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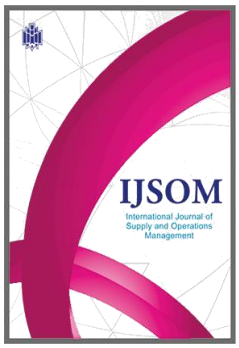

A Novel Computational Framework for Comparing CSR Performance: Evidence from India

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Abstract

The present work has three broad objectives. First, it intends to develop a novel objective measurement framework for comparing corporate social responsibility (CSR) performance. The extant literature shows a plenty of work has been done for exploring the benefits of CSR. But there is a limitation of work that provides a multi-criteria based objective measurement of CSR performance in financial terms. The second objective of the current work is to examine the impact of the recent COVID-19 on CSR performance of Indian firms. Thirdly, the present study proposes a new hybrid multi-criteria decision making (MCDM) framework with multiple normalizations using two recent models such as Logarithmic Percentage Change-driven Objective Weighting (LOPCOW) and Proximity Index Value (PIV) methods. In line with the objectives set, the ongoing work defines a new set of indicating variables to compare CSR performance from the perspectives of major stakeholders such as customer, society, government, employee, environment and shareholders. Top 20 manufacturing firms listed in the Bombay Stock Exchange (BSE)-100 in India have been selected for comparison. The study period is considered as FY 2019-20 (before pandemic) and FY 2020-21 (after pandemic). It is seen that the firms having higher market capitalization did well in their CSR performance. We observe that the overall CSR performance has not undergone any substantial changes. Further, post COVID-19 more firms from the drugs and pharmaceutical category could able to enter the top bracket. To test the reliability, a comparison with another MCDM models has been done and result is found satisfactory. The sensitivity analysis (SA) has also been conducted to investigate the stability in the outcome of the proposed model. The present work provides the policy makers a stable and reliable MCDM framework for analyzing and accessing their CSR performance with peers and evaluate their market standing to take decisions for future course of action.

Keywords: Corporate Social Responsibility; Firm Performance; Logarithmic Percentage Change-driven Objective Weighting; Proximity Index Value Method.

1. Introduction

The Business is and will always be fundamentally an economic institution but it must also have a responsibility to help society in achieving its basic goals (Steiner, 1971; Goli and Mohammadi, 2022). This ideology of business philanthropy evolved into modern Corporate Social Responsibility. The stakeholder Theory proposed by Freeman in 1984 advocated that a socially responsible firm is dedicated to the interest of all its stakeholders. Corporate Social

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Responsibility (CSR) is the social obligation of corporates as a social citizen. The mechanism of CSR is suggested by various studies made in the past, highlighting the numerous dimensions of CSR operations (responsibilities) which includes economic, ethical, legal, and philanthropic responsibilities that society expects out of a business (Carroll, 1991). The environmental aspect was identified as another aspect of CSR (Dahlsrud, 2008). Furthermore, Farooq et al. (2014) characterized various stakeholders' responsibilities in CSR to Environment, CSR to Employees, CSR to Community, and CSR to Consumers. Rezaee (2016) supported the existing literature by stating that the acknowledgment of the business towards the corporate stakeholders such as employees, governments, suppliers, and the community as a whole holds a significant impact on the existence of a business. Adebanjo et al. (2016) mentioned about the intensifying issues of the environment like global warming and others besides numerous social problems that add to the dimensions of CSR. This multi-dimensional approach to CSR makes it difficult to comprehend in one single definition. OECD (Organization for Economic Co-operation and Development) defines CSR as the social responsibility of a business to continuously develop mutual growth between itself and society. ISO 26000 defines CSR as "firms' decision making transparently and ethically considering its impact on society and environment." Further, Shabbir and Wisdom (2020) elucidated that the exchanges between organizations and the environment requires social as well as monetary commitments, when not taken care of may cause unfavorable influence on operations. The study has contributed by endorsing the concept of workforce welfare along with environmental investment. By providing activities related to social, economic, and environmental welfare, corporate social responsibility (CSR) has developed into an integral part of general company processes that helps to realize human development goals.

Over the period from a social obligation, CSR has become an integral part of business strategy as a socially responsible firm is perceived as more credible and reliable by the society which helps in the long run to attract better manpower and investors. Investors, today identify the relevance of being a part of companies with remarkable CSR performance (Park, 2013). Freeman (1984) along with other advocates of stakeholder theory established that when firms seek beyond profit making and strive for social support by viewing CSR expenditure as an investment strategy it ultimately improves its financial performance and corporate value. This has drawn a lot of attention from various researchers to evaluate the impact of CSR on financial performance and value creation of various firms across industries and across global. However, the results of previous research have been inconsistent regarding the impact of CSR on the financial performance of the companies. The existing literature highlights the corporate rewards like- Corporate reputation, employee loyalty and enhanced productivity, the satisfaction of employees and customers, and environmental sustainability, for being socially aware and acknowledging the needs of its external and internal stakeholders (Hill et al., 2007; Saeidi et al., 2015). A socially responsible firm is rewarded by a good image creating goodwill and reliability in the long run which they capitalize on by attracting a talented workforce and capital. This can be concluded by increasing investment in socially responsible mutual funds. Hill et al. (2007) evaluated the performance of socially responsible 10-year mutual funds in Asia, Europe, and the U.S. and could find a significant positive return in all of them. Lee et al. (2009) determined that the socially responsible firm are believed to have an outstanding corporate management competencies by the investors whereas firms that diverge from their social, legal, and ethical responsibilities may hurt the maximization of profits and shareholder value.

CSR has a significant linkage with firm performance. The extant literature shows a number of evidences that were attempted to establish the footfall of CSR on firm performance and value. For instance, Lin et al. (2019) established that firms in Taiwan that assigned their resources to diversity, labor rights, unions, compensation, benefits, training, health, and safety of workers benefited from improvement in the market performance of its firm. The impact of CSR on a firm's performance is studied using ROA as a profitability indicator, growth in sales revenue as a growth indicator, and Tobin's Q as the indicator of the Firm's Value, explaining the trend in capital investment (Cho et al., 2019). The study confirms the positive correlation between CSR performance and the financial performance of the firms.

However, it is seen that measurement of the tangible benefits of CSR in a straightforward way is a difficult one. There are some studies that have attempted to measure the impact and quality of CSR. For example, Gjølberg (2009) considered the degree of implementation and put forth a global CSR initiatives and rankings based CSR performance index. The work of Panayiotou et al. (2009) was grounded on the theoretical foundation of the balanced scorecard to measure the CSR performance from strategic decision to implementation. The authors (Pérez and Rodríguez del Bosque, 2013) have attempted to measure the CSR image of the firms from the viewpoint of the major stakeholders such as customers. Vargas (2015) considered the ethic rating and developed a disclosure based assessment of CSR

performance. Thao et al. (2019) proposed a measurement framework based on the parameters of CSR disclosures. In a recent work (Kamran et al., 2021) the authors divided the CSR activities (based on their nature of impact) in four categories such as social, environmental, financial and corporate and conducted a comparison of a group of local and global firms. The authors considered the impact of CSR on corporate performance and applied AHP-TOPSIS framework.

From the methodological point of view, Lin et al. (2019) employed the Panel Data Analysis to compute the effect of CSR rating on Stock return, Book to Market Ratio, and Tobin's Q to study the signaling effect and exhibit the financial performance of firms in Taiwan. Yannan et al. (2022) used panel regression estimations like fixed and random effect models for data estimation. Partial Least squares- Structure Equation Modeling and Grey Relational Analysis were adopted in Shahzad et al. (2020) to study the multiple dimension of CSR of manufacturing units in Pakistan. Descriptive Statistics, autocorrelation, correlation matrix, and multivariate regression were performed by Cherian et al. (2019) to exhibit the relationship between CSR reporting and a firm's performance. Testing of Data in form of Panel data using multiple regression premises was found to be a popular method of establishing CSR performance theory (e.g., Cho et al., 2019). However, many studies that have explored corporate social performance and corporate financial performance are criticized for low statistical significance proving methodological and epistemological issues along with misspecification of models adopted and inconsistent variable measurements (Bruna et al., 2022).

CSR, in the Indian context, is not a new phenomenon. However, the topic gained momentum after the Ministry of Corporate Affairs, India enforced the Companies Act, of 2013, and made it mandatory for certain classes of companies to spend 2 percent of their average net profit of the last three years on specified CSR activities. Indian companies are ideal for evaluating their CSR performance under globalization amongst Asian countries. They are exposed to the values and ethics of rich Indian heritage and at the same time, Indian companies are competing with companies operating globally with different ideologies challenging them to reshape themselves for survival. Hence, the importance of CSR activities is well established and justifies the need for the ongoing research to evaluate the performance of the firms in terms of their social responsibilities.
The extant literature shows the following major gaps

- There is a scantiness of objective indicator based comprehensive framework to measure and compare CSR performance
- The literature is a bit silent about assessing the impact of COVID-19 on CSR performance of the firms while considering the perspectives of multiple stakeholders

To fill up the gaps in the literature, the present work takes up the task to evaluate the CSR performance of Indian Manufacturing Companies from the perspective of various stakeholders. CSR therefore entails a multi-dimensional approach. To this end, a novel hybrid MCDM model is developed for evaluating the CSR performance of Indian manufacturing companies. The model is executed to compare the performance of the top 20 manufacturing companies listed on the Bombay Stock Exchange (BSE 100) and the period of study is FY 2019-20 and FY 2020-21. The ongoing study intends to address the following research questions.

RQ1. How can a multi-perspective evaluation framework be developed to evaluate the CSR performance of firms?
RQ2. How can an effective MCDM model be formed to compare the CSR performance of the firms?
RQ3. To what extent are the firms differing from each other in terms of CSR performance?
RQ4. Does the CSR performance differ with effect of COVID-19?

To answer the above-mentioned research questions, the criteria for evaluating CSR performance are identified through review of the literature related to the impact of CSR and a focused group discussion with the policy-makers and experts in the stated field. The MCDM framework is developed by combining two recently developed models such as LOPCOW and PIV. Table 1 shows a summary of the some of the previously published work on CSR vis-à-vis the present study.

