Ramanujan International Journal of Business and Research, 2024, 9(1), 22-32

doi: https://doi.org/10.51245/rijbr.v9i1.2024.1299
P-ISSN: 2455-5959
E-ISSN: 2583-0171

ARTICLE

Performance Evaluation of Select State-Level Public Sector Enterprises-An Integrated AHP-VIKOR Approach

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Abstract

Public Sector Enterprises are the backbone of a developing economy. These enterprises are established to play a dual role in the economy, bringing economic growth and social development. Thus, periodic evaluation of the performance of these enterprises is significant for the success of the enterprises as well as for the economic plans as both are interdependent. The common practice of judging the performance of public enterprises based on financial performance cannot justify its performance due to its multiple conflicting objectives. Thus, focusing on the multi-dimensional performance evaluation approach for public sector enterprises is imperative. The present study contributes in this context with a two-staged integrated MCDM-based methodology to evaluate the performance of State-level public sector enterprises. The AHP analysis is applied to generate criteria weights in the first stage. In the second stage, the VIKOR analysis uses the criteria weights for comparative performance analysis to rank the enterprises based on their performance. The study illustrates the methodology with a notional example of select state-level public sector enterprises. The AHP-VIKOR duo is found effective in the performance-based ranking of the firms and augments the objectivity of the concept of performance evaluation.

Keywords: Performance evaluation, Public Sector Enterprises, Analytical hierarchy process, VIKOR, multi-criteria decision-making, State-Level Public Enterprises.

1 Introduction

Public sector enterprises occupy a vital position in the nation's economy all over the world irrespective of their political positioning. These enterprises are set up to accelerate economic growth in terms of social gain and generate surplus to pave the way for further developmental activities in the economy (Chauhan, 2006). The entry of the public sector into the economic domain in India is a post-independence phenomenon. These enterprises were set up in India with multiple objectives such as to benefit the economy by accelerating the pace of economic growth and reducing regional disparities, to supply essential goods and services to the people at reasonable prices, and to perform maximum social good at the same time earn a return on investment and generate resources for further expansion (Gupta, 2005). Considering the multi-faceted role of public enterprises, it is imperative to ensure that these enterprises perform efficiently and effectively towards achieving their financial and non-financial objectives. In the case of Central Public Sector Enterprises (CPSEs) in India, their

performance is regularly evaluated through the MOU system by the Department of Public Enterprises under the Ministry of Finance. The MOU framework assesses these enterprises' efficacy towards fulfilling the core objectives for which they have been constituted. However, the performance evaluation problem of state-level public enterprises still involves selecting suitable parameters that affect the outcomes and specific methodology, for which there is no academic consensus (Mathew, 1997). The common practice of judging the performance of public enterprises based on financial performance cannot justify its performance due to its multiple conflicting objectives. Therefore, focusing on a multi-dimensional approach for evaluating the performance of public sector enterprises is crucial. Literature reviews indicate that applying a multi-criteria decision-making approach to assess these enterprises is a relatively underexplored area. This gap highlights the value of using the integrated AHP-VIKOR method, which is widely utilized for multi-criteria performance evaluation and ranking.

The present study addresses this gap by employing a two-stage integrated MCDM methodology for evaluating public sector enterprises. In the first stage, AHP analysis is used to determine the criteria weights. In the second stage, VIKOR analysis utilizes these weights to rank the enterprises based on their performance. While evaluating individual enterprise performance is crucial for its development, comparative performance evaluation is also essential, as rankings provide insights into areas for improvement.

2 Literature Review

The MCDM approach is widely used in various disciplines for complex decision-making problems, some of which this study reviews. Guru & Mahalik (2018) used a combination of AHP and VIKOR methods to measure the performance of public sector banks and rank them based on inputs and outputs criteria. (Fu et al., 2011) applied the VIKOR methodology for benchmarking analysis in the hotel industry. Salehi (2016), considering personnel selection as an MCDM problem, used hybrid AHP and VIKOR to solve the problem. (Canco et al., 2021) explored the use of the AHP method of MCDM for quality decision-making in the business. (Ahmad et al., 2017) applied integrated FAHP and VIKOR methods for supplier selection in an automotive spare parts manufacturing company. (Dincer & Hacioglu, 2013) applied Fuzzy VIKOR and AHP to evaluate the performance of Turkish banks based on customer satisfaction competencies. Rezaie et al. (2014) evaluated the performance of Iranian Cement Firms based on their financial ratios using the combined FAHP and VIKOR method. (Sennaroglu & Varlik Celebi, 2018) used the VIKOR and PROMETHEE methods for ranking and selection of locations for military airports. (Alimohammadlou & Bonyani, 2017) used an integrated model composed of the Best-Worst method and PROMETHEE II to analyze the financial performance of the companies. (Zhu et al., 2015) presented a systematic evaluation method by integrating AHP and VIKOR methods to enhance the objectivity of the decision under a subjective environment. (Jayachitra, 2019) applied a multi-criteria decision-making model with a combination of AHP and TOPSIS methods to evaluate the profitability and risk management performance of public sector banks in India. (Lin & Ma, 2011) used AHP to break through the problem of evaluation in public decision-making. (Ghadikolaei & Esbouei, 2014) provides a hybrid approach of MCDM methods in the fuzzy environment to evaluate the financial performance of automotive and spare manufacturing companies traded in TSE. (Panagiotis et al., 2018) proposed a new model of the AHP assessment system for municipalities in Greece in the era of austerity due to the economic crisis. (Baydas & Elma, 2021) conducted an experimental study to measure the financial performance of manufacturing companies in Borsa Istanbul using MCDM methods- PROMETHEE, TOPSIS, and WSA. (Lu & Zhu, 2018) used the AHP method to construct a performance evaluation system for insurance companies using financial and non-financial indicators of performance. (Ameemi, 2018) developed an evaluation model for government services based on quality dimensions through performance indicators using the AHP approach. (Dulange et al., 2014) used AHP as an MCDM tool to determine priority weights of the performance measures for Power Loom Textiles based on Financial, non-financial, and process measures. (Rayasam & Guravaian, 2022) incorporated physical and financial performance indicators to examine the performance of state transport undertakings in India. (Ghosh, 2023) conducted a comparative analysis of the efficiency of state transport corporations in two Indian cities exploring the descriptive statistics and applying the F test to estimate the equality of samples. (Paul & Attri, 2016) highlighted the growth of Himachal Pradesh State Co-operative Bank using financial and operational indicators.

