Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 32 No. 3s (2025)

Measurement of Super Efficiency for Management Colleges in India: A Case Study

Ashok R[1*], V. Rajagopalan[2], Dr. R. Ramakrishna[3], Raju Nellutla[4]

[1]Research Scholar, Department of Statistics, Annamalai University, Tamilnadu, India.

Email: ashokpts@gmail.com

[2]Professor, Department of Statistics, Annamalai University, Tamilnadu, India.

[3]Professor, Department of Mathematics, Vidya Jyothi Institute of Technology, CB Post, Aziznagar, Hyderabad, Telangana, India.

Email: ramakrishna@vjit.ac.in

[4]Associate Professor, Department of Mathematics & Statistics, Guru Nanak Institutions Technical Campus (A), Telangana

**Correspondence Author: Ashok R, Email:* ashokpts@gmail.com

Article History:

Received: 20-09-2024

Revised: 24-10-2024

Accepted: 30-11-2024

Abstract:

Objectives: The objective of this study is to measure the technical efficiency of 20 management colleges listed in the National Institutional Ranking Framework (NIRF) for the academic years 2019, 2020, 2021, and 2022. The analysis evaluates how efficiently these institutions transform multiple inputs (e.g., student strength, faculty-student ratio) into outputs (e.g., research output, graduation outcomes) using Data Envelopment Analysis (DEA) models.

Methods: Data Envelopment Analysis (DEA) was employed using the CCR (Charnes, Cooper, and Rhodes) and BCC (Banker, Charnes, and Cooper) models. Inputs considered were 'Student Strength Including Ph.D. Students (SS)', 'Faculty-Student Ratio (FSR)', 'Faculty with PhD and Experience (FQE)', and 'Financial Resources and their Utilization (FRU)', while outputs were Research and Professional Practice (RP), Graduation Outcomes (GO), and Peer Perception (PR). The analysis calculated technical efficiency (under the assumption of Output orientation of Constant Returns to Scale), pure technical efficiency (under the assumption Output orientation of Variable Returns to Scale) and Super efficiency (under the assumption of CRS).

Findings: The findings show that out of the 20 management colleges analyzed, 8 colleges consistently demonstrated technical efficiency scores across all years under the CCR model. In contrast, 12 institutions exhibited inefficiencies in resource utilization, with efficiency scores below unity in at least two years. The top-performing institution achieved a super-efficiency score of 1.454 in overall four years average, indicating its superior ability to utilize inputs compared to peers. The study also found a slight year-on-year improvement in efficiency for several institutions,

Novelty: This study is unique in applying DEA models to four years of NIRF data, allowing for a robust comparative assessment of efficiency across multiple time frames. By identifying specific areas where colleges underperform in resource utilization, the study offers actionable insights for improving operational efficiency in higher education.

Keywords:BCC Model, CCR Model, CRS, NIRF, Technical efficiency, VRS

1. Introduction

In recent years, the Indian higher education sector has undergone substantial changes, with a growing focus on enhancing institutional effectiveness, openness, and responsibility. Assessing higher education institutions, especially management schools, are vital for identifying areas of efficiency and potential improvement. Data Envelopment Analysis (DEA), a non-parametric method that evaluates the comparative efficiency of decision-making units (DMUs) by analysing inputs and outputs, has emerged as a valuable tool for such assessment**.** Within the competitive and resource-constrained environment of Indian management schools, the notion of super-efficiency in DEA has gained traction. This approach expands on traditional DEA models by allowing for the ranking of already efficient units, thus providing a more nuanced understanding of institutional performance beyond simple efficient or inefficient classifications. Super-efficiency DEA models offer deeper insights into how management schools can enhance resource allocation, teaching methods, and research productivity. Management schools in India play a crucial role in producing qualified professionals for the business and entrepreneurial sectors. However, the rapid growth of educational institutions has resulted in performance disparities, with a few institutions achieving global recognition while others struggle to meet basic standards. To promote sustainable development, it is essential to implement robust evaluation tools like DEA that can thoroughly assess both quantitative and qualitative aspects of educational performance. In response to this need, the Indian government introduced the National Institutional Ranking Framework (NIRF), which aims to provide an objective ranking of educational institutions based on multiple criteria. While NIRF is a valuable tool, it does not fully address operational inefficiencies or the specific contextual challenges faced by management schools. Integrating DEA with super-efficiency models helps address this gap by identifying not only how effectively resources are utilized but also how top-performing institutions can serve as benchmarks for others, assessed the efficiency of Indian universities but did not consider super-efficiency, limiting the ability to differentiate among top performers. By incorporating super-efficiency, this study offers a more detailed ranking of the top 20 NIRF-ranked management schools.

