MICROANALYSIS OF NIRF RANKING OF TOP-FIFTY ENGINEERING INSTITUTIONS IN INDIA: AN INTEGRATED APPROACH OF DEA and STATISTICAL ANALYSIS

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CANDIDATE'S DECLARATION

I Lakshya Saini hereby certify that the work which is being presented in the thesis entitled Microanalysis of NIRF rankings of top-fifty Engineering institutions in India: An integrated approach of DEA and Statistical analysis in partial fulfillment of the requirements for the award of the Degree of Masters of Technology, submitted in the Department of Mechanical Engineering , Delhi Technological University is an authentic record of my own work carried out during the period from 2023 to 2024 under the supervision of Dr. Pravin Kumar.

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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CERTIFICATE BY THE SUPERVISOR

Certified that **Lakshya Saini (**2k22/IEM/08) has carried out their search work presented in this thesis entitled **"Microanalysis of NIRF rankings of top-fifty Engineering institutions in India: An integrated approach of DEA and Statistical analysis"** for the award of **Master of Technology** from Department of Mechanical Engineering, Delhi Technological University, Delhi, under my supervision. The thesis embodies results of original work, and studies are carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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Microanalysis of NIRF rankings of top-fifty Engineering institutions in India: An integrated approach of DEA and Statistical analysis

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ABSTRACT

The main aim of this study is to re-examine the performance ranking processes of Higher Educational Institutions. National Institutional Ranking Framework (NIRF) is considered as the case ranking organization. The performance indicators used in NIRF are used to produce the different models of performance measurement using correlation and regression analysis. These models are used to measure the relative efficiency of the Higher Engineering Institutions (HEIs) using Data Envelopment Analysis (DEA). It is observed that the same criteria cannot be used to rank the performance of all the institutions. These institutions may be divided into different clusters based on their performance, specialties, constraints, locations, available resources, etc. A separate model of performance measurement should be developed for each cluster. The weights assigned to the different inputs and output variables should be optimal using DEA. The input variables must influence the outputs significantly and be concerned with the context of the analysis. This study may help the policymakers and the performance ranking organization in exploring the performance indicators and finding the performance considering the real situations of the educational institutions. The improved ranking system, with its well-defined outputs, empowers users to make informed decisions about higher education institutions. By providing specific and easy-to-understand information, this system allows users to compare HEIs more effectively. This newfound clarity empowers them to choose the institution that best aligns with their academic goals and career aspirations.

Keywords: Performance ranking, Higher Engineering Institutions, National Institutional Ranking Framework, Data Envelopment Analysis, and Correlation and Regression Analysis.

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CHAPTER 1

INTRODUCTION

Educational and research development play an important role in the growth of a country. India has the third-largest higher education system, globally, after the United States of America and China. India has more than 700 degree-granting institutions and 35,500 affiliated colleges, catering to a staggering 20 million students. For the competitive growth of the institutions, it is required to know the institutions stands out as the best performer considering all the performance parameters and the ranks of the other institutions. Singh et al. (2022)

Determining the relative performance of the institutions is a very complex issue due to the involvement of a large number of performance parameters and constraints. For example, many degree institutions are not concerned with the research activity but they are performing well except the research projects and publications. Malik et al. (2023) observed that due to less enrolment of Ph.D. students and less Ph.D. production in private institutions, they are less efficient than the other leading Government/autonomous institutions. Therefore, the institutions not concerned with a specific parameter, how these institutions can be compared with other similar institutions dealing with the same performance parameter. There may be some technical glitch in finding the ranks. Several organizations are providing the ranking of the institutions based on their analysis which vary with each other.

Two global ranking systems - Shanghai Academic Ranking of the World Universities and Times Higher Education Supplement of the World University Rankings are considered the most reliable ranking, which were published first in the year 2003 and 3004 respectively Harvey, (2008); Kumar and Thakur, (2019). In India, the National

Institutional Ranking Framework (NIRF) ranking is considered a standard ranking body that influences the further growth of the institutions in terms of allocation of resources, projects, funding, consultancies, students' admission, etc. Thus, the micro-analysis of the ranking systems has become very important for both the institutions and performance-measuring organizations. The National Institutional Ranking Framework (NIRF) released the India Rankings for 2023. This is the eighth consecutive edition of rankings of higher education institutions in five categories --- overall, universities, colleges, research institutions, and innovation and eight subject domains — engineering, management, pharmacy, medical, dental, law, architecture and planning, and agriculture and allied sectors.

Ranks are assigned Based on the sum of marks secured by institutions on each of these parameters. Notwithstanding some of the criticisms on the methodology adopted and the parameters chosen by the Ministry of Education (MoE), a scrutiny of the 2023 edition as well as some of the available data on higher education raises some important issues.