3 Objective of the study

The study attempts to suggest a methodology to evaluate the performance of public sector enterprises by applying an MCDM approach. It also demonstrates the methodology using a sample of state-level public sector enterprises.

4 Methodology

The study focuses on multi-criteria performance measurement as an important aspect of the performance evaluation of public sector enterprises. The study suggests a two-staged integrated MCDM-based methodology to evaluate the performance of public sector enterprises. In the first stage, the AHP analysis is applied to generate criteria weights and in the second stage, the VIKOR analysis is carried out for the performance-based ranking of the enterprises. The proposed methodology is also demonstrated using a sample of state-level public sector enterprises in Goa. The data for AHP analysis is obtained from primary sources and the VIKOR analysis is done using the secondary data from the annual reports and records of the sample units. As the chosen performance parameters are expressed in ratios, the difficulties associated with

the use of ratios are mitigated with the transformation of ratios into scores. The detailed methodology is explained below:

4.1 Criteria for Performance Evaluation

Considering the multi-dimensional role of public enterprises, the study proposes a comprehensive performance evaluation methodology incorporating multiple performance parameters in one framework. Compounding the financial and non-financial objectives of public enterprise, the study identified fifteen parameters and categorized them into four broad criteria: financial performance, physical performance, contribution to the economy, and contribution to society.

Table 1: Performance Indicators

Criteria	Parameter	Measurement
Financial performance (Jenkins, 1979)	Profitability	Return on assets $= \frac{\text{Net profit after tax}}{\text{Total assets}} \times 100$
	Liquidity	Current Ratio $= \frac{\text{Current assets}}{\text{Current liabilities}}$
	Solvency	Solvency Ratio $= \frac{\text{Total debts}}{\text{Total liabilities}}$
Physical Performance (Enterprise specific)	Output/ Deliverables	The growth rate in the output of goods or services provided
	Impact of the activity	Turnover share of GSDP $= \frac{\text{Turnover}}{\text{GSDP}}$
	Efficiency of operation	Cost of revenue ratio $= \frac{\text{Cost of revenue}}{\text{Total Revenue}}$
Contribution to Economy (Jenkins, 1979)	Internal Resource Generation	The ratio of Internal Resource generation to total Investment (IRG= Depreciation + Deferred Revenue Expenditure Written off + Retained earnings)
	Contribution to Exchequer	The ratio of Contribution to the exchequer to total Investment (Contribution=Taxes & Duties + Dividend + Interest) (Net contribution after deducting subsidies received from the Government)
	Employment Generation	The growth rate in the number of employees.
	Value Addition	The ratio of Value addition to total investment (Value addition= Interest+ Dividend+ Taxes+ wages+ Retained Profits)
Contribution to the Society (Jenkins, 1979)	Promoting Research & Development, Innovation and technological up-gradations	The ratio of expenditure on research & development, innovation, and technological advancement to total revenue
	Protection and conservation of the environment	The ratio of expenditure on conservation of the environment to total revenue.
	Community Welfare	The ratio of expenditure on social overheads (like education, health, sports, etc.) to total revenue.
	Human Resource Development	The ratio of Expenditure on the development of human resources to total revenue.
	Corporate Governance	Board Size The optimum number of board members. (Yes=1, No=0) Board independence The optimum number of independent directors. (Yes=1, No=0) Prescribed number of board meetings in a year. (Yes=1, No=0) Internal audit. (Yes=1 & No=0) (Total score out of 4)

Source: Author's Composition

4.2 The Analytical Hierarchy Process

The multiple criteria used in the framework are weighed using the widely used MCDM technique- Analytical Hierarchy Process (AHP). The AHP analysis is based on the pairwise comparison data obtained from experts who are stakeholders in public sector undertakings. Using the Delphi method, the input data is collected from 20 experts carefully selected based on their availability and knowledge in the field. A structured AHP questionnaire was developed on a nine-point scale for pairwise comparison of the performance indicators. The pairwise comparison matrix is constructed for each expert's pairwise comparison which is further normalized to obtain the relative weights. The consistency check was performed to filter the inconsistencies by calculating the consistency ratio (C.R.) and the consistency index (C.I). The scores are considered consistent when the value of the consistency index (C.I.) is less than 0.1. Upon successful consistency check, all the expert's scores are then accepted for analysis. The geometric mean of the individual score of 20 experts is calculated and entered in the aggregate comparison matrix to find out the weights of the criteria and sub-criteria.
Step 1: In the pair-wise comparison matrix (A), the scores are taken as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{bmatrix}$$

