}\right),\\ \overline{\mu}_{\widetilde{B}_i}(\text{CFP}) &= \exp\left(-\frac{\left(\text{CFP} - m_{\widetilde{B}_i}\right)^2}{\overline{\sigma}^2_{\widetilde{B}_i}}\right),\\ \underline{\mu}_{\widetilde{B}_i}(\text{CFP}) &= \exp\left(-\frac{\left(\text{CFP} - m_{\widetilde{B}_i}\right)^2}{\underline{\sigma}^2_{\widetilde{B}_i}}\right),\end{aligned} \tag{5}$$

where $m_{\widetilde{A}_i}$, $\overline{\sigma}_{\widetilde{A}_i}$, and $\underline{\sigma}_{\widetilde{A}_i}$ denote the center of $\widetilde{A}_i$, upper and lower width of $\widetilde{A}_i$, respectively. Similarly, $m_{\widetilde{B}_i}$, $\overline{\sigma}_{\widetilde{B}_i}$, and $\underline{\sigma}_{\widetilde{B}_i}$ denote the center of $\widetilde{B}_i$, upper and lower width of $\widetilde{B}_i$, respectively.

Step 3: the rules are given as follows:

1 If u_{CEP} is $\widetilde{A}_1$ and u_{CFP} is $\widetilde{B}_1$, Then y_{CORSUS} is $\widetilde{O}_1$
2 If u_{CEP} is $\widetilde{A}_1$ and u_{CFP} is $\widetilde{B}_2$, Then y_{CORSUS} is $\widetilde{O}_1$
3 If u_{CEP} is $\widetilde{A}_1$ and u_{CFP} is $\widetilde{B}_3$, Then y_{CORSUS} is $\widetilde{O}_2$
4 If u_{CEP} is $\widetilde{A}_1$ and u_{CFP} is $\widetilde{B}_4$, Then y_{CORSUS} is $\widetilde{O}_3$
5 If u_{CEP} is $\widetilde{A}_1$ and u_{CFP} is $\widetilde{B}_5$, Then y_{CORSUS} is $\widetilde{O}_4$
6 If u_{CEP} is $\widetilde{A}_2$ and u_{CFP} is $\widetilde{B}_1$, Then y_{CORSUS} is $\widetilde{O}_1$
7 If u_{CEP} is $\widetilde{A}_2$ and u_{CFP} is $\widetilde{B}_2$, Then y_{CORSUS} is $\widetilde{O}_2$
8 If u_{CEP} is $\widetilde{A}_2$ and u_{CFP} is $\widetilde{B}_3$, Then y_{CORSUS} is $\widetilde{O}_3$
9 If u_{CEP} is $\widetilde{A}_2$ and u_{CFP} is $\widetilde{B}_4$, Then y_{CORSUS} is $\widetilde{O}_4$
10 If u_{CEP} is $\widetilde{A}_2$ and u_{CFP} is $\widetilde{B}_5$, Then y_{CORSUS} is $\widetilde{O}_5$
11 If u_{CEP} is $\widetilde{A}_3$ and u_{CFP} is $\widetilde{B}_1$, Then y_{CORSUS} is $\widetilde{O}_2$
12 If u_{CEP} is $\widetilde{A}_3$ and u_{CFP} is $\widetilde{B}_2$, Then y_{CORSUS} is $\widetilde{O}_3$
13 If u_{CEP} is $\widetilde{A}_3$ and u_{CFP} is $\widetilde{B}_3$, Then y_{CORSUS} is $\widetilde{O}_4$
14 If u_{CEP} is $\widetilde{A}_3$ and u_{CFP} is $\widetilde{B}_4$, Then y_{CORSUS} is $\widetilde{O}_5$
15 If u_{CEP} is $\widetilde{A}_3$ and u_{CFP} is $\widetilde{B}_5$, Then y_{CORSUS} is $\widetilde{O}_6$
16 If u_{CEP} is $\widetilde{A}_4$ and u_{CFP} is $\widetilde{B}_1$, Then y_{CORSUS} is $\widetilde{O}_3$
17 If u_{CEP} is $\widetilde{A}_4$ and u_{CFP} is $\widetilde{B}_2$, Then y_{CORSUS} is $\widetilde{O}_4$
18 If u_{CEP} is $\widetilde{A}_4$ and u_{CFP} is $\widetilde{B}_3$, Then y_{CORSUS} is $\widetilde{O}_5$
19 If u_{CEP} is $\widetilde{A}_4$ and u_{CFP} is $\widetilde{B}_4$, Then y_{CORSUS} is $\widetilde{O}_6$