Table 1. Summary of literatures

Author (s)	Study area	Methodology
Carroll, A. B.	Provided framework for understanding multiple layers of CSR and how they are related to each other.	Conceptual
Dahlsrud, A	Studied the evolving concept of CSR over a period of time by analyzing 37 definitions and how they impact stakeholders' perception.	Conceptual
Farooq, M. et al.	Relationship between the employee's collective perception of CSR practices and its impact on CSR initiatives.	Statistical Analysis-Factor Analysis
Rezaee, Z	Explores the relatedness of various dimensions of sustainability like-Economic, Governance, Society, Ethics and Environment with the practices and performance of businesses.	Theoretical
Adebanjo, D. et al.	Impact of external forces like regulatory requirement, etc. on adoption of sustainable practices, manufacturing performance and overall environmental outcomes.	Structural Equation Modelling.
Shabbir, M. S., & Wisdom, O.	Analyze the relationship between CSR activities, Environmental investments and financial performance of manufacturing companies in Nigeria.	Panel Regression Analysis
Lin, L. et al.	Investigates the impact of CSR on financial and market performance of the Taiwan firms	Panel Regression Analysis
Cho, S. J. et al.	Empirical analysis of financial and CSR performance of firms listed in Korean Stock Exchange	Correlation and Regression Analysis
Kamran, H. et al.	Employs AHP and fuzzy TOPSIS to measure combine performance of environmental, social, corporate and financial performance of companies from emerging economics.	MCDA
Yannan, D. et al	Impact of CSR, economic innovation, green credit, and green investment on the growth of revenue in the manufacturing industry of Saudi Arabia and China (Period 2016-2020)	Panel Regression Estimations
Ecer, F., & Pamucar, D	Examines performance of banks in terms of corporate sustainability performance and proposing a novel method of LOPCOW-DOBI.	LOPCOW-DOBI
Awaysheh, A. et al.	Studies the distributional issues in CSR rating and CSR performance ratios	Multivariate Analysis
Yang, Y., & Stohl, C.	Examine the degree of congruence between popular metrics for CSR and corporate reputation	Factor Analysis
García-Sánchez, I. M. et al.	Observes CEO's ability in determining the CSR disclosure of a firm and its performance	GMM regression models
Rajesh, R. et al.	Measures and compares the ESG, CSR and CSP of firms from developed countries.	ANOVA
Koh, K. et al.	The relationship between CSR performance and the information quality and quality of CSR disclosures to stakeholders.	Content Analysis
Lopatta, K. et al.	Relationship between CSR and firm financial performance and abnormal CSR performance.	Descriptive Statistics
Present work	Provides an objective multi-criteria based measurement framework to establish CSR performance index for comparing the firms and also discerns the effect of the disruptive events like the recent pandemic	MCDM framework using LOPCOW and PIV with multiple normalization schemes

LOPCOW model is developed by Ecer and Pamucar (2022) to derive criteria weights. As compared with the widely used methods for computing criteria weights using objective information like entropy method, CRITIC, PSI etc. LOPCOW provides the following advantages:

- Able to work effectively with the presence of negative values in the decision matrix
- Ability to produce a comparatively even distribution of the criteria weights.

- Provides a reliable and stable solution while working with a large number of criteria.

In this paper, a multi-normalization scheme is used for LOPCOW which allows the decision maker more flexibility in prioritizing the criteria. After obtaining the criteria weights, the ranking of the companies are carried out using PIV method for FY 2019-20 and FY 2020-21 separately. PIV method compares the alternatives based on their proximities (measured in terms of absolute dispersion values) to the ideal solution to select the best possible option (Mufazzal and Muzakkir, 2018). The PIV method offers the following advantages:

- Lesser computational complexity
- Free from the phenomenon of rank reversal

The present paper has a number of contributions. First, the current work provides a novel CSR performance measurement framework from the perspectives of the major stakeholders utilizing objective indicators. Second, it presents a comprehensive multi-criteria based evaluation of the CSR performance. Third, the current work is a distinct one that compares the CSR performance of the firms before and after COVID-19. Fourth, from the technical point of view the ongoing work puts forth a new hybrid MCDM model using LOPCOW and PIV with multiple normalizations. The rest of the paper is organized in following sections. Section 2 discusses about the research methodology used in the present work. In section 3, major findings are highlighted. Section 4 provides the result of the validity test and sensitivity analysis. In section 5 a brief description of the managerial implications and some of the future scopes are mentioned. Section 6 finally concludes the paper.

2. Materials and Methods

In this paper we consider the perspectives of the multiple stakeholders (such as government, shareholder, society, customer, environment and employee) to decide the criteria for comparison. The list of criteria are finalized after a focused group interaction with top managers and experts. Then, a combined LOPCOW-PIV method is applied to compare the firms. The methodological steps are depicted in figure 1. The research is designed in four broad phases. The first phase establishes the criteria selection through the literature review, figures out the sample units under comparison, formulates the decision matrices and carries out the mixed normalization. In the second phase, the procedural steps of the LOPCOW method are used to find out the criteria weights which then get used for ranking the sample units using the PIV method in the phase three. Finally, the phase four carries out the comparison of the result with the other MCDM models and conducts the sensitivity analysis to reach to the concluding remarks and decision making.

2.1. Description of the criteria

The list of variables act as the criteria are described in table 2.

Table 2. List of criteria

S/L	Criteria	UOM	Direction	Stakeholder
V1	% CSR implementation = Actual CSR expenditure/ Regulatory CSR expenditure	%	(+)	Government
V2	Return on Equity	%	(+)	Shareholder
V3	Return on Capital Employed	%	(+)	Shareholder
V4	Sales	INR Mil.	(+)	Customer
V5	CSR to Reward Ratio = PBITDA/Actual CSR spent	Value	(+)	Customer
V6	Power and Fuel	INR Mil.	(-)	Environment
V7	Staff welfare and training expense	INR Mil.	(+)	Employee
V8	Social and community expense	INR Mil.	(+)	Society
V9	EPS	INR	(+)	Shareholder

The criterion V1 indicates whether the organization complies with the statutory and regulatory requirements and to what extent the firm's top management actually met their commitment. The interests of the shareholders are reflected in criteria V2, V3 and V9. Beneficial movements of the values of the criteria V2, V3 and V9 are the indication that the invested capital is being able to keep up shareholders' interest and hence, the company fulfils its obligations to common investors. The criteria V4 and V5 signifies that the company is able to gain the trust of the customers through its operations and products/services and CSR practices that gets reflected in the outcome. To protect the environment, the firms need to act sensibly. The criterion V6 is a sustainable consumption indicator that suggests that the company is protecting the environment as a part of its responsibility towards the society. Therefore, the firms need to incur as less expenditure as possible. In this context, criterion V8 shows the obligation and commitment of the organizations towards the societal development. Employees play a crucial role in discharging the responsibilities to fulfil the commitments of the firms. To ensure that the charity begins at home, it is essential to look into the development of the employees and safeguard them. The criterion V7 is a reflection of the company's intent in ensuring the well-beings of the employees that keep their morale high. In effect, the employees may feel comfortable in the organization and hence decide to stay back for long. Further, it is an indication of organization's commitment towards employment generation.

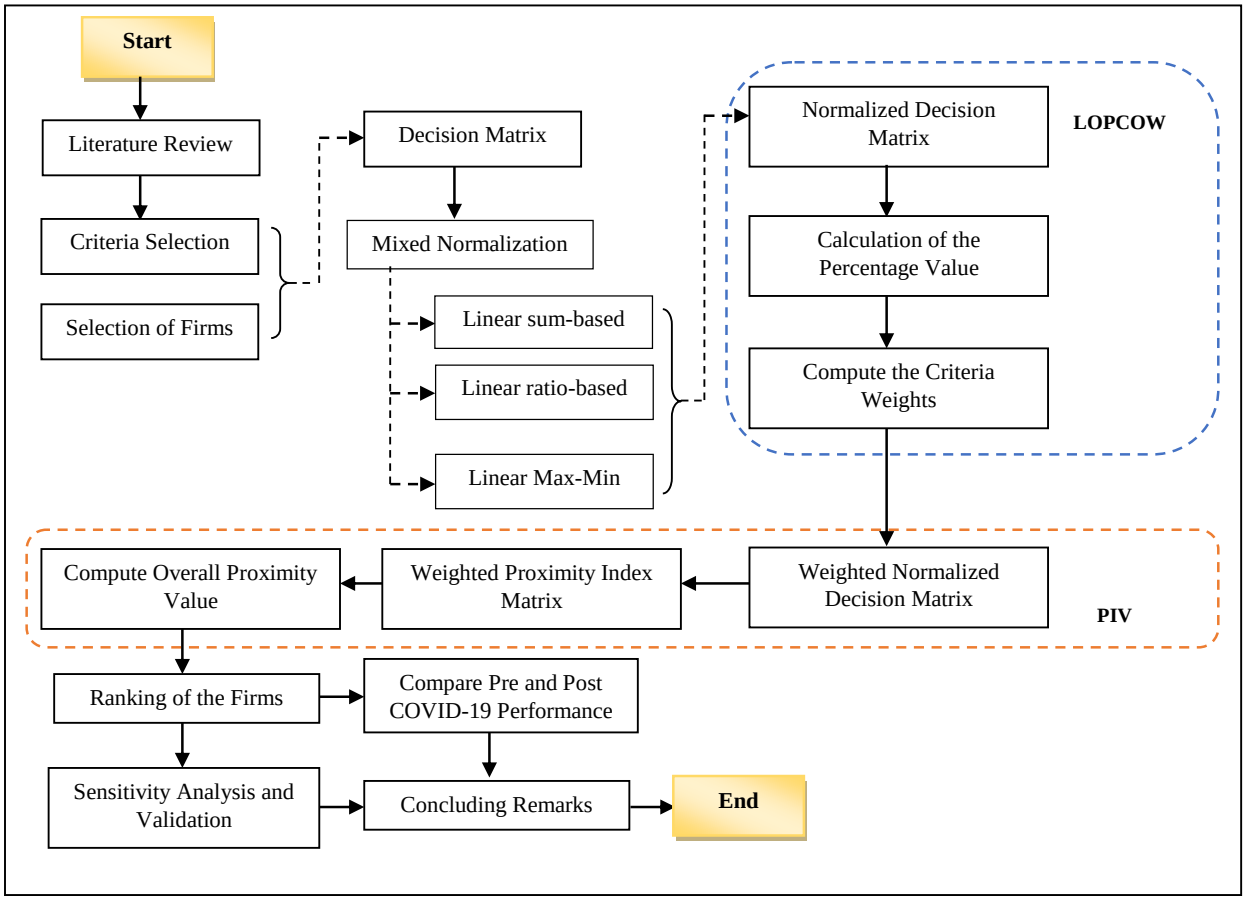

Figure 1. Flowchart of the methodological steps

2.2. Sample and Data

We select the top 20 manufacturing firms listed in BSE 100 based on their market capitalization as on FY 2019-20 (see table 3). The data is collected from the secondary database CMIE Prowess and company websites. As mentioned earlier the study period consists of two phases such as FY 2019-20 and FY 2020-21. Therefore, we have two decision matrices which are given in Appendix A.