In matrix A, a_{ij} is the degree of preference of element i to element j. The matrix A is a_{mxm} square matrix, where m is the number of evaluation criteria considered. Each entry a_{ij} of the matrix A represents the importance of the i^{th} criterion relative to the j^{th} criterion. If $a_{ij} > 1$, then the i^{th} criterion is more important than the j^{th} criterion, while if $a_{ij} < 1$, then the i^{th} criterion is less important than the j^{th} criterion. If two criteria have the same importance, then the entry a_{ij} is 1. The relative importance between the two criteria is measured according to a numerical scale from 1 to 9. The entries a_{ij} and a_{ji} satisfy the following constraint:

$$a_{ij}.a_{ji} = 1. \tag{1}$$

Step 2: The normalized pairwise comparison matrix A_{norm} is derived by making the sum of the entries on each column equal to 1. Each entry of the matrix A_{norm} is calculated by dividing each entry in the comparison matrix by its corresponding column sum.

$$A_{norm} = \begin{bmatrix} \frac{a_{11}}{\sum a_1} & \frac{a_{12}}{\sum a_2} & \cdots & \frac{a_{1j}}{\sum a_j} \\ \frac{a_{21}}{\sum a_1} & \frac{a_{22}}{\sum a_{12}} & \cdots & \frac{a_{2j}}{\sum a_j} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{a_{i1}}{\sum a_1} & \frac{a_{i2}}{\sum a_2} & \cdots & \frac{a_{ij}}{\sum a_j} \end{bmatrix} = \begin{bmatrix} a_{i1} \\ a_{i2} \\ \vdots \\ a_{ij} \end{bmatrix}$$

Step 3: The relative vector weights (W) also known as eigenvectors among the items are obtained by averaging row entries in the normalized matrix. The sum of all the elements of eigenvectors should be equal to 1.
Step 4: The eigenvalue (AW) is obtained by multiplying the comparison matrix and the relative weights column.
Step 5: Lamda (λ) is obtained by dividing the eigenvalue by the eigenvector for each element (AW/W). The average of the Lamda (λ) column is the Lamda (λ) max.
Step 6: The consistency of the scores can be determined by calculating the consistency index (C.I) and consistency ratio (C.R.). The CI is calculated using the formula:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)}$$

(Where n is the number of criteria considered for evaluation) CR is calculated using the formula:

$$CR = \frac{CI}{RI}$$

RI refers to a random consistency index, which is derived from a large sample of randomly generated reciprocal matrices using the scale $1/9, 1/8, \cdots, 1 \cdots, 8, 9$. Saaty suggested that the value of the CR should not exceed 0.1 for a confident result. Therefore, $CR < 0.10$ is acceptable.

Table 2: Random Index values for different size matrices

N	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Source: (Saaty, 1977)

4.3 VIKOR analysis

VIKOR is one of the well-known MCDM methods that is used to determine the final ranking of the alternatives. In the literature, most studies have used AHP in combination with the VIKOR method. The VIKOR method was developed for multicriteria optimization of complex systems. This method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria. Vlsekriterijumska Optimizacija lKOmpromisno Resenje method (the Serbian name of VIKOR) means multi-criteria optimization and compromise solution. It is a multi-criteria decision-making method developed in 1990 by Serafim Opricovic to solve decision problems with conflicting criteria. This method ranks the alternatives and determines the compromise solution that is the closest to the "ideal solution". The unique approach presented in the study is combining Garett scoring with VIKOR to modify the input data for the analysis. The original input data available in the ratio form is first converted into a score before using it in the VIKOR analysis to overcome the difficulties in the use of ratios and make the data easier for use.

The steps involved in converting ratio into scores:

i. In the first step the absolute or ratio values of the performance parameters of observed units are ranked.
ii. The percent position of each rank is calculated using the Garett scoring technique formula:

$$Percent\ position\ =\ \left[100\left(R_i\ -\ 0.5\right)\right]/n$$

(Where R_i refers to the rank given to the *ith* value and n refers to the number of items ranked)
iii. The percent position estimated is converted into scores by referring to the table given by Garret and Woodworth (1969).
iv. The Garret scores are then used as input data for relative performance analysis and ranking of the observed units each criterion-wise and also based on overall performance.

Steps in the VIKOR method:

Step 1: Establish a decision matrix of criteria and different alternatives.

$$f_{ij} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} A & C_{X1} & C_{X2} & \cdots & \cdots & C_{Xn} \end{array} \\ \begin{bmatrix} X_{11} & X_{12} & \cdots & \cdots & X_{1n} \\ X_{21} & X_{21} & \cdots & \cdots & X_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ X_{m1} & X_{m2} & \cdots & \cdots & X_{mn} \end{bmatrix} \end{array}$$

f_{ij} is the decision matrix with m alternatives and n criteria. Here, A represents i_{th} alternative, $i = 1, 2, \cdots, m; C_X$ represents the j_{th} criterion, $j = 1, 2, \cdots, n; X_{ij}$ is the score of each alternative with regard to each criterion.