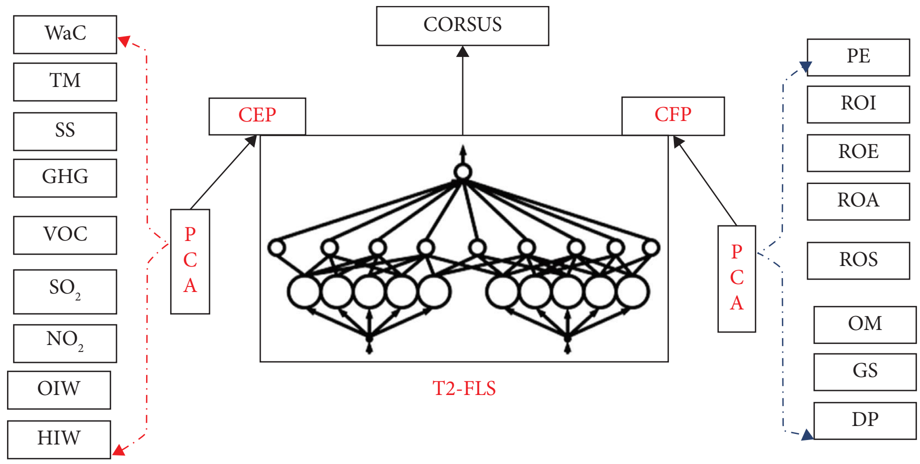

Figure 2: Block diagram for T2-FIS.

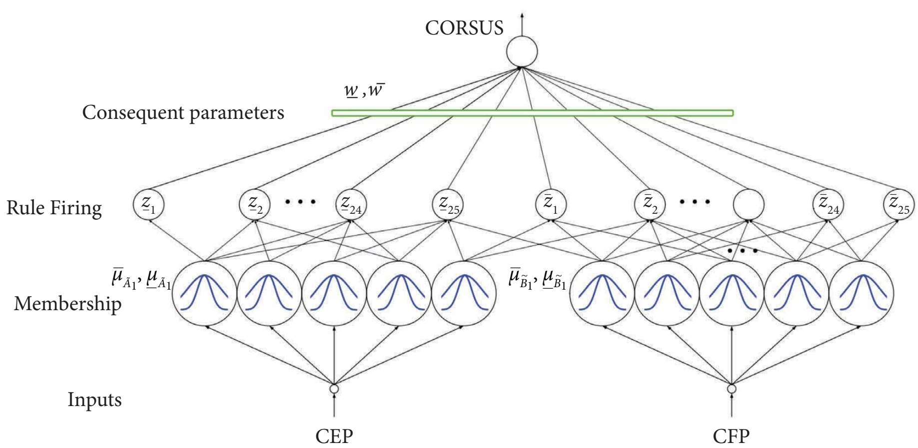

Figure 3: The designed FLS.

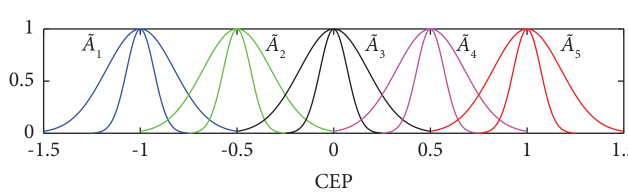

Figure 4: MFs for CEP indicators.

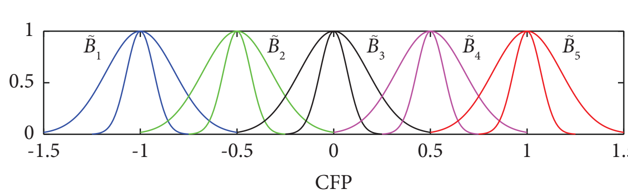

Figure 5: MFs for CFP indicators.