While studies like[1], [2] applied DEA to engineering and undergraduate departments, respectively, focusing on technical and resource efficiency, they lacked a longitudinal approach. This study bridges that gap by analyzing four years of NIRF data, offering a more comprehensive evaluation of performance over time. Furthermore, peer perception a critical factor in higher education rankings has been incorporated as an output variable, addressing limitations in studies suchas[3]is focused on evaluating the technical efficiency of the Indian higher education sector using the Data Envelopment Analysis (DEA) method.which focused primarily on technical efficiency without accounting for this important metric. An innovative framework for evaluating the performance of Indian Premier League (IPL) cricket teams using Data Envelopment Analysis (DEA)[4]. The study aims to provide insights into how effectively each team converts their resources into performance outcomes, thereby identifying areas for improvement and strategic development. The technical efficiency of agricultural decision-making entities in Telangana State using a Data Envelopment Analysis framework,[5]aims to evaluate the efficiency of various farming units in utilizing resources to achieve optimal agricultural output.The evaluation of technical efficiency in higher education institutions (HEIs) is increasingly important for optimizing resource use and improving educational outcomes, contribute

to this discourse in their study, "Technical Efficiency of Universities in Telangana State through Data Envelopment Analysis (DEA) Approach," which assesses the efficiency of universities in Telangana, India.

2. Methodology

The Data Envelopment Analysis is mostly "Data oriented," with a mathematical approach used to evaluate the performance of a group of patrician bodies known as decision making entities, which translate many inputs into multiple outputs. The CCR DEA model, introduced in 1978 by Charnes,Cooper, and Rhodes, has played a significant role in the field of DEA by providing a standardized method to assess the technical efficiency of Decision Making Units (DMU). Suppose there are n number of DMU's D_1, D_2,…D_n , i=1,2,…n is to be evaluated by m inputs (j=1,2…m) and s outputs (r=1,2,…s).

	m Inputs						s Outputs					
DMU	1	2	..	j	..	m	1	2	..	r	..	s
1	X_{11}	X_{12}	..	X_{1j}	..	X_{1m}	y_{11}	y_{12}	..	y_{1r}	..	y_{1s}
2	X_{21}	X_{22}	..	X_{2j}	..	X_{2m}	y_{21}	y_{22}	..	y_{2r}	..	y_{2s}
:	:	:		:		:						
i	Xi_1	Xi2	..	Xij	..	Xim	y_{i1}	y_{i2}	..	y_{ir}	..	y_{is}
:	:	:		:								
n	Xn_1	Xn_1	..	Xnj	..	Xnm	y_{n1}	y_{n2}	..	y_{nr}	..	y_{ns}