Step 2: Obtain weights for the criteria (as derived using AHP).

Step 3: Determine the best and worst rating score for each criterion.
For beneficial criteria (Higher value is better):
Best rating score: $f_i^+ = max\left(f_{ij}\right)$
Worst rating score: $f_i^- = min\left(f_{ij}\right)$
For non-beneficial criteria (lower value is better):
Best rating score: $f_i^+ = min\left(f_{ij}\right)$
Worst rating score: $f_i^- = max\left(f_{ij}\right)$

Step 4: Compute the distance for each alternative.

$$S_{ij}\ =\ W_j\ \frac{\left(f_i^+ - f_{ij}\right)}{\left(f_i^+ - f_i^-\right)}.$$

Here, W_j is the weight of the j_{th} criterion. Step 5: Calculate the Utility measure (S_i), Regret measure (R_i), and VIKOR Index (Q_i)

$$S_i = \sum_{j=1}^{n} W_j \frac{\left(f_i^+ - f_{ij}\right)}{\left(f_i^+ - f_i^-\right)}$$

$$R_i = max\left[\sum_{j=1}^{n} W_j \frac{\left(f_i^+ - f_{ij}\right)}{\left(f_i^+ - f_i^-\right)}\right]$$

$$Q_i = v\left[\frac{\left(S_i - S_i^-\right)}{\left(S_i^+ - S_i^-\right)}\right] + (1-v)\left[\frac{\left(R_i - R_i^-\right)}{\left(R_i^+ - R_i^-\right)}\right]$$

Here $S_i^+ = max\left(S_{ij}\right), S_i^- = min\left(S_{ij}\right), R_i^+ = max\left(R_{ij}\right)$ and $R_i^- = min\left(R_{ij}\right)$ Q_i represents the i_{th} alternative VIKOR value, $i = 1, 2, \cdots, m$ and v is the weight of the maximum group utility usually to be set to 0.5.

Step 6: Rank the VIKOR Index (Q_i) in descending order (The alternative having the smallest VIKOR value is determined to be the best alternative).

5 Analysis and discussion

5.1 Priority Weights of Performance Indicators

Table 3: Priority weights of performance indicators

Criteria	Parameter	Priority weights	Type of parameter
Financial performance	P1: Profitability	3	Beneficial
	P2: Liquidity	6	Beneficial
	P3: Solvency	5	Non-beneficial
	Total	14	
Physical performance	P4: Output/ Deliverables	4	Beneficial
	P5: Impact of activity	3	Beneficial
	P6: Efficiency of operation	5	Non-beneficial
	Total	12	
Contribution to Economy	P7: Internal Resource Generation	7	Beneficial
	P8: Contribution to Exchequer	5	Beneficial
	P9: Employment generation	14	Beneficial
	P10: Value addition	7	Beneficial
	Total	33	
Contribution to Society	P11: Promoting research & development, innovation, and technological up-gradation	4	Beneficial
	P12: Protection and conservation of the environment	5	Beneficial
	P13: Community welfare	14	Beneficial
	P14: Human resource development	12	Beneficial
	P15: Corporate Governance	6	Beneficial
	Total	41	
	Overall performance	100	

Source: Author's computation

5.2 Profile of the Sample Units

5.3 Performance analysis using VIKOR

5.3.1 *Rating best and worst scores*

5.3.2 *Utility measure* (S_i), *Regret measure* (R_i), *and VIKOR Index* (Q_i)

Table six shows the utility measure (S_i), regret measure (R_i), and VIKOR index (Q_i). The VIKOR index (Q_i) is calculated with the help of utility measures (S_i) and regret measures (R_i). The VIKOR index (Q_i) is useful to rank the alternatives (SLPEs) in the descending order of (Q_i) (the alternative having the smallest VIKOR value is determined to be the best alternative).

Table 4: Brief profile of the select state-level public sector enterprises

Name of the unit	Status
Goa Industrial Development Corporation (GIDC)	Working Statutory corporation
Economic Development Corporation Ltd (EDC)	Working Government company
Goa State Infrastructure Development Corporation Ltd (GSIDCL)	Working Government company
Goa Meat Complex Ltd (GMCL)	Working Government company
Sewerage and Infrastructural Development Corporation Ltd (SIDCL)	Working Government company
Goa State Scheduled Tribes Finance & Development Corporation Limited (GSSTFDCL)	Working Government company
Goa Tourism Development Corporation (GTDC)	Working Government company
Kadamba Transport Corporation Ltd (KTCL)	Working Government company

Source: Author's composition

Table 5: Rating (best and worst) scores of the parameters

Ideal solutions	Performance Parameters														
	Financial performance			Physical performance			Contribution to Economy				Contribution to society				
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Best (fi+)	80	80	21	80	80	80	80	80	80	80	0	0	80	80	80
Worst (fi-)	21	21	80	80	80	80	21	21	80	21	0	0	0	21	68

Source: Author's computation

5.3.3 Ranking of enterprises

Table seven outlines the rankings of various alternatives across five criteria: financial performance, physical performance, contribution to the economy, contribution to society, and overall performance during the period from 2008-09 to 2019-20, including their aggregate ranks. From the analysis, it is observed that GSIDCL holds the top position for financial performance, followed by GTDC and EDC, while KTCL ranks the lowest among the SLPEs studied. Regarding physical performance, the leading entities are GTDC, GSIDCL, and GSSTFDCL, with EDC ranking the lowest. Vis-á-vis contribution to the economy, GSIDCL, SIDCL, and EDC are the top three, while GIDC is at the bottom. EDC, KTCL, and GIDC rank highest for contribution to society, while GSIDCL ranks the lowest. Overall performance rankings place EDC first, GSIDCL second, and SIDCL third, with GMCL occupying the lowest position among the remaining entities.