Table 3. List of firms

S/L	Name of the firm	Industry	Market Cap*
F1	Asian Paints Ltd.	Paints & varnishes	1598.69
F2	Bajaj Auto Ltd.	Automobile	585.94
F3	Britannia Industries Ltd.	FMCG	646.78
F4	Cipla Ltd.	Drugs & pharmaceuticals	341.04
F5	Colgate-Palmolive (India) Ltd.	FMCG	340.78
F6	Dabur India Ltd.	FMCG	795.62
F7	Divi'S Laboratories Ltd.	Drugs & pharmaceuticals	527.63
F8	Dr. Reddy'S Laboratories Ltd.	Drugs & pharmaceuticals	517.98
F9	Eicher Motors Ltd.	Automobile	357.34
F10	Godrej Consumer Products Ltd.	FMCG	532.27
F11	Hero Motocorp Ltd.	Automobile	318.42
F12	Hindustan Unilever Ltd.	FMCG	4975.14
F13	I T C Ltd.	FMCG	2114.26
F14	Mahindra & Mahindra Ltd.	Automobile	354.31
F15	Marico Ltd.	FMCG	354.84
F16	Maruti Suzuki India Ltd.	Automobile	1295.24
F17	Nestle India Ltd.	FMCG	1571.81
F18	Pidilite Industries Ltd.	Chemical Products	689.35
F19	Sun Pharmaceutical Inds. Ltd.	Drugs & pharmaceuticals	845.05
F20	Titan Company Ltd.	Consumer Durables	828.75

*in INR (billion)

2.3. MCDM Model: LOPCOW-PIV with Multi-normalization

In this study we utilize a combined MCDM model of LOPCOW and PIV methods while leveraging the benefits of multiple schemes for normalization. The MCDM models differ from each other based on the features of the algorithm and given assumptions like selection of alternatives and criteria, type of information and so on (Pamucar et al., 2021; Biswas and Pamucar, 2021; Karmakar et al., 2018). Normalization is an essential feature that significantly influences the results of MCDM models. Normalization is done to bring the performance values of the alternatives under the influence of various criteria of different nature, scale and unit of measurement (UOM) to a uniform platform and converts them into unit less values (Jahan and Edwards, 2015). Each normalization scheme has its own usefulness and applicability in a given scenario. The extant literature shows several evidences (for instance, Vafaei et al., 2016; Jahan, 2018; Wu et al., 2020; Wen et al., 2020; Aytekin, 2021) wherein multiple normalization schemes have been utilized to reduce the variations in the normalized values and scale effect. In this paper, a mixed normalization scheme using linear sum based, ratio based and max-min type operators has been selected.

LOPCOW method has been already applied in solving complex real-life issues with subjective and objective information, for example, sustainable performance assessment for banks (Ecer and Pamucar, 2022), comparison of insurance products (Bektas, 2022), site selection for railway (Niu, 2022), comparison of firms' dividend payment capabilities (Biswas et al., 2022a), COVID 19 impact on firm performance (Biswas et al., 2022b), objective measurement of sales and operational performance (Biswas et al., 2022c), stock selection for portfolio formulation (Biswas et al., 2022d) and personality style based selection of sales persons (Biswas et al., 2022e).

The PIV method has been notably used by the researchers in various problems. Examples include optimization of engine parameters (Seraj et al., 2019), comparison of BRICS and G7 countries based on their logistics competitiveness (Biswas and Anand, 2020), selection of additive manufacturing process (Raigar et al., 2020), material selection for automotive process (Wakeel et al., 2021), green renewable energy selection (Goswami et al., 2022), green campus transportation selection (Deveci et al., 2022) among others.

The procedural steps are described below.

Step 1. Formation of the decision matrix $X = \left[x_{ij} \right]_{m \times n}$

As mentioned earlier in our case there are 20 alternatives (m = 20) and nine criteria (n = 9).

Step 2. Normalization

i) Linear sum based r_{ij}^{1}

$$r_{ij}^{1} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \text{ (when } j \in j^{+}\text{, desired effect: maximizing)} \quad (1)$$

$$r_{ij}^{1} = \frac{\left(\frac{1}{x_{ij}}\right)}{\sum_{i=1}^{m} \frac{1}{x_{ij}}} \text{ (when } j \in j^{-}\text{, desired effect: minimizing)} \quad (2)$$

The sum based normalization expresses the performance values in terms of the proportions with respect to the total value. It considers inverse values in case of non-beneficial criteria (i.e., desired effect is minimizing.

ii) Linear ratio based r_{ij}^{2}

$$r_{ij}^{2} = \frac{x_{ij}}{\max_{i}(x_{ij})} \text{ (when } j \in j^{+}\text{, desired effect: maximizing)} \quad (3)$$

$$r_{ij}^{2} = \frac{\min_{i}(x_{ij})}{x_{ij}} \text{ (when } j \in j^{-}\text{, desired effect: minimizing)} \quad (4)$$

The ratio based normalization treats the performance values in the decision matrix with respect to the optimum solution (i.e., column maximum or minimum depending on the nature of the criteria)

iii) Linear max-min r_{ij}^{3}

$$r_{ij}^{3} = \frac{x_{ij} - x_{\min}^{j}}{x_{\max}^{j} - x_{\min}^{j}} \text{ (when } j \in j^{+}\text{, desired effect: maximizing)} \quad (5)$$

$$r_{ij}^{3} = \frac{x_{\max}^{j} - x_{ij}}{x_{\max}^{j} - x_{\min}^{j}} \text{ (when } j \in j^{-}\text{, desired effect: minimizing)} \quad (6)$$

Linear max-min normalization considers both the extreme values. In case of presence of dispersed values and/or negative or zero values in the decision matrix, linear max-min normalization effectively maps the original values to the interval [0,1].

Step 3. Aggregation and final normalization

$$r_{ij} = \lambda r_{ij}^{1} + \xi r_{ij}^{2} + (1-\lambda-\xi) r_{ij}^{3} \quad (7)$$

$$0 \le \lambda, \xi \le 1; \lambda + \xi \le 1$$

Here, λ and ξ are called as the adjustment coefficients which provide the flexibility to the decision makers in terms of their emphasis in the decision making process. The significance of the values of λ and ξ are mentioned below

a) Higher is the value of λ more is the focus of the decision maker on specific alternatives out of all available options.
b) Higher is the value of ξ more is the preference for the best performance of the alternatives.
c) Smaller are the values of λ and ξ more is the preference on the best and worst possible performance while highlighting the former one.

Step 4. Derive the Percentage Value (PV) for the criteria

The PV for each criterion is given by

$$P_j = \left| \ln \left(\frac{\sqrt{\frac{\sum_{i=1}^{m} r_{ij}^2}{m}}}{\sigma} \right) .100 \right| \quad (8)$$

σ denotes the standard deviation

Step 5. Computation of criteria weights

The weight for the j^{th} criterion is given by

$$w_j = \frac{P_j}{\sum_{j=1}^{n} P_j} \quad (9)$$

Where, $\sum_{j=1}^{n} w_j = 1$ (i.e., sum of the weights of all criteria = 1)

Step 6. Construct the weighted normalized decision matrix

The weighted normalized decision matrix is represented by $V = \left[v_{ij} \right]_{m \times n}$ where the elements are calculated as

$$v_{ij} = r_{ij} w_j \quad (10)$$

$$i \in \{1, 2.....m\}; j \in \{1, 2.....n\}$$

w_j is the weight of j[th] criterion

Step 7. Formation of the Weighted Proximity Index (WPI) matrix

$$I_{ij} = \begin{cases} (v_j^+ - v_{ij}); j \in j^+ \\ (v_{ij} - v_j^-); j \in j^- \end{cases} \quad (11)$$

Here,

$$v_j^+ = \underset{i}{Max}(v_j); v_j^- = \underset{i}{Min}(v_j)$$

Step 8. Determination of Overall Proximity Value (OPV)

$$\delta_i = \sum_{j=1}^{n} I_{ij} \quad (12)$$

Decision Rule: Lower is the OPV, better is the proximity of the alternative to the ideal reference point and hence to be ranked first and so on.

3. Results

In this section we present the findings of the step by step data analysis for the two FYs. Let start with FY 2019-20. Considering the decision matrix (refer Appendix A), we proceed for normalization using the three schemes given by the expressions (1) to (6). Accordingly, we obtain the normalized decision matrix as given in tables 4 to 6.

Table 4. Normalized decision matrix (Linear sum based)-FY 2019-20

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9
Company	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)
F1	0.0545	0.0511	0.0507	0.0423	0.0226	0.0609	0.0511	0.0499	0.0145
F2	0.0422	0.0422	0.0444	0.0742	0.0231	0.0435	0.0558	0.0798	0.0918
F3	0.0420	0.0605	0.0561	0.0271	0.0301	0.0376	0.0095	0.0190	0.0317
F4	0.1199	0.0243	0.0257	0.0312	0.0143	0.0222	0.0454	0.0243	0.0151
F5	0.0422	0.0870	0.0870	0.0112	0.0260	0.1118	0.0042	0.0132	0.0147
F6	0.0424	0.0474	0.0477	0.0155	0.0239	0.0785	0.0114	0.0186	0.0035
F7	0.0718	0.0323	0.0339	0.0131	0.0163	0.0181	0.0078	0.0339	0.0263
F8	0.0472	0.0364	0.0354	0.0292	0.0552	0.0187	0.0904	0.0184	0.0924
F9	0.0420	0.0425	0.0446	0.0228	0.0205	0.0807	0.0291	0.0370	0.3631
F10	0.0323	0.0405	0.0416	0.0143	0.0319	0.0538	0.0048	0.0130	0.0060
F11	0.0568	0.0370	0.0390	0.0703	0.0163	0.0383	0.0636	0.0872	0.0756
F12	0.0425	0.1474	0.1490	0.0956	0.0300	0.0193	0.0424	0.0962	0.0162
F13	0.0421	0.0433	0.0458	0.1154	0.0258	0.0068	0.1671	0.2181	0.0064
F14	0.0420	0.0074	0.0073	0.1117	0.0286	0.0204	0.1187	0.0846	0.0062
F15	0.0404	0.0542	0.0530	0.0145	0.0306	0.1536	0.0095	0.0127	0.0041
F16	0.0424	0.0207	0.0218	0.1813	0.0264	0.0068	0.1435	0.1124	0.0965
F17	0.0423	0.1208	0.1232	0.0315	0.0323	0.0149	0.0661	0.0256	0.1095
F18	0.0445	0.0456	0.0479	0.0156	0.0242	0.0875	0.0113	0.0176	0.0117
F19	0.0680	0.0198	0.0165	0.0339	0.4877	0.0140	0.0206	0.0180	0.0059
F20	0.0423	0.0396	0.0294	0.0493	0.0341	0.1127	0.0475	0.0207	0.0088

Example of calculation (FY 2019-20)
Normalization using scheme 1(consider criterion 2)

$$r_{12}^{\ 1} = \frac{x_{12}}{\sum_{i=1}^{20} x_{i2}} = \frac{29.77}{(29.77 + 24.54 + ... + 23.07)} = \frac{29.77}{582.11} = 0.0511$$

$$r_{92}^{\ 1} = \frac{x_{92}}{\sum_{i=1}^{20} x_{i2}} = \frac{24.75}{(29.77 + 24.54 + ... + 23.07)} = \frac{24.75}{582.11} = 0.0425$$