Where Matrix X is an dimension of (n x m) and Matrix Y is an dimension of (n x s) matrix. By the CCR model, we calculate the efficiency score of the o^{th}DMUe_o is

$$\text{Max } e_O = \frac{v_{O1}y_{O1} + v_{O2}y_{O2} + v_{O3}y_{O3} \ldots + v_{OS}y_{OS}}{u_{O1}x_{O1} + u_{O2}x_{O2} + u_{O3}x_{O3} \ldots + u_m x_{Om}}, \quad o = 1,2,3, \ldots, n \qquad (2.1)$$

$$\text{S. T}: \frac{v_{i1}y_{i1} + v_{i2}y_{i2} + \cdots + v_{is}y_{is}}{u_{i1}x_{i1} + u_{i2}x_{i2} + \cdots + u_{im}x_{im}} \leq 1, \quad i = 1,2, \ldots n \qquad (2.2)$$

$$\text{Non negativity} \quad u_1, u_2, u_3, \ldots, u_m \geq 0 \;\&\; v_1, v_2, v_3, \ldots v_s \geq 0$$

Where x_{ij} is the amount of j^{th}input belongs to i^{th}DMU, y_{ir} is the amount of r^{th} output corresponding i^{th} DMU. In the education sector, we used to calculate the performance of the colleges can see by the best performance in terms of no of students passed, no of students placed and no of students went for higher education. First, some formal relationship between inputs and outputs exists and a ‘‘best performance’’ can be identified by comparing different units transforming in to inputs to output; $v_{Or} and u$are the weights corresponding to be CCR efficient if e_o = 1, otherwise DMU is inefficient.

2.1. CCR Model: The CCR (Charnes, Cooper, and Rhodes) model is a foundational approach in Data Envelopment Analysis (DEA), a performance measurement technique used to evaluate the efficiency of decision-making units (DMUs) like businesses, schools, or hospitals. We have two approaches input and output orientation, the former minimizes inputs for a given output level, while the latter maximizes outputs for a given input level.

2.1.1. Input Orientated CCR Model:

Min eO $= \sum_{j=1}^{m} u_{oj} x_{oj}$ o = 1,2, …. nand S.T: $\sum_{r=1}^{s} v_{or} y_{or} = 1$

$\sum_{r=1}^{s} v_{ir} y_{ir} - \sum_{j=1}^{m} u_{ij} x_{ij} \leq 1$; i = 1,2,3, … ,n ……(2.3)

Non negativity $u_1, u_2, u_3, \ldots, u_m \geq 0$ & $v_1, v_2, v_3, \ldots v_s \geq 0$

2.1.2. Output Orientated CCR Model:

Max $e_O = \sum_{r=1}^{s} v_{or} y_{or}$ o = 1,2,….n and S.T: $\sum_{j=1}^{m} u_{oj} x_{oj} = 1$

$\sum_{r=1}^{s} v_{ir} y_{ir} - \sum_{j=1}^{m} u_{ij} x_{ij} \leq 1$; i = 1,2,3, …, n ……..(2.4)

Non negativity $u_1, u_2, u_3, \ldots, u_m \geq 0$ & $v_1, v_2, v_3, \ldots v_s \geq 0$

The technical efficiency of the DMU for o = 1,2,….n. A DMU was considered efficient if its technical efficiency score, e_o, was equal to 1; otherwise, it was considered technically inefficient.

2.2. The BCC Model

The pure technical efficiency of DMUs is calculated by the input-oriented BCC model. By solving the linear programming problem in its enveloped form:

Min e_BS.T: $=\theta_B$; $\theta_B x_o - X\lambda \geq 0$; $Y\lambda \geq y_0$; $e\lambda = 1$ …… ……(2.5)

$\lambda \geq 0$…..…… (2.6)

Dual multiplier form of the linear programming problem (BCC) is expressed as

Maximize $e_B = vy_0 - v_0$:S.T: $ux_0 = 1$; $-uX - vY - v_0 e \leq 0$, $u \geq 0, v \geq 0$……(2.7)

The CCR model operates under Constant Returns to Scale, whereas the BCC model operates under Variable Returns to Scale. The efficiency score in the CCR model is known as Overall Technical

Efficiency or Technical Efficiency Score. A DMU is deemed efficient if e_o = 1 and the corresponding slacks are zero. In the VRS model, the efficiency score is referred to as Pure Technical Efficiency score. The Scale efficiency refers to the ability of a decision making unit to operate at an optimal scale or size. In other words, scale efficiency measures the extent to which a DMU is able to achieve maximum output with its given input level. Scale efficiency (SE) = $= e_o/e_B$

The BCC model optimal solution is presented by$(e_B^*, \lambda^*, s^{-*}, s^{+*})$. Where $e_B^*\lambda^* s^{-*}$ and s^{+*} represents maximal Pure Technical Efficiency (PTE), peer weight, input excesses and output short fall respectively.