5.3.4 Summary of the relative performance of the State level public enterprises

Table eight summarizes the arrangement of SLPEs based on their aggregate ranks for each criterion and overall performance. EDC, which ranks first in overall performance, excels in its contribution to society-an area with the highest weightage according to the AHP-derived weightings. GSIDCL ranked second overall and leads in financial performance and contribution to the economy. SIDCL follows in third place, with GTDC in fourth, GIDC in fifth, KTCL in sixth, GSSTFDCL in seventh, and GMCL in eighth.

6 Conclusion

The multi-dimensional framework developed through this study is a novel approach for the objective evaluation of state-level public sector enterprises. The proposed methodology suggests how the MCDM-based performance measurement approach can be developed and used to evaluate the performance. This study productively adds to the existing rare literature on performance evaluation systems for public sector enterprises based on multiple criteria. The AHP-VIKOR duo is found effective in performing the relative performance evaluation among the firms and augments the objectivity of the concept of performance evaluation. The framework developed and demonstrated through this study is robust and easy to compute the criteria weights and ranking of the enterprises not only in the public sector but also in the private sector using multiple criteria.

7 Limitations of the study

The indicators used in the study are identified from the literature and are those which can be quantified and expressed in operational form but are not exhaustive in measuring the performance. Other ratios can be used instead of the ones which are used in the study. Also, the application of the MCDM approach to performance analysis of enterprise is rare in the literature. The criteria weights are calculated based on the qualitative data collected from the experts which can be subjective and the perspective of the participants may vary as they are not from the same functional role in the enterprise.

8 Scope for further research

The performance indicators can be chosen and adjusted according to the requirements of the study. The study can be extended to even private sector enterprises with suitable indicators of their performance. The study can be conducted with

Table 6: Utility measure (S_i), Regret measure (R_i), and VIKOR Index (Q_i)