Table 5. Normalized decision matrix (Linear ratio based)-FY 2019-20

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9
Company	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)
F1	0.4547	0.3470	0.3401	0.2330	0.0464	0.3962	0.3060	0.2286	0.0400
F2	0.3523	0.2860	0.2983	0.4090	0.0473	0.2831	0.3338	0.3658	0.2529
F3	0.3504	0.4108	0.3765	0.1494	0.0617	0.2446	0.0570	0.0871	0.0873
F4	1.0000	0.1649	0.1727	0.1723	0.0294	0.1444	0.2718	0.1112	0.0417
F5	0.3520	0.5900	0.5837	0.0615	0.0534	0.7277	0.0254	0.0607	0.0405
F6	0.3536	0.3217	0.3202	0.0853	0.0491	0.5108	0.0683	0.0853	0.0095
F7	0.5985	0.2190	0.2275	0.0722	0.0334	0.1176	0.0469	0.1552	0.0724
F8	0.3939	0.2468	0.2376	0.1611	0.1133	0.1220	0.5407	0.0842	0.2544
F9	0.3504	0.2885	0.2993	0.1257	0.0420	0.5253	0.1740	0.1697	1.0000
F10	0.2695	0.2750	0.2795	0.0786	0.0655	0.3504	0.0286	0.0597	0.0166
F11	0.4740	0.2508	0.2618	0.3874	0.0334	0.2496	0.3805	0.4000	0.2083
F12	0.3542	1.0000	1.0000	0.5274	0.0615	0.1255	0.2538	0.4411	0.0445
F13	0.3507	0.2937	0.3074	0.6365	0.0529	0.0443	1.0000	1.0000	0.0177
F14	0.3504	0.0504	0.0488	0.6161	0.0587	0.1329	0.7105	0.3877	0.0171
F15	0.3372	0.3678	0.3556	0.0798	0.0628	1.0000	0.0568	0.0582	0.0112
F16	0.3537	0.1402	0.1464	1.0000	0.0541	0.0445	0.8585	0.5152	0.2659
F17	0.3526	0.8199	0.8273	0.1736	0.0663	0.0969	0.3956	0.1173	0.3015
F18	0.3714	0.3092	0.3218	0.0862	0.0496	0.5696	0.0678	0.0806	0.0324
F19	0.5671	0.1345	0.1109	0.1872	1.0000	0.0909	0.1234	0.0825	0.0163
F20	0.3531	0.2689	0.1977	0.2721	0.0699	0.7333	0.2842	0.0949	0.0242

Normalization using scheme 2 (consider criterion 2)

$$r_{12}^{\ 2} = \frac{x_{12}}{\max\limits_{i}(x_{i2})} = \frac{29.77}{85.79} = 0.347$$

$$r_{92}^{\ 2} = \frac{x_{92}}{\max\limits_{i}(x_{i2})} = \frac{24.75}{85.79} = 0.288$$

Normalization using scheme 3 (consider criterion 2)

$$r_{12}^{\ 3} = \frac{x_{12} - x_{\min}^2}{x_{\max}^2 - x_{\min}^2} = \frac{29.77 - 4.32}{85.79 - 4.32} = 0.3124$$

Now using the expression (7) we move forward to aggregate the three normalization schemes to get the final normalized decision matrix (see table 7) for FY 2019-20.

Aggregated normalization (consider criterion 2)

$r_{12} = \lambda r_{12}^{\ 1} + \xi r_{12}^{\ 2} + (1-\lambda-\xi) r_{12}^{\ 3} = \lambda(0.0511) + \xi(0.3470) + (1-\lambda-\xi)0.3124$ Considering equal priority for all normalization schemes (i.e., $\lambda = \xi = 0.3333$) we obtain the value as $r_{12} = 0.2368$

Table 6. Normalized decision matrix (Linear max-min based)-FY 2019-20

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9
Company	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)
F1	0.2536	0.3124	0.3062	0.1827	0.0175	0.9293	0.2879	0.1809	0.0308
F2	0.1133	0.2482	0.2623	0.3703	0.0185	0.8826	0.3165	0.3266	0.2457
F3	0.1107	0.3795	0.3445	0.0936	0.0333	0.8567	0.0325	0.0307	0.0785
F4	1.0000	0.1207	0.1303	0.1180	0.0000	0.7251	0.2529	0.0563	0.0325
F5	0.1129	0.5683	0.5624	0.0000	0.0247	0.9826	0.0000	0.0026	0.0313
F6	0.1151	0.2857	0.2854	0.0253	0.0203	0.9556	0.0440	0.0288	0.0000
F7	0.4504	0.1776	0.1879	0.0114	0.0041	0.6518	0.0221	0.1030	0.0635
F8	0.1703	0.2068	0.1984	0.1061	0.0864	0.6664	0.5287	0.0276	0.2472
F9	0.1107	0.2508	0.2634	0.0684	0.0130	0.9581	0.1525	0.1183	1.0000
F10	0.0000	0.2365	0.2425	0.0182	0.0372	0.9140	0.0033	0.0016	0.0072
F11	0.2799	0.2111	0.2239	0.3472	0.0041	0.8606	0.3644	0.3630	0.2006
F12	0.1159	1.0000	1.0000	0.4964	0.0330	0.6768	0.2344	0.4065	0.0353
F13	0.1112	0.2563	0.2719	0.6126	0.0242	0.0000	1.0000	1.0000	0.0083
F14	0.1107	0.0000	0.0000	0.5910	0.0302	0.6974	0.7030	0.3499	0.0076
F15	0.0927	0.3342	0.3225	0.0194	0.0344	1.0000	0.0323	0.0000	0.0016
F16	0.1153	0.0946	0.1026	1.0000	0.0255	0.0033	0.8548	0.4852	0.2588
F17	0.1138	0.8104	0.8184	0.1194	0.0381	0.5678	0.3799	0.0628	0.2948
F18	0.1395	0.2726	0.2870	0.0263	0.0208	0.9649	0.0435	0.0237	0.0231
F19	0.4074	0.0886	0.0653	0.1339	1.0000	0.5361	0.1005	0.0259	0.0068
F20	0.1145	0.2301	0.1565	0.2244	0.0417	0.9831	0.2655	0.0390	0.0148

Table 7. Normalized decision matrix (Aggregated)-FY 2019-20

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9
Company	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)
F1	0.2543	0.2368	0.2323	0.1527	0.0288	0.4621	0.2150	0.1531	0.0285
F2	0.1693	0.1921	0.2017	0.2845	0.0296	0.4030	0.2354	0.2574	0.1968
F3	0.1677	0.2836	0.2590	0.0900	0.0417	0.3796	0.0330	0.0456	0.0658
F4	0.7066	0.1033	0.1096	0.1072	0.0146	0.2972	0.1900	0.0639	0.0298
F5	0.1690	0.4151	0.4110	0.0242	0.0347	0.6074	0.0099	0.0255	0.0289
F6	0.1703	0.2183	0.2178	0.0420	0.0311	0.5149	0.0412	0.0442	0.0043
F7	0.3735	0.1430	0.1498	0.0322	0.0179	0.2625	0.0256	0.0974	0.0541
F8	0.2038	0.1633	0.1571	0.0988	0.0850	0.2691	0.3866	0.0434	0.1980
F9	0.1677	0.1939	0.2024	0.0723	0.0251	0.5214	0.1185	0.1083	0.7877
F10	0.1006	0.1840	0.1879	0.0370	0.0449	0.4394	0.0123	0.0248	0.0099
F11	0.2703	0.1663	0.1749	0.2683	0.0179	0.3828	0.2695	0.2834	0.1615
F12	0.1709	0.7158	0.7163	0.3731	0.0415	0.2738	0.1769	0.3146	0.0320
F13	0.1680	0.1978	0.2084	0.4548	0.0343	0.0170	0.7224	0.7394	0.0108
F14	0.1677	0.0193	0.0187	0.4396	0.0392	0.2836	0.5108	0.2741	0.0103
F15	0.1568	0.2521	0.2437	0.0379	0.0426	0.7179	0.0329	0.0236	0.0056
F16	0.1705	0.0852	0.0903	0.7271	0.0353	0.0182	0.6189	0.3709	0.2071
F17	0.1695	0.5837	0.5896	0.1081	0.0456	0.2265	0.2805	0.0686	0.2353
F18	0.1852	0.2091	0.2189	0.0427	0.0315	0.5407	0.0409	0.0406	0.0224
F19	0.3475	0.0810	0.0643	0.1183	0.8292	0.2136	0.0815	0.0421	0.0097
F20	0.1700	0.1796	0.1279	0.1819	0.0486	0.6097	0.1991	0.0516	0.0159

Similarly, we compute the values and formulate the decision matrix for FY 2020-21 as given in table 8. Next, we calculate the weights of the criteria for both FY 2019-20 and 2020-21. The expressions (8) and (9) are used.

Example of calculation for FY 2019-20

Let us consider criterion 4

$$P_4 = \left| \ln \left(\frac{\sqrt{\frac{\sum_{i=1}^{m} r_{i4}^2}{m}}}{\sigma} \right).100 \right| = \left| \ln\left(\frac{\sqrt{\frac{1.3226}{20}}}{0.1315} \right).100 \right| = 67.098$$

$$w_4 = \frac{P_4}{\sum_{j=1}^{n} P_j} = \frac{67.098}{363.8621} = 0.1844$$

In the similar way we calculate the weights of all criteria and tabulate in table 9.

Table 8. Normalized decision matrix (Aggregated)-FY 2020-21

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9
Company	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)
F1	0.135	0.194	0.199	0.209	0.550	0.423	0.250	0.116	0.098
F2	0.240	0.136	0.147	0.279	0.180	0.394	0.258	0.258	0.513
F3	0.236	0.318	0.246	0.110	0.411	0.346	0.067	0.050	0.235
F4	0.236	0.070	0.076	0.098	0.471	0.277	0.294	0.072	0.077
F5	0.247	0.500	0.508	0.027	0.352	0.537	0.013	0.026	0.115
F6	0.239	0.188	0.198	0.053	0.292	0.436	0.042	0.042	0.020
F7	0.269	0.159	0.173	0.049	0.430	0.208	0.038	0.049	0.236
F8	0.261	0.069	0.070	0.120	0.631	0.238	0.612	0.083	0.337
F9	0.236	0.097	0.106	0.072	0.119	0.483	0.131	0.102	0.154
F10	0.329	0.146	0.154	0.046	0.192	0.412	0.011	0.053	0.034
F11	0.248	0.136	0.146	0.306	0.159	0.364	0.318	0.128	0.483
F12	0.245	0.196	0.207	0.476	0.358	0.218	0.471	0.337	0.107
F13	0.237	0.143	0.155	0.504	0.212	0.013	0.667	0.746	0.029
F14	0.160	0.007	0.006	0.457	0.436	0.258	0.711	0.206	0.011
F15	0.246	0.269	0.268	0.050	0.336	0.731	0.032	0.024	0.024
F16	0.236	0.055	0.060	0.721	0.266	0.102	0.686	0.285	0.462
F17	0.237	0.732	0.731	0.125	0.348	0.212	0.285	0.080	0.730
F18	0.266	0.144	0.154	0.042	0.251	0.491	0.038	0.040	0.064
F19	0.699	0.019	0.016	0.147	0.695	0.187	0.100	0.038	0.007
F20	0.239	0.092	0.061	0.199	0.309	0.602	0.156	0.062	0.032

Table 9. Criteria weights (FY 2019-20)

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9	
Mean Square	0.066	0.080	0.079	0.067	0.036	0.171	0.085	0.054	0.042	
Std. Dev.	0.131	0.167	0.168	0.187	0.178	0.186	0.208	0.178	0.179	
PV	67.098	52.800	51.721	32.770	6.211	79.837	33.958	26.449	13.019	
Wj	0.1844	0.1451	0.1421	0.0901	0.0171	0.2194	0.0933	0.0727	0.0358	Σ=1.000

The criteria weights for FY 2020-21 are also calculated using the same procedure and recorded in table 10.