2.3. Radial Super-Efficiency Model

To address this, Andersen and Petersen proposed a super-efficiency model that allows the score of an efficient unit to exceed 100% by removing that unit from the reference set

The vector form of this model is

Super Radial: $\theta^* = \min\theta - \epsilon\varepsilon s^+$, Sub.To: $\theta x_0 = \sum_{j=1,\neq 0}^{n} \lambda_j x_j + s^+ y_0 = \sum_{j=1,\neq 0}^{n} \lambda_j y_j - s^+$

Where all components of the $\lambda, s^+ and s^-$ are constrained to be non negative, $\in > 0$ is the usual non-Archimedean element and e is a row vector with unity for all elements. We refer equation as a "Radial Supper-Efficiency" model and note that the vectorsx_0, y_0 are omitted from the expression on the right in the constraints.This super-efficiency approach has been applied in several studies, including evaluations of university department performance and bank efficiency.

2.4 Data Consideration

We applied CCR and BCC models of DEA to calculate the technical and pure efficiency of Indian management colleges using NIRF data from 2019 to 2022. The study used inputs and outputs based on secondary data collected from the NIRF website. This study assesses the technical efficiency of management institutions using inputs for teaching resources and outputs like graduation outcomes, placements, median salary, further education, research quality, and peer perception.

Table 2. Definitions and Measurement of Input and Output Variables

Variable and Definition	
Inputs:	**Outputs:**
Student Strength Including PhD Students (SS)	Combined metric for Publications (PU)
Faculty Student Ratio (FSR)	Footprint of Projects, Professional Practice and Executive Development Programs (FPPP)
Combined metric for Faculty with PhD and Experience (FQE)	Quality Publications (QP) Combined metric for Placement and Higher Studies

	(GPH)
Financial resources and their utilization(FRU)	Metric for University Examinations (GUE)
	Median Salary (GMS)& Peer Perception (PR)

2.5. Calculation of Technical, Pure and Super Efficiency:

The assessment of technical, pure, and super efficiency was performed using Data Envelopment Analysis (DEA) models, specifically the CCR (Constant Returns to Scale) and BCC (Variable Returns to Scale) models. Additionally, the Radial Super Efficiency model was employed to provide a comprehensive evaluation of the performance of management college

2.6 Selection of DMU's

Table 3 The 20 selected Indian management colleges with DMU's

DMU	Name of the College	DMU	Name of the College
D1	IIM Ahmedabad	D11	IIM Tiruchirappalli
D2	IIM Bangalore	D12	IIM Udaipur
D3	IIM Calcutta	D13	IIT Bombay
D4	IIM Indore	D14	IIT Delhi
D5	IIM Kozhikode	D15	IIT Kanpur
D6	IIM Lucknow	D16	IIT Kharagpur
D7	IIM Raipur	D17	IITRoorkee
D8	IIM Ranchi	D18	Management Development Institute
D9	IIMRohtak	D19	S. P. Jain Institute of Management
D10	IIM Tiruchirappalli	D20	Symbiosis Institute of Business Management

3. Results and Discussion

Table 4.T.E, P.T.E& Supper Efficiency of 20 selected Indian management colleges (2019&2020)