SLEP	Performance Criteria											
	Financial performance			Physical performance			Contribution to economy			Contribution to society		
	Si	Ri	Qi	Si	Ri	Qi	Si	Ri	Qi	Si	Ri	Qi
2008-09												
GIDC	0.076	0.048	0.620	0.050	0.033	0.526	0.075	0.028	0.297	0.204	0.140	0.789
EDC	0.043	0.026	0.000	0.060	0.050	0.895	0.079	0.031	0.332	0.114	0.053	0.020
KTCL	0.090	0.060	0.932	0.028	0.022	0.123	0.190	0.070	1.000	0.107	0.067	0.082
GTDC	0.073	0.033	0.375	0.030	0.017	0.068	0.096	0.046	0.519	0.259	0.140	0.952
GMCL	0.097	0.040	0.699	0.024	0.024	0.105	0.047	0.033	0.263	0.240	0.140	0.894
SIDCL	0.060	0.040	0.351	0.070	0.040	0.846	0.107	0.046	0.552	0.276	0.140	1.000
GSSTFDCL	0.067	0.050	0.568	0.030	0.020	0.110	0.151	0.056	0.762	0.221	0.140	0.837
GSIDCL	0.053	0.028	0.115	0.028	0.028	0.211	0.014	0.014	0.000	0.260	0.140	0.954
2009-10												
GIDC	0.086	0.048	0.734	0.050	0.033	0.375	0.155	0.078	0.509	0.221	0.140	0.830
EDC	0.043	0.026	0.058	0.078	0.050	0.838	0.176	0.112	0.679	0.114	0.053	0.000
KTCL	0.090	0.060	0.932	0.061	0.028	0.377	0.218	0.070	0.590	0.119	0.079	0.169
GTDC	0.067	0.033	0.360	0.044	0.017	0.086	0.150	0.047	0.377	0.247	0.140	0.912
GMCL	0.097	0.040	0.734	0.063	0.030	0.423	0.135	0.093	0.529	0.240	0.140	0.890
SIDCL	0.056	0.040	0.348	0.100	0.040	0.849	0.180	0.062	0.488	0.276	0.140	1.000
GSSTFDCL	0.070	0.050	0.614	0.032	0.024	0.105	0.291	0.140	1.000	0.164	0.140	0.656
GSIDCL	0.051	0.022	0.071	0.054	0.032	0.387	0.014	0.014	0.000	0.266	0.140	0.970
2010-11												
GIDC	0.105	0.048	0.858	0.034	0.018	0.000	0.191	0.093	0.629	0.140	0.140	0.726
EDC	0.044	0.034	0.319	0.074	0.050	1.000	0.143	0.078	0.487	0.088	0.067	0.241
KTCL	0.090	0.060	0.910	0.066	0.032	0.621	0.218	0.070	0.590	0.041	0.041	0.000
GTDC	0.062	0.028	0.363	0.046	0.022	0.218	0.161	0.062	0.453	0.219	0.140	0.907
GMCL	0.090	0.040	0.673	0.073	0.030	0.687	0.136	0.112	0.606	0.189	0.140	0.838
SIDCL	0.023	0.017	0.000	0.072	0.040	0.819	0.166	0.047	0.406	0.236	0.140	0.944
GSSTFDCL	0.082	0.050	0.745	0.053	0.033	0.473	0.291	0.140	1.000	0.193	0.140	0.847
GSIDCL	0.065	0.026	0.369	0.062	0.040	0.697	0.014	0.014	0.000	0.260	0.140	1.000
2011-12												
GIDC	0.090	0.048	0.855	0.060	0.026	0.432	0.154	0.062	0.425	0.204	0.140	0.817
EDC	0.066	0.040	0.532	0.064	0.040	0.673	0.143	0.078	0.469	0.128	0.067	0.255
KTCL	0.090	0.060	1.000	0.048	0.032	0.395	0.218	0.070	0.591	0.081	0.041	0.000
GTDC	0.085	0.034	0.648	0.031	0.018	0.000	0.207	0.093	0.658	0.233	0.140	0.890
GMCL	0.073	0.040	0.593	0.080	0.030	0.691	0.112	0.112	0.537	0.240	0.140	0.909
SIDCL	0.039	0.017	0.000	0.070	0.050	0.894	0.166	0.047	0.394	0.276	0.140	1.000
GSSTFDCL	0.063	0.050	0.620	0.065	0.033	0.584	0.282	0.140	1.000	0.259	0.140	0.958
GSIDCL	0.053	0.026	0.249	0.062	0.040	0.661	0.039	0.014	0.000	0.260	0.140	0.960
2012-13												
GIDC	0.078	0.048	0.721	0.035	0.017	0.000	0.201	0.112	0.736	0.233	0.140	0.911
EDC	0.073	0.040	0.596	0.068	0.040	0.639	0.136	0.078	0.482	0.157	0.096	0.357
KTCL	0.090	0.060	0.952	0.070	0.033	0.549	0.218	0.070	0.603	0.107	0.067	0.000
GTDC	0.065	0.028	0.394	0.044	0.017	0.079	0.159	0.056	0.436	0.259	0.140	0.998
GMCL	0.097	0.040	0.764	0.048	0.030	0.309	0.140	0.093	0.546	0.240	0.140	0.935
SIDCL	0.028	0.022	0.059	0.070	0.050	0.806	0.155	0.047	0.395	0.204	0.140	0.818
GSSTFDCL	0.087	0.050	0.815	0.092	0.040	0.849	0.282	0.140	1.000	0.187	0.140	0.760
GSIDCL	0.042	0.017	0.104	0.054	0.032	0.393	0.014	0.014	0.000	0.260	0.140	1.000

the application of other MCDM techniques available in the literature.