20 If u_{CEP} is $\tilde{A}_4$ and u_{CFP} is $\tilde{B}_5$, Then y_{CORSUS} is $\tilde{O}_1$
21 If u_{CEP} is $\tilde{A}_5$ and u_{CFP} is $\tilde{B}_1$, Then y_{CORSUS} is $\tilde{O}_4$
22 If u_{CEP} is $\tilde{A}_5$ and u_{CFP} is $\tilde{B}_2$, Then y_{CORSUS} is $\tilde{O}_5$
23 If u_{CEP} is $\tilde{A}_5$ and u_{CFP} is $\tilde{B}_3$, Then y_{CORSUS} is $\tilde{O}_6$
24 If u_{CEP} is $\tilde{A}_5$ and u_{CFP} is $\tilde{B}_4$, Then y_{CORSUS} is $\tilde{O}_1$
25 If u_{CEP} is $\tilde{A}_5$ and u_{CFP} is $\tilde{B}_5$, Then y_{CORSUS} is $\tilde{O}_1$

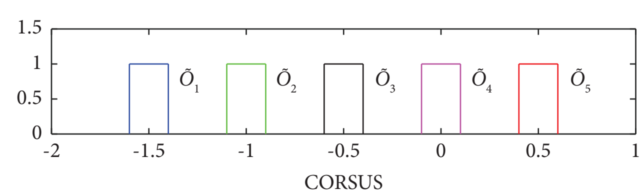

Figure 6: MFs for CORSUS.

If p_1-th MF is fired for CEP, and p_2-th MF is fired for CFP, then the upper/lower rule firing are obtained as

$$\begin{aligned} \overline{z}_l &= \overline{\mu}_{\tilde{A}_{p_1}}(\text{CEP})\overline{\mu}_{\tilde{B}_{p_2}}(\text{CFP}), \\ \underline{z}_l &= \underline{\mu}_{\tilde{A}_{p_1}}(\text{CEP})\underline{\mu}_{\tilde{B}_{p_2}}(\text{CFP}). \end{aligned} \tag{6}$$

Step 4: the CORSUS is computed as

$$\text{CORSUS} = \frac{\sum_{l=1}^{25}\left(\overline{z}_l\overline{w}_l + \underline{z}_l\underline{w}_l\right)}{\sum_{l=1}^{25}\overline{z}_l + \underline{z}_l}, \tag{7}$$

where $\underline{w}_l$ and $\overline{w}_l$ represent the mean of l-th fired MF in output.

5. Results Analysis

We constructed a framework for optimizing CORSUS assessment using an imprecise data set from the field and two input parameters and one output parameter. To make proper decisions, the IT2-FLC was used. Some statistical data analysis was successfully computed to monitor and access the sensitivity and accuracy of the suggested model on. The statistical techniques such as (a) (R^2) and (b) RMSE have been calculated and compared with the predicted and measured values of flexibility of the proposed model. The value of RMSE is defined by the following mathematical equation:

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(a_i - b_i\right)^2}, \tag{8}$$

where a_i denotes the actual values of the output, b_i denotes the predicted values of the output, and n is the number of the points. In the following (9), we have calculated the determination coefficient (R^2) as

$$R^2 = 1 - \frac{\sum_{i=1}^{n}\left(a_i - b_i\right)^2}{\sum_{i=1}^{n} b_i^2}. \tag{9}$$

The average of the squares of the errors can be measured by the value of MAPE. The very smaller values of MAPE make sure better performance. The MAPE has been calculated by using the (10) as

$$\mathrm{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\frac{\left|\left(a_i - b_i\right)\right|}{b_i} \times 100\%. \tag{10}$$

The performance of the proposed models' efficiency has been assessed using mean absolute error as a benchmark (MAE). The MAE can be determined using the following formula:

$$\mathrm{MAE} = \frac{1}{n}\sum_{i=1}^{n}\left|a_i - b_i\right|. \tag{11}$$

Here, we have considered n number of data patterns from the industry data set, x_{pred_i} denotes the predicted value of one data point i and x_{obs_i} denotes the observed value of one data point i. The summary of statistical data analysis of output has been given in the Table 2.

Table 2: Statistical parameters for sensitivity analysis of T2 and T1-FLS.