DMU	Year 2019								Year 2020							
	NIRF						Super Efficiency		NIRF						Super Efficiency	
	Sco	Ra	TE	RT	Ref	PT	TE	Ra	Sco	Ra	TE	RT	Ref	PT	TE	Ra

	re	nk		S	erences	E		nk	re	nk		S	erences	E		nk
D1	80.61	2	1	CRS	0	1	1.04	13	82.75	1	1	CRS	0	1	1.15	7
D2	81.34	1	1	CRS	0	1	1.19	8	81.32	2	1	CRS	0	1	1.11	10
D3	79.05	3	1	CRS	0	1	1.02	15	80.39	3	1	CRS	0	1	1.18	5
D4	67.01	5	0.88	DRS	4	1	0.88	19	69.04	7	0.9	DRS	5	0.93	0.9	19
D5	64.82	8	1	CRS	0	1	1.02	14	69.96	6	1	CRS	0	1	1.09	12
D6	67.29	4	0.88	DRS	4	1	0.89	18	73.85	4	0.93	DRS	6	0.94	0.94	16
D7	53.86	19	0.95	DRS	4	1	0.95	16	56.12	19	1	CRS	0	1	1.09	11
D8	51.02	28	1	CRS	0	1	1.05	12	55.97	20	0.99	DRS	3	1	0.99	13
D9	53.11	23	1	CRS	0	1	1.08	10	55.91	21	1	CRS	0	1	1.19	4
D10	59.15	14	1	CRS	0	1	1.09	9	60.79	15	1	CRS	0	1	1.12	9
D11	60.79	13	1	CRS	0	1	1.06	11	59.57	17	0.83	DRS	5	0.88	0.83	20
D12	62.74	10	1	CRS	0	1	2.01	1	65.76	11	0.93	DRS	4	1	0.94	15
D13	62.89	9	1	CRS	0	1	1.45	3	67.19	8	1	CRS	0	1	1.76	1
D14	53.37	22	1	CRS	0	1	1.66	2	60.53	16	1	CRS	0	1	1.14	8
D15	66.64	6	1	CRS	0	1	1.44	4	70.43	5	1	CRS	0	1	1.16	6
D16	62.11	11	1	CRS	0	1	1.24	7	62.87	12	1	CRS	0	1	1.33	3

D17	61.89	12	0.89	DRS	3	1	0.89	17	65.95	10	0.92	DRS	4	1	0.92	18
D18	55.67	16	1	CRS	0	1	1.42	5	56.93	18	1	CRS	0	1	1.51	2
D19	53.56	20	1	CRS	0	1	1.26	6	55.82	22	0.97	DRS	4	1	0.97	14
D20	65.33	7	0.86	DRS	4	1	0.86	20	67.11	9	0.93	DRS	4	1	0.93	17

The results in Table 4 illustrate the Technical Efficiency (TE), Pure Technical Efficiency (PTE), and Super Efficiency (SE) scores for 20 management colleges across 2019 and 2020. Here's a summary of the findings:

2019 Analysis: Out of the 20 colleges, 15 were technically efficient, while the remaining 5 were inefficient, indicating that the efficient colleges had an optimal ratio of inputs to outputs. Super Efficiency (SE) analysis further differentiated the 15 efficient colleges. Among them, college D12 achieved the highest ranking with an SE-TE score of 2.01. This score suggests that D12 had an output level exceeding 100% of what is considered efficient, showing a substantial excess in performance compared to its peers. The remaining efficient colleges were ranked based on their Supper efficiency scores in descending order.

2020 Analysis: The number of technically inefficient colleges increased to 8, leaving 12 colleges as technically efficient. In the Super Efficiency ranking for 2020, college D13 took the top spot, indicating the highest level of output relative to its peers among the efficient colleges. These findings suggest a shift in efficiency dynamics between 2019 and 2020, with an increase in the number of inefficient colleges. Super Efficiency analysis helped to rank the efficient colleges more precisely by identifying those that exceeded the benchmark efficiency levels.