It has been observed that many parameters do not influence the performance significantly but these are considered the independent variables in determining the performance. On the other hand, some institutions are not dealing with some specific parameters but they are compared with others on the same parameters. Thus, the major objectives of the study are to find the significant parameters for measuring the performance of the institutions, perform the correlation and regression analysis for the dependent and independent variables, prepare the different models of performance measurement based on the various combinations of inputs and outputs, and then compare the institutions based on these models.

In this study, all the different parameters considered by the National Institutional Ranking Framework (NIRF) ranking are incorporated and 15 models for Data envelopment analysis (DEA) are prepared based on the combination of different inputs and outputs. Using these models, the top 50 Engineering Indian institutions are ranked using Data Envelopment Analysis (DEA). Majority of the Higher education organizations are not-for-profit organizations. Gauging the efficiency of a not-for-

profit organization is always a nonparametric type of situation; DEA is a well-established nonparametric method to compare and rank various DMUs. DEA, as a methodology, has been used to measure the research performance of Chinese HEIs and monitor and assess the institutional performance of HEIs Abbott and Doucouliagos, (2003); Alexander (2000); Chu Ng and Li (2000); Johnes and Li (2008). Very less studies are available on the analysis of ranking systems for educational institutions especially, in developing countries Johnes et al. (2022). Data Envelopment Analysis (DEA) and statistical tools like correlation and regression analysis are used to microanalyze the NIRF performance ranking of the top 50 institutions of India in the year 2023. Determining the best-performing decision-making unit (DMU) can be a subject of intense debate. DEA provides a reliable solution to this question. It is a data-driven technique that measures the performance of DMUs, which are entities that utilize multiple inputs to generate multiple outputs. Examples of DMUs include educational institutions, hospitals, libraries, banks, transportation sectors, airlines, and telecom companies, as previously reported by Bhattacharyya et al. (1997), Arya and Yadav (2018), Puri and Yadav (2013), and Nigam et al. (2012), among others.

CHAPTER 2

LITERATURE REVIEW

University rankings are widely used as a measure of the quality and reputation of higher educational institutions. They provide valuable information to prospective students, researchers, employers, policymakers, funding agencies, and other stakeholders. However, it's important to interpret rankings with caution and consider their limitations. In recent years, many governments, accreditation agencies, and higher education organizations have developed evaluation and ranking systems of institutional performance. Some of the major evaluation and ranking systems are- *QS World University Rankings*, Times Higher Education (THE) World University Rankings, Academic Ranking of World Universities (ARWU) by Shanghai Ranking Consultancy, U.S. News & World Report Best Global Universities Rankings, CHE (Germany), CIEES (Mexico), NAAC, NBA, NIRF (India)HEC and TUBITAK (Turkey), HEEACT(Taiwan), etc. Kumar and Thakur, (2019). Among these ranking systems, *QS World University Rankings*, Times Higher Education (THE) World University Rankings, Academic Ranking of World Universities (ARWU) by Shanghai Ranking Consultancy, and U.S. News & World Report Best Global Universities Rankings are used globally.

2.1 QS World University Rankings*:* QS (Quacquarelli Symonds) is a well-known global ranking organization that evaluates universities based on various indicators. QS ranks universities in overall categories as well as subject-specific categories, including engineering and technology, which use additional indicators relevant to the field, such as research reputation in engineering and technology, and the proportion of faculty with a Ph.D. in relevant disciplines.

There are four Pillars of QS ranking- Research, Teaching, Employability, and Internationalization Estrada-Real and Cantu-Ortiz, (2022). These four pillars consist of six indicators and measures on a scale of 1 to 100. The details of the evaluation criteria and the indicators are mentioned in Table 1.

Table 1.1: QS ranking criteria and Indicators (Nagoc and Tian, (2023); Wang and Shih, (2023); Estrada-Real and Cantu-Ortiz, (2022); Qureshi et al., (2023); Quacquarelli Symonds, (2022); Tian, (2022))

Evaluation Criteria of QS Ranking	**Indicators**	**Weightage**	**Method of data collection**
Teaching and Research Performance	Academic Reputation	40%	Questionnaire Survey
Student Performance	Employer Reputation	10%	Questionnaire Survey
Teaching	Faculty/ Student Ratio	20%	Provided by the University/School
Research	Citation per Faculty	20%	Scopus Data of the last 5 years
Internationalization	International Faculty Ratio	5%	Provided by the University/School
	International Student Ratio	5%	Provided by the University/School

2.2 Academic Ranking of World Universities (ARWU) by Shanghai Ranking Consultancy: ARWU, also known as the Shanghai Rankings, was first published in June 2003 by the Centre for World-Class Universities and the Institute of Higher Education of Shanghai Jiao Tong University. ARWU uses the following indicators to rank world universities, including: - the number of alumni and staff winning Nobel Prizes and Fields Medals, - the number of highly cited researchers selected by Thomson Scientific, the number of articles published in journals of Nature and Science, - the number of articles indexed in Science Citation Index - Expanded and Social Sciences Citation Index, and per capita performance concerning the size of an institution ARWU, (2023). ARWU provides a separate ranking for engineering and technology.