FIS	RMSE	R^2	MAPE
T1-FLS	0.115	0.952	4.823
T2-FLS	0.062	0.991	3.971

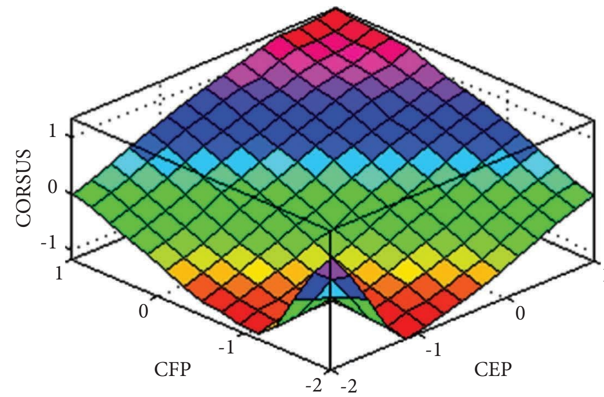

Figure 7: The diagram of CORSUS.

6. Simulation Results and Discussion

There are two types of data collected from an industry (CEP and CFP) and we have used the IT2FIS. The IT2FS retrieves these data and, as an output, develops a sustainability performance model based on the data characteristics shown in Figure 7.

6.1. Managerial Inferences. The 2008 financial and economic crisis has led to worries about the impact of CEP and CFP. Banks' CSR policies have been questioned as a real strategic commitment to the major stakeholders in light of the controversies and scandals surrounding their participation in the crisis. These scandals and controversies have also brought to light shortcomings in several CSP areas. This study demonstrates that merely executing socially and environmentally conscious actions is inadequate to boost financial success; rather, management's disregard for such practices hurts financial performance. Instead, taking advantage of corporate sustainability performance benefits depends on the industry's ability to profit from such efforts, since properly managing CORSUS fosters stakeholder linkages that boost performance. For this reason, it is crucial for any industry to grasp that "being excellent" is not enough and that "how they need to be good" by striking the right balance between CEP and CFP is crucial. It is now necessary to have this degree of industrial mindfulness and awareness.

Remark 1. In this study, a type-2 FLS is introduced for attaining corporate sustainability. More recently the new type-3 FLSs have been presented with better ability in practical problems. For the future studies, the suggested approach can be developed by the use of type-3 FLSs, new risk analysis techniques, and new optimization methods [11, 30–37].

7. Conclusions

For the purpose of evaluating corporate sustainable performance (CSP) assessment, we have created and formulated an interval type-2 fuzzy logic control technique. The input parameters (CEP and CFP) and an output parameter were helped to track by the IT2FLC (CORSUS). In order to foresee a range of corporate environmental and financial performance assessment circumstances for an industry, this study contains a safe and reliable approach for drawing conclusions. Because it is more difficult and complex to make judgments from the perspective of the industry, including significant uncertainty, we have taken for the implementation of CSP with the aid of this specific IT2FLC by employing Principal components analysis (PCA). The prediction of different economic, social, and environmental factors aids in CORSUS optimization during an industry's CSP monitoring system. The authors claim that the recommended IT2FLC strategy is a brand-new and distinctive way to build and regulate the CSP that must be met in order to provide a successful workplace output.