Table 10. Criteria weights (FY 2020-21)

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9	
Mean Square	0.080	0.061	0.061	0.078	0.145	0.149	0.124	0.047	0.077	
Std. Dev.	0.110	0.171	0.169	0.194	0.155	0.175	0.244	0.170	0.209	
PV	94.739	37.266	37.944	36.048	90.029	78.979	36.449	24.468	28.338	
Wj	0.2041	0.0803	0.0817	0.0776	0.1939	0.1701	0.0785	0.0527	0.0610	Σ=1.000

Now we proceed for ranking of the companies for both FY 2019-20 and 2020-21 separately using the steps of PIV method. The expressions (10) to (12) are used.

Example of calculation (for FY 2019-20)

Let us calculate the 4th element of the weighted normalized decision matrix for criterion 1 (for the weight of the criterion 1 please refer table 9 and for the normalized value of the 4th element, please refer table 6)

$$v_{41} = r_{41} w_1 = 0.7066 \times 0.1844 = 0.1303$$

Table 11 provides the values of all elements of the weighted normalized decision matrix for FY 2019-20.

Using the values of the weighted normalized decision matrix we find the ideal reference points.

For example, $v_4^+ = \underset{i}{Max}(v_4) = 0.0655; v_4^- = \underset{i}{Min}(v_4) = 0.0022; i = 1, 2....20$

Similarly,

$$v_1^+ = 0.1303; v_2^+ = 0.1039; v_3^+ = 0.1018; v_5^+ = 0.0142$$

$$v_6^+ = 0.1575; v_7^+ = 0.0674; v_8^+ = 0.0537; v_9^+ = 0.0282$$

The other negative reference points are

$$v_1^- = 0.0186; v_2^- = 0.0028; v_3^- = 0.0027; v_5^- = 0.0002$$

$$v_6^- = 0.0037; v_7^- = 0.0009; v_8^- = 0.0017; v_9^- = 0.0002$$

Table 11. Weighted normalized decision matrix (FY 2019-20)

	Criteria								
Company	V1	V2	V3	V4	V5	V6	V7	V8	V9
F1	0.0469	0.0344	0.0330	0.0138	0.0005	0.1014	0.0201	0.0111	0.0010
F2	0.0312	0.0279	0.0287	0.0256	0.0005	0.0884	0.0220	0.0187	0.0070
F3	0.0309	0.0412	0.0368	0.0081	0.0007	0.0833	0.0031	0.0033	0.0024
F4	0.1303	0.0150	0.0156	0.0097	0.0002	0.0652	0.0177	0.0046	0.0011
F5	0.0312	0.0602	0.0584	0.0022	0.0006	0.1333	0.0009	0.0019	0.0010
F6	0.0314	0.0317	0.0310	0.0038	0.0005	0.1130	0.0038	0.0032	0.0002
F7	0.0689	0.0207	0.0213	0.0029	0.0003	0.0576	0.0024	0.0071	0.0019
F8	0.0376	0.0237	0.0223	0.0089	0.0015	0.0590	0.0361	0.0032	0.0071
F9	0.0309	0.0281	0.0288	0.0065	0.0004	0.1144	0.0111	0.0079	0.0282
F10	0.0186	0.0267	0.0267	0.0033	0.0008	0.0964	0.0011	0.0018	0.0004
F11	0.0498	0.0241	0.0249	0.0242	0.0003	0.0840	0.0252	0.0206	0.0058
F12	0.0315	0.1039	0.1018	0.0336	0.0007	0.0601	0.0165	0.0229	0.0011
F13	0.0310	0.0287	0.0296	0.0410	0.0006	0.0037	0.0674	0.0537	0.0004
F14	0.0309	0.0028	0.0027	0.0396	0.0007	0.0622	0.0477	0.0199	0.0004
F15	0.0289	0.0366	0.0346	0.0034	0.0007	0.1575	0.0031	0.0017	0.0002
F16	0.0314	0.0124	0.0128	0.0655	0.0006	0.0040	0.0578	0.0270	0.0074
F17	0.0313	0.0847	0.0838	0.0097	0.0008	0.0497	0.0262	0.0050	0.0084
F18	0.0341	0.0303	0.0311	0.0038	0.0005	0.1186	0.0038	0.0030	0.0008
F19	0.0641	0.0118	0.0091	0.0107	0.0142	0.0469	0.0076	0.0031	0.0003
F20	0.0313	0.0261	0.0182	0.0164	0.0008	0.1338	0.0186	0.0037	0.0006

Then the values of the elements of the weighted proximity index matrix are calculated using expression (11).

For example,
$$I_{24} = (v_4^+ - v_{24}) = 0.0655 - 0.0256 = 0.0399$$
$$I_{26} = (v_{26} - v_6^-) = 0.0884 - 0.0037 = 0.0847$$

We now move to calculate the OPVs for all alternatives using the expression (12) and rank the firms according to their OPVs. The alternative having minimum OPV is considered as the best one (see table 12)
For instance,

$$\delta_1 = \sum_{j=1}^{9} I_{1j} = 0.0834 + 0.0695 + ... + 0.0272 = 0.5019$$

$$\delta_{17} = \sum_{j=1}^{9} I_{17j} = 0.0990 + 0.0192 + ... + 0.0198 = 0.3611$$

Table 12. Weighted Proximity Index matrix and ranking of firms (FY 2019-20)

	Criteria										
Company	V1	V2	V3	V4	V5	V6	V7	V8	V9	δ	Rank
F1	0.0834	0.0695	0.0688	0.0517	0.0137	0.0977	0.0473	0.0426	0.0272	0.5019	12
F2	0.0991	0.0760	0.0731	0.0399	0.0136	0.0847	0.0455	0.0350	0.0211	0.4881	10
F3	0.0994	0.0627	0.0650	0.0574	0.0134	0.0796	0.0643	0.0504	0.0258	0.5181	13
F4	0.0000	0.0889	0.0862	0.0558	0.0139	0.0615	0.0497	0.0491	0.0271	0.4322	5
F5	0.0991	0.0436	0.0434	0.0633	0.0136	0.1295	0.0665	0.0519	0.0272	0.5381	15
F6	0.0989	0.0722	0.0709	0.0617	0.0136	0.1092	0.0636	0.0505	0.0280	0.5686	16
F7	0.0614	0.0831	0.0805	0.0626	0.0138	0.0539	0.0650	0.0467	0.0262	0.4933	11
F8	0.0927	0.0802	0.0795	0.0566	0.0127	0.0553	0.0313	0.0506	0.0211	0.4800	8
F9	0.0994	0.0757	0.0730	0.0590	0.0137	0.1107	0.0564	0.0459	0.0000	0.5337	14
F10	0.1118	0.0772	0.0751	0.0622	0.0134	0.0927	0.0663	0.0519	0.0278	0.5783	18
F11	0.0805	0.0797	0.0770	0.0413	0.0138	0.0803	0.0423	0.0331	0.0224	0.4704	6
F12	0.0988	0.0000	0.0000	0.0319	0.0134	0.0563	0.0509	0.0309	0.0270	0.3093	1
F13	0.0993	0.0752	0.0722	0.0245	0.0136	0.0000	0.0000	0.0000	0.0278	0.3126	2
F14	0.0994	0.1011	0.0992	0.0259	0.0135	0.0585	0.0197	0.0338	0.0278	0.4789	7
F15	0.1014	0.0673	0.0672	0.0621	0.0134	0.1538	0.0643	0.0520	0.0280	0.6095	20
F16	0.0989	0.0915	0.0890	0.0000	0.0136	0.0003	0.0097	0.0268	0.0208	0.3504	3
F17	0.0990	0.0192	0.0180	0.0557	0.0134	0.0460	0.0412	0.0488	0.0198	0.3611	4
F18	0.0962	0.0735	0.0707	0.0616	0.0136	0.1149	0.0636	0.0508	0.0274	0.5723	17
F19	0.0662	0.0921	0.0927	0.0548	0.0000	0.0431	0.0598	0.0507	0.0278	0.4873	9
F20	0.0990	0.0778	0.0836	0.0491	0.0133	0.1300	0.0488	0.0500	0.0276	0.5793	19

In the similar fashion, the firms are ranked based on their CSR performance during FY 2020-21 (see table 13).

From table 12 we observe that Hindustan Unilever Ltd.(F_{12}), I T C Ltd (F_{13}), Maruti Suzuki India Ltd.(F_{16}), Nestle India Ltd. (F_{17}) and Cipla Ltd. (F_4) hold the top 5 positions while Dabur India Ltd. (F_6), Pidilite Industries Ltd. (F_{18}), Godrej Consumer Products Ltd. (F_{10}), Titan Company Ltd. (F_{20}) and Marico Ltd. (F_{15}) remain in the bottom 5 bracket during FY 2019-20. It is seen that the firms having higher market capitalization did well in their CSR performance. Hence, it may be contended that CSR performance shows a positive influence on the market capitalization in FY 2019-20.