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SLEP	Performance Criteria											
	Financial performance			Physical performance			Contribution to economy			Contribution to society		
	Si	Ri	Qi	Si	Ri	Qi	Si	Ri	Qi	Si	Ri	Qi
2013-14												
GIDC	0.059	0.040	0.494	0.059	0.032	0.523	0.204	0.112	0.727	0.204	0.140	0.777
EDC	0.104	0.050	0.850	0.074	0.050	0.952	0.150	0.093	0.534	0.140	0.079	0.019
KTCL	0.112	0.060	1.000	0.066	0.033	0.612	0.227	0.070	0.589	0.136	0.096	0.134
GTDC	0.072	0.034	0.498	0.044	0.017	0.141	0.198	0.062	0.493	0.221	0.140	0.842
GMCL	0.083	0.033	0.558	0.070	0.040	0.762	0.135	0.078	0.439	0.240	0.140	0.920
SIDCL	0.022	0.012	0.000	0.060	0.040	0.652	0.102	0.046	0.230	0.233	0.140	0.891
GSSTFDCL	0.053	0.040	0.460	0.078	0.028	0.667	0.275	0.140	1.000	0.247	0.140	0.948
GSIDCL	0.054	0.020	0.262	0.030	0.022	0.077	0.028	0.028	0.000	0.260	0.140	1.000
2014-15												
GIDC	0.092	0.040	0.783	0.066	0.032	0.565	0.219	0.140	0.941	0.204	0.140	0.790
EDC	0.094	0.048	0.878	0.083	0.050	1.000	0.141	0.093	0.487	0.157	0.096	0.261
KTCL	0.077	0.060	0.900	0.072	0.040	0.749	0.242	0.070	0.627	0.119	0.079	0.000
GTDC	0.069	0.034	0.586	0.037	0.014	0.000	0.223	0.078	0.624	0.233	0.140	0.887
GMCL	0.089	0.033	0.704	0.070	0.040	0.725	0.172	0.112	0.668	0.240	0.140	0.911
SIDCL	0.010	0.010	0.000	0.053	0.033	0.442	0.142	0.046	0.243	0.247	0.140	0.936
GSSTFDCL	0.082	0.050	0.830	0.054	0.024	0.330	0.135	0.056	0.276	0.181	0.140	0.709
GSIDCL	0.047	0.020	0.324	0.046	0.028	0.292	0.047	0.047	0.006	0.266	0.140	1.000
2015-16												
GIDC	0.094	0.048	0.859	0.059	0.032	0.497	0.212	0.140	0.926	0.204	0.140	0.790
EDC	0.079	0.040	0.668	0.074	0.050	0.860	0.148	0.078	0.412	0.142	0.067	0.078
KTCL	0.062	0.034	0.485	0.072	0.040	0.710	0.227	0.070	0.597	0.157	0.096	0.322
GTDC	0.050	0.026	0.327	0.027	0.014	0.000	0.237	0.093	0.747	0.233	0.140	0.887
GMCL	0.092	0.050	0.874	0.092	0.040	0.863	0.140	0.112	0.567	0.200	0.140	0.775
SIDCL	0.087	0.060	0.957	0.053	0.033	0.467	0.142	0.046	0.224	0.119	0.079	0.084
GSSTFDCL	0.080	0.040	0.677	0.049	0.024	0.312	0.135	0.056	0.255	0.221	0.140	0.846
GSIDCL	0.017	0.017	0.000	0.054	0.028	0.409	0.064	0.047	0.006	0.266	0.140	1.000
2016-17												
GIDC	0.076	0.040	0.582	0.088	0.040	0.862	0.202	0.140	0.892	0.204	0.140	0.802
EDC	0.073	0.040	0.566	0.074	0.050	0.890	0.133	0.078	0.376	0.157	0.096	0.267
KTCL	0.112	0.060	1.000	0.070	0.033	0.629	0.242	0.070	0.627	0.119	0.079	0.000
GTDC	0.051	0.033	0.370	0.021	0.013	0.000	0.237	0.093	0.736	0.233	0.140	0.904
GMCL	0.078	0.028	0.467	0.080	0.040	0.802	0.177	0.112	0.674	0.240	0.140	0.929
SIDCL	0.065	0.048	0.602	0.042	0.022	0.273	0.143	0.046	0.232	0.221	0.140	0.860
GSSTFDCL	0.081	0.050	0.715	0.074	0.028	0.594	0.128	0.056	0.242	0.247	0.140	0.954
GSIDCL	0.023	0.013	0.000	0.031	0.017	0.119	0.058	0.047	0.006	0.260	0.140	1.000
2017-18												
GIDC	0.057	0.034	0.398	0.067	0.040	0.755	0.202	0.140	0.892	0.164	0.140	0.722
EDC	0.079	0.040	0.627	0.074	0.050	1.000	0.133	0.078	0.376	0.088	0.067	0.000
KTCL	0.100	0.048	0.859	0.061	0.028	0.497	0.242	0.070	0.627	0.096	0.096	0.217
GTDC	0.062	0.028	0.367	0.035	0.017	0.000	0.237	0.093	0.736	0.193	0.140	0.805
GMCL	0.083	0.033	0.575	0.070	0.040	0.801	0.177	0.112	0.674	0.200	0.140	0.825
SIDCL	0.070	0.060	0.797	0.053	0.033	0.475	0.115	0.046	0.155	0.219	0.140	0.882
GSSTFDCL	0.082	0.050	0.762	0.073	0.032	0.714	0.156	0.056	0.319	0.181	0.140	0.769
GSIDCL	0.027	0.017	0.000	0.048	0.026	0.319	0.058	0.047	0.006	0.260	0.140	1.000
2018-19												
GIDC	0.072	0.048	0.690	0.059	0.040	0.616	0.280	0.140	1.000	0.204	0.140	0.772
EDC	0.073	0.040	0.616	0.060	0.050	0.791	0.138	0.078	0.366	0.128	0.067	0.028
KTCL	0.098	0.040	0.775	0.064	0.028	0.456	0.213	0.062	0.456	0.119	0.079	0.084
GTDC	0.047	0.020	0.236	0.066	0.032	0.539	0.213	0.093	0.608	0.221	0.140	0.824
GMCL	0.079	0.033	0.583	0.080	0.040	0.805	0.160	0.112	0.580	0.240	0.140	0.886
SIDCL	0.099	0.060	1.000	0.028	0.020	0.000	0.121	0.046	0.165	0.276	0.140	1.000
GSSTFDCL	0.068	0.050	0.691	0.083	0.033	0.719	0.132	0.039	0.156	0.233	0.140	0.863
GSIDCL	0.023	0.013	0.000	0.040	0.022	0.142	0.064	0.047	0.041	0.260	0.140	0.950
2019-20												
GIDC	0.056	0.040	0.471	0.060	0.033	0.517	0.227	0.140	0.946	0.035	0.035	0.000
EDC	0.088	0.048	0.705	0.074	0.050	0.902	0.133	0.078	0.371	0.100	0.079	0.356
KTCL	0.081	0.034	0.527	0.072	0.040	0.723	0.242	0.070	0.612	0.096	0.096	0.423
GTDC	0.066	0.024	0.361	0.059	0.032	0.490	0.247	0.112	0.848	0.164	0.140	0.788
GMCL	0.074	0.028	0.441	0.087	0.040	0.834	0.153	0.093	0.498	0.241	0.140	0.957
SIDCL	0.123	0.060	1.000	0.020	0.020	0.000	0.123	0.056	0.223	0.207	0.140	0.882
GSSTFDCL	0.051	0.033	0.380	0.060	0.028	0.434	0.139	0.046	0.214	0.193	0.140	0.851
GSIDCL	0.020	0.010	0.000	0.048	0.026	0.323	0.058	0.047	0.006	0.260	0.140	1.000