Nomenclature

WaC: Water consumption
SS: Suspended solids
OIW: Ordinary industrial waste
TM: Toxic metals
GHG: Greenhouse gas
VOC: Volatile organic compound
SO_2: Sulphur dioxide
NO_2: Nitrogen oxides
ROA: Return on assets
HIW: Hazardous industrial waste
CFP: Corporate financial performance
PE: Price-earnings
ROI: Return on investment
ROE: Return on equity
OM: operating margin
GS: Growth in sales
ROS: Return on sales
DP: Days payable
CEP: Corporate environmental performance
CORSUS: Corporate sustainable performance
CSP: Corporate sustainability performance
EI: Eco-innovation
LCA: Life Cycle Assessment.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] M. Tan-Mullins and G. Mohan, "The potential of corporate environmental responsibility of Chinese state-owned enterprises in Africa," *Environment, Development and Sustainability*, vol. 15, pp. 265–284, 2013.
[2] S. Basu, M. Roy, and P. Pal, "Corporate greening in a large developing economy: pollution prevention strategies," *Environment, Development and Sustainability*, vol. 21, pp. 1603–1633, 2019.
[3] Y. A. Ünvan and C. Ergenç, "Financial performance analysis with the fuzzy COPRAS and entropy-COPRAS approaches," *Computational Economics*, vol. 59, no. 4, pp. 1577–1605, 2022.
[4] R. Venugopal, C. Veeramani, and S. A. Edalatpanah, "Analysis of fuzzy DEMATEL approach for financial ratio performance evaluation of NASDAQ exchange," in *Proceedings of the International Conference on Data Science and Applications*, pp. 637–648, Springer, Singapore, November 2022.
[5] Ž. Stević, D. K. Das, R. Tešić, M. Vidas, and D. Vojinović, "Objective criticism and negative conclusions on using the fuzzy SWARA method in multi-criteria decision making," *Mathematics*, vol. 10, p. 635, 2022.
[6] I. M. Hezam, A. R. Mishra, P. Rani et al., "A hybrid intuitionistic fuzzy-MEREC-RS-DNMA method for assessing the alternative fuel vehicles with sustainability perspectives," *Sustainability*, vol. 14, no. 9, p. 5463, 2022.
[7] Y. Chen and V. Sivakumar, "Investigation of finance industry on risk awareness model and digital economic growth," *Annals of Operations Research*, pp. 1–22, 2021.
[8] X. T. Lei, Q. Y. Xu, and C. Z. Jin, "Nature of property right and the motives for holding cash: empirical evidence from Chinese listed companies," *Managerial and Decision Economics*, vol. 43, no. 5, pp. 1482–1500, 2022.
[9] Y. Wu and W. Zhu, "The role of CSR engagement in customer-company identification and behavioral intention during the COVID-19 pandemic," *Frontiers in Psychology*, vol. 12, p. 721410, 2021.
[10] N. Anderson, K. Potočnik, and J. Zhou, "Innovation and creativity in organizations: a state-of-the-science review, prospective commentary, and guiding framework," *Journal of Management*, vol. 40, no. 5, pp. 1297–1333, 2014.
[11] C. De Lucia, P. Balena, M. R. Stufano Melone, and D. Borri, "Policy, entrepreneurship, creativity and sustainability: the case of 'principi attivi' ('Active ingredients') in apulia region (southern Italy)," *Journal of Cleaner Production*, vol. 135, pp. 1461–1473, 2016.
[12] C. Lane and D. Lup, "Cooking under fire: managing multilevel tensions between creativity and innovation in haute cuisine," *Industry & Innovation*, vol. 22, no. 8, pp. 654–676, 2015.
[13] B. K. B. Joo, G. N. McLean, and B. Yang, "Creativity and human resource development: an integrative literature review and a conceptual framework for future research," *Human Resource Development Review*, vol. 12, no. 4, pp. 390–421, 2013.
[14] S. Paramanathan, C. Farrukh, R. Phaal, and D. Probert, "Implementing industrial sustainability: the research issues in technology management," *R & D Management*, vol. 34, no. 5, pp. 527–537, 2004.
[15] N.. Roome, "Business strategy, R&D management and environmental imperatives," *R & D Management*, vol. 24, no. 1, pp. 065–082, 1994.
[16] P. H. Andersen and H. Kragh, "Managing creativity in business market relationships," *Industrial Marketing Management*, vol. 42, no. 1, pp. 82–85, 2013.
[17] A. Moldavska and T. Welo, "A Holistic approach to corporate sustainability assessment: incorporating sustainable development goals into sustainable manufacturing performance evaluation," *Journal of Manufacturing Systems*, vol. 50, pp. 53–68, 2019.