Table 13. Weighted Proximity Index matrix and ranking of firms (FY 2020-21)

Company	Criteria										
	V1	V2	V3	V4	V5	V6	V7	V8	V9	δ	Rank
F1	0.1152	0.0431	0.0435	0.0397	0.0280	0.0698	0.0362	0.0332	0.0386	0.4473	11
F2	0.0936	0.0478	0.0478	0.0343	0.0998	0.0647	0.0356	0.0258	0.0132	0.4627	13
F3	0.0946	0.0332	0.0397	0.0475	0.0550	0.0566	0.0506	0.0367	0.0302	0.4440	9
F4	0.0945	0.0531	0.0536	0.0484	0.0433	0.0448	0.0328	0.0355	0.0399	0.4459	10
F5	0.0924	0.0186	0.0183	0.0538	0.0665	0.0892	0.0548	0.0380	0.0375	0.4690	14
F6	0.0940	0.0437	0.0436	0.0519	0.0780	0.0719	0.0525	0.0371	0.0433	0.5161	15
F7	0.0878	0.0460	0.0457	0.0522	0.0513	0.0332	0.0528	0.0368	0.0301	0.4359	8
F8	0.0895	0.0532	0.0541	0.0466	0.0123	0.0383	0.0078	0.0349	0.0240	0.3606	5
F9	0.0946	0.0509	0.0512	0.0504	0.1116	0.0799	0.0455	0.0340	0.0351	0.5532	20
F10	0.0757	0.0470	0.0472	0.0524	0.0975	0.0679	0.0550	0.0365	0.0425	0.5217	16
F11	0.0922	0.0478	0.0478	0.0322	0.1039	0.0597	0.0309	0.0326	0.0150	0.4623	12
F12	0.0927	0.0430	0.0428	0.0190	0.0654	0.0348	0.0189	0.0215	0.0380	0.3762	6
F13	0.0944	0.0472	0.0471	0.0168	0.0935	0.0000	0.0035	0.0000	0.0428	0.3453	4
F14	0.1100	0.0582	0.0593	0.0205	0.0502	0.0416	0.0000	0.0285	0.0439	0.4121	7
F15	0.0926	0.0371	0.0379	0.0521	0.0696	0.1221	0.0533	0.0381	0.0431	0.5459	19
F16	0.0946	0.0543	0.0549	0.0000	0.0832	0.0151	0.0020	0.0243	0.0164	0.3447	3
F17	0.0943	0.0000	0.0000	0.0463	0.0672	0.0338	0.0334	0.0351	0.0000	0.3102	1
F18	0.0884	0.0471	0.0472	0.0527	0.0861	0.0813	0.0529	0.0372	0.0406	0.5336	17
F19	0.0000	0.0572	0.0585	0.0445	0.0000	0.0295	0.0480	0.0373	0.0441	0.3193	2
F20	0.0939	0.0513	0.0548	0.0405	0.0747	0.1001	0.0436	0.0361	0.0426	0.5376	18

Table 13 reflects that there has been change in the comparative ranking based on CSR performance after COVID-19. We notice that Nestle India Ltd. (F_{17}), Sun Pharmaceutical Inds. Ltd. (F_{19}), Maruti Suzuki India Ltd.(F_{16}), I T C Ltd (F_{13}) and Dr. Reddy'S Laboratories Ltd. (F_8) could able to secure top positions while Godrej Consumer Products Ltd. (F_{10}), Pidilite Industries Ltd. (F_{18}), Titan Company Ltd. (F_{20}), Marico Ltd. (F_{15}) and Eicher Motors Ltd. (F_9). This reveals an interesting inference. We observe that though there are some change in the ranking orders, the overall CSR performance has not undergone any substantial changes. We find that majority of the top (or bottom) performers remained in their respective classes. Further, post COVID-19 more firms from the drugs and pharmaceutical category could able to enter the top bracket. The market capitalization again shows a positive linkage with the CSR performance. To check the consistency in the CSR performance before and after COVID-19 we perform a Spearman's rank correlation test (see table 14). The result shows a considerably high consistency which concludes that COVID-19 has not affected the CSR performance notably.

Table 14. Spearman's rank correlation test (CSR performance before and after COVID-19)

	Spearman's rho	CSR Perf. (FY 19-20)
CSR Perf. (FY 20-21)	Correlation Coefficient	.782**
	Sig. (2-tailed)	0.000

** Correlation is significant at the 0.01 level (2-tailed).

4. Sensitivity Analysis and Validation

Stability of the result is an important aspect for any MCDM based analysis (Biswas et al., 2022f). The stability of the MCDM result depends on various conditions like changes in the criteria and alternative set, changes in the criteria weights and so on. To check the stability of the result the extant literature (for example, Biswas et al., 2022g; Gupta et al., 2022; Pamucar et al., 2022a) show evidences of carrying out sensitivity analysis (SA). To this end, the present work carries out the SA by changing the values of λ and ξ (adjustment coefficients). Table 15 exhibits various

experimental scenarios generated by varying the values of the adjustment coefficients. The variations in the values of the adjustment coefficients reflect changes in the weightages to different normalization schemes and have direct impact on the formulation of the normalized decision matrix and criteria weights.

Table 15. Experimentations for SA

	Priorities				Priorities		
	Norm 1	Norm 2	Norm 3		Norm 1	Norm 2	Norm 3
Cases	λ	ξ	(1-λ-ξ)	Cases	λ	ξ	(1-λ-ξ)
Original	0.333	0.333	0.333	Case 8	0.333	0.250	0.417
Case 1	0.500	0.333	0.167	Case 9	0.333	0.200	0.467
Case 2	0.250	0.333	0.417	Case 10	0.333	0.167	0.500
Case 3	0.200	0.333	0.467	Case 11	0.333	0.143	0.524
Case 4	0.167	0.333	0.500	Case 12	0.333	0.125	0.542
Case 5	0.143	0.333	0.524	Case 13	0.167	0.500	0.333
Case 6	0.125	0.333	0.542	Case 14	0.500	0.250	0.250
Case 7	0.333	0.500	0.167	Case 15	0.143	0.125	0.732

Accordingly, we carry out the ranking of the firms under study for both FY 2019-20 and FY 2020-21. Figure 2 shows the result of SA for FY 2020-21 which indicates that there has not any significant changes in the ranking pattern for various experimental scenarios (represented as series 1, 2,..15; series 1: original case).

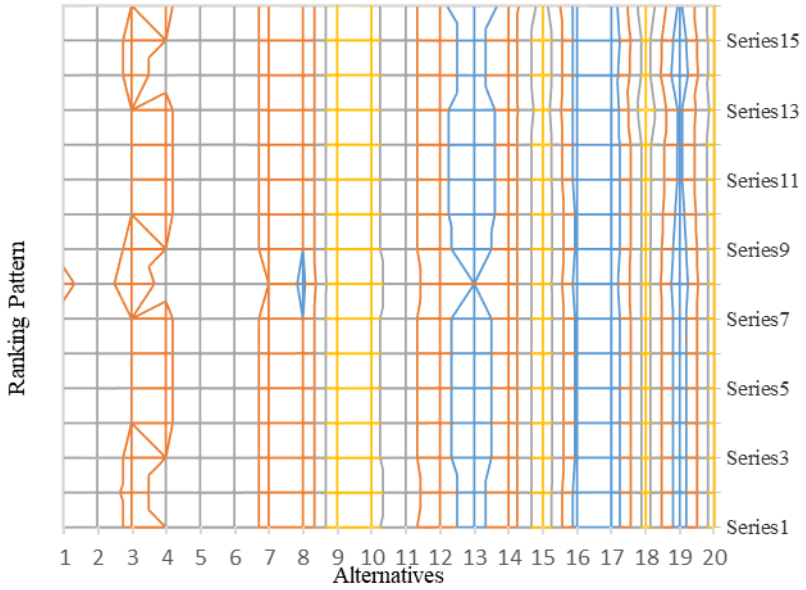

Figure 2. Result of SA

In the similar way we also carry out the SA for FY 2019-20 and observe no substantial variations in the ranking order. Therefore, we conclude that the LOPCOW-PIV model provides a stable result.

Next, we proceed for examining the reliability and validity of the ranking provided by LOPCOW-PIV model. To this end, we follow a two step process. First, we compare our model with another popular MCDM model such as COPRAS as considered in many previous work (for instance, Biswas et al., 2022h; Biswas et al., 2021a; Pramanik et al., 2021). We find out the ranking of the alternatives using COPRAS and compute the Spearman's rank correlation coefficient. Table 16 shows that the ranking of firms using our model and COPRAS are highly consistent for FY 2020-21. Similarly, we notice consistency for FY 2019-20.

Table 16. Spearman's rank correlation test (CSR performance using PIV and COPRAS for FY 2020-21)

	Spearman's rho	PIV_20_21
COPRAS_20_21	Correlation Coefficient	.946**

** Correlation is significant at the 0.01 level (2-tailed).

In the second step, we test for possibility of any rank reversal. We delete an optimal alternative (e.g., F_{17} for FY 2019-20) as suggested in Biswas et al. (2021b) and obtain the rank of the rest. We notice that there is no change in the preferential order of the firms after deleting F_{17} from the list.

$F_{12} \succ F_{13} \succ F_{16} \succ F_{17} \succ F_4 \succ ..... \succ F_{15}$ (Ranking order before deleting F_{17})

$F_{12} \succ F_{13} \succ F_{16} \succ F_4 \succ ..... \succ F_{15}$ (Ranking order after deleting F_{17})

The same scenario is observed for FY 2020-21. Hence, we conclude that our method does not show any rank reversal issue. In this way we validate the result and contend that our model provides a reliable and stable outcome.

5. Managerial Implications and Future Scope

Over the years since CSR has gained momentum in corporate world by creating both monetary as well as non-monetary value for the shareholders. This present study strives to provide a robust ranking model for all the stakeholders to compare the CSR performance of companies by considering multiple financial proxies like: Return on Equity, Return on Capital Employed, Sales, CSR to Reward Ratio, Power and Fuel, Staff welfare and training expense, Social & Community expense and EPS. It also provides the management an important tool for analysis and accessing their performance with peers and evaluate their market standing to take decisions for future course of action.
However, the present work has some future scopes. The notable limitation of the model is that it has not considered any subjective information. Hence, it provides an opportunity to us for further extensions using various variants of fuzzy numbers and rough sets. In addition, the current work may further be extended for optimizing CSR performance following the methodologies suggested in the past work (for example, Alinaghian and Goli, 2017; Goli et al., 2019; 2021; 2022a; 2022b; 2023; Goli and Keshavarz, 2022). Next, our framework uses a number proxy variables (based on objective information) to gauge the CSR performance. A future work may attempt to include qualitative attributes and carry out a mix of objective and subjective information based analysis. Some other future scopes include causal analysis of impact of individual components on the CSR performance, longitudinal study on CSR performance, relating CSR performance with valuation and stock performance and macroeconomic variables, assessment of organization's fundamental practices and their linkages with CSR performance. The present work provides the policy makers a stable and reliable MCDM framework for analyzing and accessing their CSR performance with peers and evaluate their market standing to take decisions for future course of action.

6. Conclusion

The present work is an attempt to develop a multi-criteria based objective model for assessing and comparing CSR performance of firms. The ongoing work considers to 20 manufacturing firms listed in BSE 100 which are compared with respect to nine criteria such as % CSR implementation, return on Equity, return on Capital Employed, Sales, CSR to Reward Ratio, Power and Fuel, Staff welfare and training expense, Social and community expense and EPS as proxies of company's responsibility toward multiple stakeholders such as government, shareholders, customers, environment, employees and society. Two consecutive financial years such as FY 2019-20 (before COVID 19) and FY 2020-21 (after COVID 19) have been considered to compare the CSR performance and discern the impact of the pandemic. For comparison of the firm performance a novel hybrid MCDM model using LOPCOW and PIV has been developed that provide the benefits like ability to deal with large number of criteria and alternative, negative performance values, provide a comparatively even distribution of criteria weights, carry out the analysis with lesser computational complexity and without presence of any rank reversal phenomenon and generate considerably reliable and stable result. We observe that the firms having higher market capitalization did well in their CSR performance.