Table 5T.E, P.T.E & Supper Efficiency of 20 selected Indian management colleges (2021 & 2022)

DMU	Year 2021								Year 2022							
	NIRF						Super Efficiency		NIRF						Super Efficiency	
	Score	Rank	TE	RTS	References	PTE	TE	Rank	Score	Rank	TE	RTS	References	PTE	TE	Rank
D1	83.69	1	1	CRS	0	1	1.03	10	83.35	1	1	CRS	3	1	1	10

D2	83.48	2	1	CRS	0	1	1.148	7	82.62	2	1	CRS	0	1	1.09	6
D3	80.04	3	1	CRS	0	1	1.071	8	78.64	3	1	CRS	0	1	1.13	5
D4	71.1	6	0.89	DRS	5	1	0.894	18	70.66	7	0.81	DRS	3	1	0.81	18
D5	73.34	4	1	CRS	0	1	1.063	9	74.74	5	0.96	DRS	3	1	0.96	12
D6	71.02	7	0.98	DRS	4	1	0.98	11	74.55	6	0.9	DRS	3	1	0.9	15
D7	62.12	15	0.87	DRS	3	1	0.87	19	63.57	14	0.78	DRS	2	1	0.78	19
D8	58.26	21	0.96	DRS	3	1	0.962	12	62.33	15	0.98	DRS	3	1	0.98	11
D9	55.4	28	1	CRS	0	1	1.472	2	62.2	16	0.91	DRS	3	1	0.91	14
D10	61.1	17	0.96	DRS	3	1	0.962	13	61.88	18	1	CRS	0	1	1.03	8
D11	60.94	18	0.79	DRS	3	1	0.789	20	59.28	22	0.73	DRS	2	1	0.73	20
D12	68.08	10	0.91	DRS	2	1	0.912	16	61.2	20	1	CRS	0	1	1.52	3
D13	72.15	5	1	CRS	0	1	1.457	4	66.24	11	1	CRS	0	1	1.03	9
D14	61.31	16	1	CRS	0	1	1.497	1	75.1	4	1	CRS	0	1	1.52	4
D15	69.5	9	1	CRS	0	1	1.197	6	65.15	12	1	CRS	0	1	1.77	1
D16	63.79	14	1	CRS	0	1	1.469	3	61.76	19	1	CRS	0	1	1.7	2
D17	67.59	11	0.96	DRS	3	1	0.961	14	64.7	13	0.88	DRS	2	1	0.88	16
D18	58.73	19	1	CRS	0	1	1.292	5	59.51	21	1	CRS	0	1	1.04	7
D1	58.	20	0.	DR	4	1	0.9	15	61.	17	0.	D	4	1	0.9	13

9	64		94	S			45		97		93	RS			3	
D20	69.93	8	0.9	DRS	4	1	0.9	17	69.67	8	0.84	DRS	3	1	0.84	17

Table 5 presents the Technical Efficiency (TE), Pure Technical Efficiency (PTE), and Super Efficiency (SE) scores for the years 2020 and 2021. Here is a summary of the results:

For the year 2020: Ten DMUs were technically efficient, achieving a TE score of 1, indicating their position on the efficiency frontier. In contrast, DMUs D1, D4, D5, D6, D7, D8, D9, D11, D17, D19, and D20 were technically inefficient, with TE scores below 1, falling short of the efficiency frontier. According to the BCC Model, all DMUs were technically efficient, with PTE scores of 1. To rank these DMUs, Super Efficiency scores were used, with the highest score ranked first. The next highest ranked DMU was D1, which had an NIRF score of 1. Under the CCR model, D1's TE score was also 1, confirming its technical efficiency. Its Super Efficiency score of 1.03044 placed it 10th among the top 20 management colleges. The top-ranked DMU was D14, with a Super Efficiency score of 1.497, despite being ranked 16th in the NIRF rankings.

For the year 2021: There was an equal split, with ten DMUs being technically efficient and ten inefficient. when ranked by Super Efficiency scores, D15 took the top spot with a score of 1.77, while it was ranked 9th in the NIRF rankings.These findings provide insights into the performance and ranking discrepancies between the Super Efficiency scores and NIRF rankings, indicating opportunities for enhancing efficiency among the management colleges.