[18] A. G. Besné, D. Luna, A. Cobos, D. Lameiras, H. Ortiz-Moreno, and L. P. Güereca, "A methodological framework of eco-efficiency based on fuzzy logic and Life Cycle Assessment applied to a Mexican SME," *Environmental Impact Assessment Review*, vol. 68, pp. 38–48, 2018.
[19] S. Mustafa, A. A. Bajwa, and S. Iqbal, "A new fuzzy grach model to forecast stock market technical analysis," *Operational Research in Engineering Sciences: Theory and Applications*, vol. 5, no. 1, pp. 185–204, 2022.
[20] M. R. Gharib, "Comparison of robust optimal QFT controller with TFC and MFC controller in a multi-input multi-output system," *Reports in Mechanical Engineering*, vol. 1, no. 1, pp. 151–161, 2020.
[21] V. Lukovac and M. Popović, "Fuzzy Delphi approach to defining a cycle for assessing the performance of military drivers," *Decision Making: Applications in Management and Engineering*, vol. 1, no. 1, pp. 67–81, 2018.
[22] W. Zheng, X. Liu, and L. Yin, "Sentence representation method based on multi-layer semantic network," *Applied Sciences*, vol. 11, no. 3, p. 1316, 2021.
[23] W. Zheng, L. Yin, X. Chen, Z. Ma, S. Liu, and B. Yang, "Knowledge base graph embedding module design for Visual question answering model," *Pattern Recognition*, vol. 120, Article ID 108153, 2021.
[24] T. Rasham, M. S. Shabbir, P. Agarwal, and S. Momani, "On a pair of fuzzy dominated mappings on closed ball in the multiplicative metric space with applications," *Fuzzy Sets and Systems*, vol. 437, no. 2022, pp. 81–96, 2022.
[25] E. Zambrano-Serrano, S. Bekiros, M. A. Platas-Garza et al., "On chaos and projective synchronization of a fractional difference map with no equilibria using a fuzzy-based state feedback control," *Physica A: Statistical Mechanics and Its Applications*, vol. 578, Article ID 126100, 2021.
[26] D. K. Jana, S. Roy, S. Bhattacharjee, P. Dostal, and S. Roy, "Saw dust-derived activated carbon in different impregnation ratios and its application in de-fluoridation of waste water using it2flc and rsm," *Biomass Conv. Bioref*, 2021.
[27] S. Bhattacharjee, K. A. Alattas, F. F. M. El-Sousy et al., "A type-2 fuzzy logic approach for forecasting of effluent quality parameters of wastewater treatment," *Mathematical Problems in Engineering*, vol. 2022, Article ID 1965157, 10 pages, 2022.
[28] P. Wicher, F. Zapletal, and R. Lenort, "Sustainability performance assessment of industrial corporation using Fuzzy Analytic Network Process," *Journal of Cleaner Production*, vol. 241, Article ID 118132, 2019.
[29] M. Pislaru, I. V. Herghiligiu, and I. B. Robu, "Corporate sustainable performance assessment based on fuzzy logic," *Journal of Cleaner Production*, vol. 223, pp. 998–1013, 2019.
[30] B. A. Hennessey and T. M. Amabile, *Annual Review of Psychology*, vol. 61, no. 1, pp. 569–598, 2010.
[31] J. K. Hall, G. A. Daneke, and M. J. Lenox, "Sustainable development and entrepreneurship: past contributions and future directions," *Journal of Business Venturing*, vol. 25, no. 5, pp. 439–448, 2010.
[32] J. Klewitz and E. G. Hansen, "Sustainability-oriented innovation of SMEs: a systematic review," *Journal of Cleaner Production*, vol. 65, pp. 57–75, 2014.
[33] S. Kristiansen, "Social networks and business success: the role of subcultures in an African context," *The American Journal of Economics and Sociology*, vol. 63, no. 5, pp. 1149–1171, 2004.
[34] P. Marius, D. Trandabat, and A. Trandabat, "Assessment of corporate environmental performance based on fuzzy approach," *APCBEE Procedia*, vol. 5, pp. 368–372, 2013.
[35] A. H. Rahdari, "Developing a fuzzy corporate performance rating system: a petrochemical industry case study," *Journal of Cleaner Production*, vol. 131, pp. 421–434, 2016.
[36] S. Rajak and S. Vinodh, "Application of fuzzy logic for social sustainability performance evaluation: a case study of an Indian automotive component manufacturing organization," *Journal of Cleaner Production*, vol. 108, pp. 1184–1192, 2015.
[37] A. Kumar and R. Anbanandam, "Assessment of environmental and social sustainability performance of the freight transportation industry: an index-based approach," *Transport Policy*, vol. 124, 2020.