Hence, it may be contended that CSR performance shows a positive influence on the market capitalization. We further notice that due to the impact of the pandemic there are some change in the ranking orders but the overall CSR performance has not undergone any substantial changes. We observe that the firms like I T C Ltd (F_{13}), Maruti Suzuki India Ltd.(F_{16}), Nestle India Ltd. (F_{17}) remain in the top bracket and Pidilite Industries Ltd. (F_{18}), Godrej Consumer Products Ltd. (F_{10}), Titan Company Ltd. (F_{20}) and Marico Ltd. (F_{15}) continue their positions in the lower bracket before and after the pandemic. It is seen that post COVID-19 more firms from the drugs and pharmaceutical category could able to enter the top bracket. Based on the result we contemplate that CSR activities carried out in an effective way upholds the image of the firm and enables to gain trust of the stakeholders. In effect, the firms become able to retain a higher market capitalization irrespective of the massive disruptive events like COVID-19. This paper thus communicates an important direction for the policy makers. Further, the reliability, stability and simplicity of the MCDM model used in this paper shall provide a useful tool for the decision makers and analysts to solve various real-life issues. We do hope that the current work shall excite the readers to take it forward.

References

Adebanjo, D., Teh, P. L., & Ahmed, P. K. (2016). The impact of external pressure and sustainable management practices on manufacturing performance and environmental outcomes. *International Journal of Operations & Production Management*, *36*(9), 995-1013.

Alinaghian, M., & Goli, A. (2017). Location, allocation and routing of temporary health centers in rural areas in crisis, solved by improved harmony search algorithm. *International journal of computational intelligence systems*, *10*(1), 894-913.

Awaysheh, A., Heron, R. A., Perry, T., & Wilson, J. I. (2020). On the relation between corporate social responsibility and financial performance. *Strategic Management Journal*, *41*(6), 965-987.

Aytekin, A. (2021). Comparative analysis of normalization techniques in the context of MCDM problems. *Decision Making: Applications in Management and Engineering*, 4(2), 1-25.

Bektas, S. (2022). Evaluating the Performance of the Turkish Insurance Sector for the Period 2002-2021 with MEREC, LOPCOW, COCOSO, EDAS CKKV Methods. *Journal of BRSA Banking and Financial Markets*, *16*(2), 247-283.

Biswas, S., & Pamučar, D. S. (2021). Combinative distance based assessment (CODAS) framework using logarithmic normalization for multi-criteria decision making. *Serbian Journal of Management*, *16*(2), 321-340.

Biswas, S., Bandyopadhyay, G., & Mukhopadhyaya, J. N. (2022a). A multi-criteria framework for comparing dividend pay capabilities: Evidence from Indian FMCG and consumer durable sector. *Decision Making: Applications in Management and Engineering*, *5*(2), 140-175.

Biswas, S., Bandyopadhyay, G., & Mukhopadhyaya, J. N. (2022b). A multi-criteria based analytic framework for exploring the impact of Covid-19 on firm performance in emerging market. *Decision Analytics Journal*, *5*, 100143.

Biswas, S., Bandyopadhyay, G., Pamucar, D., & Sanyal, A. (2022c). A decision making framework for comparing sales and operational performance of firms in emerging market. *International Journal of Knowledge-based and Intelligent Engineering Systems*, *26*(3), 229-248.

Biswas, S., Bandyopadhyay, G., Pamucar, D., & Joshi, N. (2022d). A Multi-criteria based stock selection framework in emerging market. *Operational Research in Engineering Sciences: Theory and Applications*, *5*(3), 153-193.

Biswas, S., Chatterjee, S., & Majumder, S. (2022e). A spherical fuzzy framework for sales personnel selection. *Journal of Computational and Cognitive Engineering*. https://doi.org/10.47852/bonviewJCCE2202357

Biswas, S., Pamučar, D., Božanić, D., & Halder, B. (2022f). A new spherical fuzzy LBWA-MULTIMOOSRAL framework: Application in evaluation of leanness of MSMEs in India. *Mathematical Problems in Engineering*, *2022*, 1-17. https://doi.org/10.1155/2022/5480848

Biswas, S., Pamucar, D., & Mukhopadhyaya, J. N. (2022g). A multi-criteria-based analytical study of the impact of COVID-19 on ELSS fund performance. *International Journal of Management and Decision Making*, *21*(4), 339-378.

Biswas, S., Pamucar, D., & Kar, S. (2022h). A preference-based comparison of select over-the-top video streaming platforms with picture fuzzy information. *International Journal of Communication Networks and Distributed Systems*, *28*(4), 414-458.

Biswas, S., & Anand, O. P. (2020). Logistics Competitiveness Index-Based Comparison of BRICS and G7 Countries: An Integrated PSI-PIV Approach. *IUP Journal of Supply Chain Management*, *17*(2), 32-57.

Biswas, S., Pamucar, D., Chowdhury, P., & Kar, S. (2021a). A new decision support framework with picture fuzzy information: comparison of video conferencing platforms for higher education in India. *Discrete Dynamics in Nature and Society*, *2021*, 1-22. https://doi.org/10.1155/2021/2046097

Biswas, S., Pamucar, D., Kar, S., & Sana, S. S. (2021b). A new integrated FUCOM–CODAS framework with fermatean fuzzy information for multi-criteria group decision-making. *Symmetry*, *13*(12), 2430.

Bruna, M. G., & Lahouel, B. B. (2022). CSR & financial performance: Facing methodological and modeling issues commentary paper to the eponymous FRL article collection. *Finance Research Letters*, *44*, 102036.

Carroll, A. B. (1991). The pyramid of corporate social responsibility: Toward the moral management of organizational stakeholders. *Business horizons*, *34*(4), 39-48.

Cherian, J., Umar, M., Thu, P. A., Nguyen-Trang, T., Sial, M. S., & Khuong, N. V. (2019). Does corporate social responsibility affect the financial performance of the manufacturing sector? Evidence from an emerging economy. *Sustainability*, *11*(4), 1182.

Cho, S. J., Chung, C. Y., & Young, J. (2019). Study on the Relationship between CSR and Financial Performance. *Sustainability*, *11*(2), 343.

Dahlsrud, A. (2008). How corporate social responsibility is defined: an analysis of 37 definitions. *Corporate social responsibility and environmental management*, *15*(1), 1-13.

Deveci, M., Gokasar, I., Pamucar, D., Biswas, S., & Simic, V. (2022). An Integrated Proximity Indexed Value and q-Rung Orthopair Fuzzy Decision-Making Model for Prioritization of Green Campus Transportation. In q-Rung Orthopair Fuzzy Sets (pp. 303-332), Springer, Singapore.

Ecer, F., & Pamucar, D. (2022). A novel LOPCOW-DOBI multi-criteria sustainability performance assessment methodology: An application in developing country banking sector. *Omega*, 112. https://doi.org/10.1016/j.omega.2022.102690

Farooq, M., Farooq, O., & Jasimuddin, S. M. (2014). Employees response to corporate social responsibility: Exploring the role of employees' collectivist orientation. *European Management Journal*, *32*(6), 916-927.

Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston: Pitman.

García-Sánchez, I. M., Aibar-Guzmán, B., Aibar-Guzmán, C., & Azevedo, T. C. (2020). CEO ability and sustainability disclosures: The mediating effect of corporate social responsibility performance. *Corporate Social Responsibility and Environmental Management*, *27*(4), 1565-1577.

Goli, A., & Mohammadi, H. (2022). Developing a sustainable operational management system using hybrid Shapley value and Multimoora method: case study petrochemical supply chain. *Environment, Development and Sustainability*, 24(9), 10540-10569.

Goli, A., Khademi-Zare, H., Tavakkoli-Moghaddam, R., Sadeghieh, A., Sasanian, M., Malekalipour Kordestanizadeh, R. (2021). An integrated approach based on artificial intelligence and novel meta-heuristic algorithms to predict demand for dairy products: a case study. *Network: computation in neural systems*, 32(1), 1-35.

Goli, A., Ala, A., & Mirjalili, S. (2022a). A robust possibilistic programming framework for designing an organ transplant supply chain under uncertainty. *Annals of Operations Research*, 1-38.

Goli, A., Golmohammadi, A. M., & Verdegay, J. L. (2022b). Two-echelon electric vehicle routing problem with a developed moth-flame meta-heuristic algorithm. *Operations Management Research*, 15(3-4), 891-912.

Goli, A., & Keshavarz, T. (2022). Just-in-time scheduling in identical parallel machine sequence-dependent group scheduling problem. *Journal of Industrial and Management Optimization*, 18(6), 3807-3830.

Goli, A., Ala, A., & Hajiaghaei-Keshteli, M. (2023). Efficient multi-objective meta-heuristic algorithms for energy-aware non-permutation flow-shop scheduling problem. *Expert Systems with Applications*, 213, 119077.

Goli, A., Zare, H. K., Tavakkoli-Moghaddam, R., & Sadeghieh, A. (2019). Hybrid artificial intelligence and robust optimization for a multi-objective product portfolio problem Case study: The dairy products industry. *Computers & industrial engineering*, 137, 106090.

Gjølberg, M. (2009). Measuring the immeasurable?: Constructing an index of CSR practices and CSR performance in 20 countries. *Scandinavian journal of management*, 25(1), 10-22.

Goswami, S. S., Mohanty, S. K., & Behera, D. K. (2022). Selection of a green renewable energy source in India with the help of MEREC integrated PIV MCDM tool. *Materials today: proceedings*, 52, 1153-1160.

Gupta, S., Bandyopadhyay, G., Biswas, S., & Mitra, A. (2023). An integrated framework for classification and selection of stocks for portfolio construction: Evidence from NSE, India. *Decision Making: Applications in Management and Engineering*, *6*(1), 774-803. https://doi.org/10.31181/dmame0318062021g

Hill, R. P., Ainscough, T., Shank, T., & Manullang, D. (2007). Corporate social responsibility and socially responsible investing: A global perspective. *Journal of business ethics*, *70*, 165-174.

Jahan, A., & Edwards, K. L. (2015). A state-of-the-art survey on the influence of normalization techniques in ranking: Improving the materials selection process in engineering design. *Materials & Design (1980-2015)*, *65*, 335-342.

Jahan, A. (2018). Developing WASPAS-RTB method for range target-based criteria: toward selection for robust design. *Technological and Economic Development of Economy*, *24*(4), 1362-1387.

Kamran, H. W., Pantamee, A. A., Patwary, A. K., Ghauri, T. A., Long, P. D., & Nga, D. Q. (2021). Measuring the association of environmental, corporate, financial, and social CSR: evidence from fuzzy TOPSIS nexus in emerging economies. *Environmental Science and Pollution Research*, 28(9), 10749-10762.