Source: Author's computation

Table 7: Criteria-wise and Overall Ranking of Enterprises

SLEP	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Average	Overall rank
Ranking based on financial performance														
GIDC	6	6	7	7	6	4	5	6	5	3	5	5	5.45	7
EDC	1	1	2	3	1	7	7	5	4	5	4	7	3.64	3
KTCL	8	8	8	8	8	8	8	3	8	8	6	6	7.36	8
GTDC	4	4	3	6	4	5	3	2	2	2	2	2	3.36	2
GMCL	7	6	5	4	7	6	4	7	3	4	3	4	5.09	5
SIDCL	3	3	1	1	3	1	1	8	6	7	8	8	3.82	4
GSSTFDCL	5	5	6	5	5	3	6	4	7	6	7	3	5.36	6
GSIDCL	2	2	4	2	2	2	2	1	1	1	1	1	1.82	1
Ranking based on physical performance														
GIDC	6	3	1	3	1	7	5	5	7	6	5	5	4.45	4
EDC	8	7	8	6	6	4	8	7	8	8	7	8	7.00	8
KTCL	4	4	4	2	5	5	7	6	5	4	3	6	4.45	4
GTDC	1	1	2	1	2	8	1	1	1	1	4	4	2.09	1
GMCL	2	6	5	7	3	6	6	8	6	7	8	7	5.82	7
SIDCL	7	8	7	8	7	1	4	4	3	3	1	1	4.82	6
GSSTFDCL	3	2	3	4	8	2	3	2	4	5	6	3	3.82	3
GSIDCL	5	5	6	5	4	3	2	3	2	2	2	2	3.55	2
Ranking based on contribution to economy														
GIDC	3	4	7	3	7	7	8	8	8	8	8	8	6.45	8
EDC	4	7	4	4	4	5	4	4	4	4	4	4	4.36	3
KTCL	8	6	5	6	6	6	5	6	5	5	5	6	5.73	7
GTDC	5	2	3	7	3	4	6	7	7	7	7	7	5.27	5
GMCL	2	5	6	5	5	3	7	5	6	6	6	5	5.09	4
SIDCL	6	3	2	2	2	2	2	2	2	2	3	3	2.55	2
GSSTFDCL	7	8	8	8	8	8	3	3	3	3	2	2	5.55	6
GSIDCL	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1
Ranking based on contribution to society														
GIDC	3	4	3	3	5	3	4	5	3	3	3	1	3.55	3
EDC	1	1	2	2	2	1	2	1	2	1	1	2	1.45	1
KTCL	2	2	1	1	1	2	1	3	1	2	2	3	1.64	2
GTDC	6	6	6	4	7	4	5	7	5	5	4	4	5.36	5
GMCL	5	5	4	5	6	6	6	4	6	6	6	7	5.36	5
SIDCL	8	8	7	8	4	5	7	2	4	7	8	6	6.18	7
GSSTFDCL	4	3	5	6	3	7	3	6	7	4	5	5	4.82	4
GSIDCL	7	7	8	7	8	8	8	8	8	8	7	8	7.64	8
Ranking based on overall performance														
GIDC	3	3	6	5	6	5	7	7	6	4	7	3	5.17	5
EDC	1	1	1	1	2	3	3	3	2	1	1	1	1.67	1
KTCL	4	5	5	3	5	6	5	4	7	7	6	6	5.25	6
GTDC	6	4	4	6	4	4	6	6	4	6	4	7	5.08	4
GMCL	8	8	8	8	8	8	8	8	8	8	8	8	8.00	8
SIDCL	7	7	3	4	3	1	2	1	3	3	5	5	3.67	3
GSSTFDCL	5	6	7	7	7	7	4	5	5	5	3	4	5.42	7
GSIDCL	2	2	2	2	1	2	1	2	1	2	2	2	1.75	2

Source: Author's computation

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Table 8: Summary of the relative performance of the SLPEs

Aggregate Rank	Financial performance	Physical performance	Contribution to economy	Contribution to society	Overall performance
1	GSIDCL	GTDC	GSIDCL	EDC	EDC
2	GTDC	GSIDCL	SIDCL	KTCL	GSIDCL
3	EDC	GSSTFDCL	EDC	GIDC	SIDCL
4	SIDCL	GIDC & KTCL	GMCL	GSSTFDCL	GTDC
5	GMCL	___	GTDC	GTDC & GMCL	GIDC
6	GSSTFDCL	SIDCL	GSSTFDCL	____	KTCL
7	GIDC	GMCL	KTCL	SIDCL	GSSTFDCL
8	KTCL	EDC	GIDC	GSIDCL	GMCL

Source: Author's computation

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Appendix

List of Abbreviations used:

AHP	Analytical Hierarchy Process
FAHP	Fuzzy Analytical Hierarchy Process
VIKOR	VIekriterijumsko KOmpromisno Rangiranje
MCDM	Multi Criteria Decision Making
SOE	State Owned Enterprises
SLPE	State-Level Public Sector Enterprises
PROMETHEE	Prefernce Ranking Organisation Method for Enrichment Evaluation
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
WSA	Weighted Sum Product Analysis