The main focus of ARWU is only on research and academic factors, and it does not consider the Academic reputation like QS (50%) and THE World University Rankings

(33%). ARWU gives 60% weightage to the citations of the research papers published in reputed journals whereas QS and THE World University Rankings give only (20%) and (30%) weightage respectively to the citations of the publications Komotar, (2020); Glass and Cruz, (2023)

Table 1.2: ARWU ranking criteria and Indicators (Nagoc and Tian, (2023); Qureshi et al., (2023); Avalos et al., (2023); Singh et al., (2022))

Evaluation Criteria of QS Ranking	**Indicators**	**Weightage**	**Method of data collection**
Education Quality	Alumni as Nobel Laureates and field medallists	10%	Websites of Nobel Laureates and field medallists
Teacher Quality	Staff as Nobel Laureates and field medallists	20%	Websites of Nobel Laureates and field medallists
	Highly Cited Researchers	20%	Thomson Reuters (Clarivate Index/Web of Science) Survey of highly cited researchers.
Research Output	Papers published in Nature and Science	20%	Citation Index
	Papers published in SCIE and SSCI	20%	
Average Academic Performance	Per capita academic performance of the Institution	10%	National Agencies such as the Ministry of Education.

2.3 U.S. News & World Report Best Global Universities Rankings: This is a popular ranking framework that evaluates universities globally based on indicators like global research reputation, publications, conference papers, normalized citation impact, international collaboration, and more. U.S. News & World Report also provides rankings for engineering, among other fields. Szluka et al. (2023) observed that THE ranking gives more stress on the publication activity in social sciences whereas USNews and QS ranking gives more stress on publications in science, technology, and medicine fields and a lower score in social sciences.

2.4 Times Higher Education (THE) World University Rankings: THE is another reputable ranking organization that uses indicators such as teaching, research, citations, international diversity, and industry income to assess universities. THE also provides both overall and subject-specific rankings, including engineering and technology.

THE produces rankings that are specific to certain fields of study, such as engineering and technology, and these rankings employ specialized indicators that are relevant to those fields. Examples of such indicators include research reputation within the engineering and technology domain, as well as the proportion of faculty members holding PhDs in relevant disciplines.

Table 1.3: Times higher Education Structure (Times Higher Education. (2023))

Pillar	**Indicators (Number)**	**Weight (%)**
1. Teaching (30%)	Teaching Reputation	15.00%
	Student-faculty ratio	2.50%
	Doctorate degrees awarded per faculty member	2.50%
	Master's degrees awarded per faculty member	2.50%
	Institutional income	2.50%
2. Research (30%)	Research Reputation	15.00%
	Research income to expenditure ratio	5.00%
	Research citations per faculty member	5.00%
	International collaboration	5.00%
3. Knowledge Transfer (2.5%)	Industry income	2.50%
4. International Outlook (7.5%)	International faculty ratio	2.50%
	International students' ratio	2.50%
	Doctoral students' ratio	2.50%
5. Citations (30%)	Citations per faculty	10.00%
	Citations per paper	6.00%
	International collaboration	14.00%

2.5 National University Rankings: Many countries have their national ranking systems that assess engineering universities within their respective countries. For example, the National Institutional Ranking Framework (NIRF) in India, the QS World

University Rankings by Subject for Engineering and Technology in the UK, and the Excellence in Research for Australia (ERA) ranking for engineering in Australia.

2.6 Need for University Ranking Systems

University ranking systems may create healthy competition among the HEIs. Also, it is helpful for the students in the selection of the institutions. Also, employers have more trust in the products/students passed out from top-ranked institutions. Some of the major advantages of the university ranking systems are mentioned below:

(i) Rankings provide an indication of a university's overall performance and reputation, which can be useful for students when comparing different options QS, (2019); THE, (2019).

(ii) Institutions with high rankings are often perceived to have a strong research culture and expertise, which can attract top researchers and students ARWU, (2021); QS, (2019).

(iii) University rankings can influence the perception of employers about the quality of graduates from a particular institution. Higher-ranked universities are often associated with better job prospects and career opportunities for their graduates QS, (2019); THE, (2019).