Table 6 Overall Technical and Scale Efficiency of top Management colleges in India

DMU	Overall Technical Efficiency					Overall Scale Efficiency					Overrall Supper Efficiency					
	2019	2020	2021	2022	**Average TE**	2019	2020	2021	2022	**Average TE**	2019	2020	2021	2022	Average	Ranking
D1	1	1	1	1	**1**	1	1	1	1	**1**	1.04	1.15	1.03	1	1.06	10
D2	1	1	1	1	**1**	1	1	1	1	**1**	1.19	1.11	1.148	1.09	1.14	8
D3	1	1	1	1	**1**	1	1	1	1	**1**	1.02	1.18	1.071	1.13	1.10	9
D4	0.88	0.9	0.89	0.81	**0.87**	0.88	0.97	0.89	0.81	**0.89**	0.88	0.9	0.894	0.81	0.87	19

D5	1	1	1	0.96	**0.99**	1	1	1	0.96	**0.99**	1.02	1.09	1.063	0.96	1.03	12
D6	0.88	0.93	0.98	0.9	**0.92**	0.88	0.99	0.98	0.9	**0.94**	0.89	0.94	0.98	0.9	0.93	15
D7	0.95	1	0.87	0.78	**0.9**	0.95	1	0.87	0.78	**0.9**	0.95	1.09	0.87	0.78	0.92	16
D8	1	0.99	0.96	0.98	**0.98**	1	0.99	0.96	0.98	**0.98**	1.05	0.99	0.962	0.98	1.00	14
D9	1	1	1	0.91	**0.98**	1	1	1	0.91	**0.98**	1.08	1.19	1.472	0.91	1.16	7
D10	1	1	0.96	1	**0.99**	1	1	0.96	1	**0.99**	1.09	1.12	0.962	1.03	1.05	11
D11	1	0.83	0.79	0.73	**0.84**	1	0.94	0.79	0.73	**0.87**	1.06	0.83	0.789	0.73	0.85	20
D12	1	0.93	0.91	1	**0.96**	1	0.93	0.91	1	**0.96**	2.01	0.94	0.912	1.52	1.35	5
D13	1	1	1	1	**1**	1	1	1	1	**1**	**1.45**	**1.76**	**1.457**	**1.03**	**1.42**	**3**
D14	1	1	1	1	**1**	1	1	1	1	**1**	**1.66**	**1.14**	**1.497**	**1.52**	**1.45**	**1**
D15	1	1	1	1	**1**	1	1	1	1	**1**	1.44	1.16	1.197	1.77	1.39	4
D16	1	1	1	1	**1**	1	1	1	1	**1**	**1.24**	**1.33**	**1.469**	**1.7**	**1.44**	**2**
D17	0.89	0.92	0.96	0.88	**0.91**	0.89	0.92	0.96	0.88	**0.91**	0.89	0.92	0.961	0.88	0.91	17
D18	1	1	1	1	**1**	1	1	1	1	**1**	1.42	1.51	1.292	1.04	1.32	6
D19	1	0.97	0.94	0.93	**0.96**	1	0.97	0.94	0.93	**0.96**	1.26	0.97	0.945	0.93	1.03	13
D20	0.86	0.93	0.9	0.84	**0.88**	0.86	0.93	0.9	0.84	**0.88**	0.86	0.93	0.9	0.84	0.88	18
Mean	0.97	0.97	0.96	0.94	**0.96**	0.97	0.98	0.96	0.94	**0.96**	1.18	1.11	1.09	1.08	1.11	

Table 6 shows the Average TE, which indicates the colleges' ability to optimally utilize their resources over the four years. An average TE of 1 reflects that the college has maintained perfect technical efficiency, and the Average SE indicates how well the colleges have managed their operational scale over the four-year period. An Average SE of 1 suggests optimal scale efficiency. Here, D1, D2, D3, D13, D14, D15, D16, and D18 have maintained an average technical and scale efficiency score of 1 over the four years, reflecting consistently optimal performance. Also it shows the overall ranking of the top Indian management colleges ranking by the supper efficiency models. Few colleges were top ranking with the low ranking in NIRF ranking system.