Karmakar, P., Dutta, P., & Biswas, S. (2018). Assessment of mutual fund performance using distance based multi-criteria decision making techniques-An Indian perspective. *Research bulletin*, 44(1), 17-38.

Koh, K., Li, H., & Tong, Y. H. (2023). Corporate social responsibility (CSR) performance and stakeholder engagement: Evidence from the quantity and quality of CSR disclosures. *Corporate Social Responsibility and Environmental Management*, *30*(2), 504-517.

Lopatta, K., Canitz, F., & Tideman, S. A. (2022). Abnormal CSR and financial performance. *European Accounting Review*, 1-27.

Lee, M.S.; Park, D.S.; & Kim, J.B. (2009). Firms' characteristics and corporate social responsibilities. *Bus. Res*. 5, 70–81.

Lin, L., Hung, P. H., Chou, D. W., & Lai, C. W. (2019). Financial performance and corporate social responsibility: Empirical evidence from Taiwan. *Asia Pacific Management Review*, 24(1), 61-71.

Mehralian, G., Nazari, J. A., Zarei, L., & Rasekh, H. R. (2016). The effects of corporate social responsibility on organizational performance in the Iranian pharmaceutical industry: The mediating role of TQM. *Journal of cleaner production*, *135*, 689-698.

Mufazzal, S., & Muzakkir, S. M. (2018). A new multi-criterion decision making (MCDM) method based on proximity indexed value for minimizing rank reversals. *Computers & Industrial Engineering*, 119, 427-438.

Niu, W., Rong, Y., Yu, L., & Huang, L. (2022). A Novel Hybrid Group Decision Making Approach Based on EDAS and Regret Theory under a Fermatean Cubic Fuzzy Environment. *Mathematics*, 10(17), 3116.

Pamucar, D., Žižović, M., Biswas, S., & Božanić, D. (2021). A new logarithm methodology of additive weights (LMAW) for multi-criteria decision-making: Application in logistics. *Facta Universitatis, Series: Mechanical Engineering*, 19(3), 361-380.

Pamucar, D., Torkayesh, A. E., & Biswas, S. (2022a). Supplier selection in healthcare supply chain management during the COVID-19 pandemic: a novel fuzzy rough decision-making approach. *Annals of Operations Research*, 1-43. https://doi.org/10.1007/s10479-022-04529-2

Panayiotou, N. A., Aravossis, K. G., Moschou, P. (2009). A new methodology approach for measuring corporate social responsibility performance. *Water, Air, & Soil Pollution: Focus*, 9(1), 129-138.

Park, Y. K. (2013). Evaluating the performance of trading strategies based on corporate social responsibility. *Korea J. Bus. Adm*, 26, 891-907.

Pérez, A., & Rodríguez del Bosque, I. (2013). Measuring CSR image: Three studies to develop and to validate a reliable measurement tool. *Journal of business ethics*, *118*, 265-286.

Pramanik, P. K. D., Biswas, S., Pal, S., Marinković, D., & Choudhury, P. (2021). A comparative analysis of multi-criteria decision-making methods for resource selection in mobile crowd computing. *Symmetry*, 13(9), 1713.

Raigar, J., Sharma, V. S., Srivastava, S., Chand, R., & Singh, J. (2020). A decision support system for the selection of an additive manufacturing process using a new hybrid MCDM technique. *Sādhanā*, *45(1)*, 1-14.
Rajesh, R., Rajeev, A., & Rajendran, C. (2022). Corporate social performances of firms in select developed economies: A comparative study. *Socio-Economic Planning Sciences*, *81*, 101194.

Rezaee, Z. (2016). Business sustainability research: A theoretical and integrated perspective. *Journal of Accounting literature*, 36, 48-64.

Saeidi, S. P., Sofian, S., Saeidi, P., Saeidi, S. P., & Saaeidi, S. A. (2015). How does corporate social responsibility contribute to firm financial performance? The mediating role of competitive advantage, reputation, and customer satisfaction. *Journal of business research*, 68(2), 341-350.

Seraj, M., Yahya, S. M., Badruddin, I. A., Anqi, A. E., Asjad, M., & Khan, Z. A. (2019). Multi-response optimization of nanofluid-based IC engine cooling system using fuzzy PIV method. *Processes*, *8*(1), 30.

Shabbir, M. S., & Wisdom, O. (2020). The relationship between corporate social responsibility, environmental investments and financial performance: evidence from manufacturing companies. *Environmental Science and Pollution Research*, 27(32), 39946-39957.

Shahzad, M., Qu, Y., Javed, S. A., Zafar, A. U., & Rehman, S. U. (2020). Relation of environment sustainability to CSR and green innovation: A case of Pakistani manufacturing industry. *Journal of Cleaner Production*, 253, 119938.

Steiner, G. A. (1971). *Business and society*. New York: Random House.

Thao, L.H.N., Anh, D. N. P., & Velencei, J. (2019). Measuring corporate social performance. *Serbian Journal of Management*, 14(1), 193-204.

Vafaei, N., Ribeiro, R. A., & Camarinha-Matos, L. M. (2016). Normalization techniques for multi-criteria decision making: analytical hierarchy process case study. In doctoral conference on computing, electrical and industrial systems (pp. 261-269) (2016, April) Springer, Cham.

Vargas, L. (2015). Measuring CSR Performance: An Approach to Evaluate Colombian Companies. In Cross-Cultural Business Conference 2015 (p. 93).

Wakeel, S., Bingol, S., Ahmad, S., Bashir, M. N., Emamat, M. S. M. M., Ding, Z., & Hussain, F. (2021). A new hybrid LGPMBWM-PIV method for automotive material selection. *Informatica*, 45(1), 105-115.

Wen, Z., Liao, H., & Zavadskas, E. K. (2020). MACONT: Mixed aggregation by comprehensive normalization technique for multi-criteria analysis. *Informatica*, 31(4), 857-880.

Wu, L. C., Chang, K. L., & Liao, S. K. (2020). A hybrid MCDM model to select optimal hosts of variety shows in the social media era. *Symmetry*, 12(1), 125.

Yannan, D., Ahmed, A. A. A., Kuo, T. H., Malik, H. A., Nassani, A. A., Haffar, M., ... Iramofu, D. P. F. (2022). Impact of CSR, innovation, and green investment on sales growth: new evidence from manufacturing industries of China and Saudi Arabia. *Economic Research-Ekonomska Istraživanja*, 35(1), 4537-4556.
Yang, Y., & Stohl, C. (2020). The (in) congruence of measures of corporate social responsibility performance and stakeholder measures of corporate social responsibility reputation. *Corporate Social Responsibility and Environmental Management*, *27*(2), 969-981.

Appendix A

Decision Matrix – FY 2019-20

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9
Company	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)
F1	129.7861	29.77	27.8	171373.3	56.23218	833	807.7	746.4	27.95
F2	100.5387	24.54	24.39	300824.8	57.36788	1165.7	881.1	1194.4	176.52
F3	100	35.24	30.78	109866.8	74.78333	1349.3	150.5	284.3	60.93
F4	285.4029	14.15	14.12	126683.1	35.6385	2285.9	717.5	363.1	29.13
F5	100.4564	50.62	47.72	45250.5	64.7153	453.5	67	198.1	28.3
F6	100.9058	27.6	26.18	62700.3	59.48079	646.1	180.2	278.5	6.65
F7	170.8123	18.79	18.6	53105.7	40.4485	2807.3	123.8	506.8	50.56
F8	112.4132	21.17	19.42	118504	137.3375	2704	1427	275	177.6
F9	100	24.75	24.47	92446	50.90215	628.2	459.3	553.9	698.11
F10	76.91397	23.59	22.85	57810.5	79.36737	941.8	75.6	194.9	11.6
F11	135.2771	21.52	21.4	284906.3	40.45326	1322.2	1004.3	1306.1	145.39
F12	101.083	85.79	81.75	387850	74.52345	2630	670	1440	31.09
F13	100.0981	25.2	25.13	468073.4	64.15881	7445.5	2639.4	3264.9	12.38
F14	100	4.32	3.99	453113.3	71.20983	2483.2	1875.4	1265.9	11.93
F15	96.24413	31.55	29.07	58670	76.15176	330	150	190	7.79
F16	100.9604	12.03	11.97	735427	65.61593	7422	2266	1682	185.61
F17	100.6304	70.34	67.63	127639.4	80.41373	3405.3	1044.2	383.1	210.5
F18	106.0056	26.53	26.31	63379.5	60.1327	579.4	179	263	22.59
F19	161.8519	11.54	9.07	137654.1	1212.32	3631	325.6	269.5	11.36
F20	100.7805	23.07	16.16	200100	84.73701	450	750	310	16.9

Decision Matrix – FY 2020-21

Criteria	V1	V2	V3	V4	V5	V6	V7	V8	V9
Company	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)
F1	76.56871	28.65	26.98	215200.3	101.2614	747.1	801.3	629.8	31.58
F2	101.0559	20.24	20.13	278763	48.68959	913.4	825.5	1282.5	157.53
F3	100	46.32	33.2	123777.9	81.52219	1294.2	236.4	324.4	73.02
F4	100.0935	10.8	10.76	113186.2	90.04832	2128.3	935.1	428.4	24.99
F5	102.5238	72.42	67.69	48436.9	73.06456	409.6	71.8	215.3	36.74
F6	100.6662	27.67	26.78	71626.3	64.65796	691.6	161	287.1	7.78
F7	107.7478	23.55	23.5	67986.1	84.18777	3191.5	149.2	318.8	73.57
F8	105.8065	10.76	9.93	133491	112.7772	2706	1917	479	104.05
F9	100	14.77	14.64	89152.4	40.03601	529.4	435.2	563.7	48.58
F10	121.533	21.69	21.02	65361.8	50.36345	804.7	64.4	340.8	12.19
F11	102.7509	20.24	20.03	303731.6	45.68595	1129.1	1009.3	683.5	148.56
F12	102.0903	28.93	28.06	459960	73.91568	3040	1480	1650	34.14
F13	100.1757	21.32	21.2	485245.6	53.33073	6721.1	2085.1	3534.6	10.63
F14	82.42715	1.82	1.57	442219.6	84.98577	2405.7	2221.7	1043.9	5.07
F15	102.2511	39.3	36.04	69320	70.84149	220	130	204.4	9.01
F16	100	8.72	8.65	684229	60.86018	5073	2144	1409	141.99
F17	100.2592	105.51	97.2	137528.4	72.54567	3136.8	909.7	464.2	223.46
F18	107.0325	21.47	21.06	62205.4	58.73105	507	148.1	277	21.19
F19	207.6271	3.55	2.8	158401.2	121.7473	3560.6	337.5	269.5	3.79
F20	100.7783	14.02	8.81	206020	67.05726	320	510	380	11.35