For the years 2019, 2020, 2021, and 2022, we computed the Technical Efficiency (TE), Pure Technical Efficiency (PTE), and Super Efficiency for 20 management colleges. The results are summarized as follows:

2019: Out of 20 Decision Making Units (DMUs), five were found to be technically inefficient, while fifteen were technically efficient under the CCR Model. However, under the BCC Model, all DMUs were technically efficient, with PTE scores equal to unity. Super efficiency scores were used to rank the DMUs, which differed from NIRF rankings. For instance, D1 ranked second in NIRF but was 13th in super efficiency ranking, while DMU D2 ranked first in NIRF but only 8th in terms of super efficiency. [14] Found that out of DMU D61, D3- IITB, D4-IIT Delhi and D5- IIT Kharagpur were super-efficient and consistent during 2016-18.

2020: In 2020, twelve of the 20 DMUs were technically efficient under the CCR Model, indicating that these 12 institutions maximized their output with the given inputs. For rankings, DMU D1, which ranked first in NIRF, was ranked 7th by super efficiency, while DMU D2 ranked second in NIRF but 10th in super efficiency.

2021: In 2021, ten of the 20 DMUs were technically efficient, and ten were inefficient under the CCR Model. By contrast, 17 DMUs were deemed technically efficient under the BCC Model, indicating unity PTE scores. Super efficiency scores were used to rank the efficient DMUs.

2022: In 2022, only nine of the 20 DMUs were technically efficient under the CCR Model, while the remaining DMUs were inefficient. However, under the BCC Model, all DMUs were technically efficient. The ranking of these DMUs was determined using super efficiency scores.

4. Conclusion

In this paper, the conclusions were made with the help of comparing the references on the application of DEA with the evaluation of the efficiency of the Indian management colleges. The following are the synthesized comparison of the relevant studies:

Comparison of Efficiency Models: Efficiency is what has received much attention in the higher education sector although the authors have suggested that DEA should be used[6]. The current paper extends this by using both the CCR and BCC models on data for four years through National Institutional Ranking Framework (NIRF). However, this paper contributes by accurately implementing the super-efficiency model to rank efficient units, addressing the gap identified by [7] that did not use super-efficiency, it employs the Data Envelopment Analysis (DEA) approach to achieve a full ranking of Decision-Making Units (DMUs).

Technical Efficiency over Time: Where as considers short term analysis of engineering and undergraduate departments this paper concerns with mapping management colleges from 2019 to 2022. The results reveal firms' technical efficiency trends over time: Most firms experienced a technical efficiency increase similar to those of [8]on higher education efficiency escalations. However, more worrisome is the fact that only nine institutions were strictly and continually efficient which supports [9]observation that, sustaining efficiency over time is a major issue.

Peer Perception and Outputs: Another improvement is the identification of peer perception as an output variable**.**The research presented in this paper demonstrates how incorporating peer perception into efficiency analysis can enhance the multi-dimensional evaluation of college performance.

Super Efficiency Ranking: One advantage of the super-efficiency approach used in this study is that it offers a better demarcation of the efficient institutions in contrast to previous, which introduced a new DEA model for slacks-based measures and super-efficiency, providing more precise identification of highly efficient institutions**.**By applying this method in the current study, it is evident that the rankings reflecting technical efficiency are not always reflective of super-efficiency rankings like [10]that also employed similar models in other contexts. In conclusion, this paper builds upon prior research by using super-efficiency DEA models for a span of four years with peer perception and identifies how management colleges could enhance utilisation of resources. They complement existing studies, fill the identified gaps, and provide practical suggestions for institutional change.

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