(iv) Higher-ranked universities are often seen as more internationally renowned and may have more global competition, diverse faculty and student populations QS, (2019); THE, (2019).

(v) Governments, funding agencies, and policymakers often use rankings as a benchmark to allocate resources and make strategic decisions about higher education ARWU, (2021); QS, (2019).

2.7 National Institutional Ranking Framework (NIRF)

The National Institutional Ranking Framework (NIRF) is a ranking system introduced by the Ministry of Education, Government of India, to assess and rank higher educational institutions in India. The methodology used by NIRF to rank institutions is based on the following key components:

(i) Teaching, Learning & Resources (TLR) (40%): This indicator includes factors such as student-faculty ratio, faculty qualifications and experience, and availability of resources such as libraries and laboratories.

(ii) Research and Professional Practice (RP) (20%): This indicator assesses the research output and professional activities of the institution, including factors such as research publications, patents filed, and sponsored research projects.

(iii) Graduation Outcomes (GO) (15%): This indicator measures the outcomes of a higher education institution in terms of student graduation rate, university examination pass percentage, and placement records.

(iv) Outreach and Inclusivity (OI) (10%): This indicator evaluates the institution's efforts in promoting inclusivity and diversity, including factors such as the representation of women and economically challenged students, and outreach activities to underprivileged communities.

(v) Perception (PR) (15%): This indicator involves a perception survey where various stakeholders, including academics, employers, and alumni, rate the institution's overall reputation.

It's important to note that NIRF rankings are specific to Indian institutions and are based on data provided by the institutions themselves. NIRF also emphasizes data transparency and allows institutions to review and verify their data to ensure accuracy.

2.8 Critiques of the World University Ranking Systems

Many authors have already highlighted the shortcomings of different university ranking systems and their adverse effects on the universities. Hamann and Ringel (2023) identified two major critiques of University ranking Systems – methodological shortcomings of the performance measurement frameworks and their negative effects. These negative effects are concerned with rising levels of inequality, the spread of opportunistic behavior, and a restriction of scholarly autonomy. Some of the major critiques of World University Ranking Systems are discussed below:

(i) *Less weightage to the undergraduate programs*: THE academic rankings have more inclination towards the science-based institutions having relatively few undergraduate programs. This methodology gives less

weightage to the institutions that have more comprehensive programs and undergraduates. This methodology has criticism due to favoring more to English HEIs Qureshi et al., (2023); Olcay, (2016).

(ii) *Controversial performance indicators and weights assigned to them*: The ranking of the HEIs is based on the scores generated for the different academic performance indicators. The weights assigned to the indicators are controversial Olcay, (2016); Millot, (2015). The ARWU academic ranking system uses performance indicators like "Alumni as Nobel laureates and Fields Medalists" and "The staff as Nobel Laureates and Fields Medalists." Such types of outstanding indicators and contributions are rare and not applicable to a large number of global HEIs.

(iii) *Lack of transparency of the ranking results*: Some of the ranking systems are not transparent enough in the calculation of the final score. The calculation of overall final scores must be comprehensive and transparent. Also, the choice of the performance indicators and their weights is a debatable issue Olcay, (2016).

(iv) *Ignorance of the regional and national HEIs*: The international ranking systems have intrinsic limitations to accurately present the regional and national HEIs. They are intended to highlight the world-class universities. The world university ranking systems do not cover the diversity of higher education. Their lists cover only 5-8% of the HEIs worldwide Millot, (2015).

(v) *Unavailability of the data*: Some of the universities do not show the data publicly online and many universities are not interested in sharing the data with any agency. In this situation, the ranking list may not cover some of the major HEIs Qureshi et al., (2023).

(vi) *Biases in performance evaluation of HEIs*: The evaluation of academic reputation may be biased toward famous universities or domestic universities of the reviewers. Another major criticism faced by the rankings is the biases in the selection of academic publications such as publications in Just Science and Nature which raises controversy Garcia et al., (2014); Aguillo and Bar-Ilan, (2010).

(vii) *Use of subjective indicators*: Some of the indicators are subjective such as opinions on institutional prestige, academic peer review, employer reputation, etc. The use of subjective indicators may affect the final score obtained by an HEI in their rankings.

2.9 Critiques of National Institutional Ranking Framework

(i) A large number of performance indicators are considered under NIRF for performance measurement of HEIs in India. Some of the indicators may not be equally relevant for all the HEIs.

(ii) Many HEIs in India are teaching-oriented institutions and they are putting less effort into research and publications. However, the weights of these factors are the same for all the HEIs.

(iii) Some HEIs may have excellent performance in a particular area but poor performance in another area. Only one model of performance measurement of HEIs may not justify the ranks obtained by all HEIs. Therefore, testing multiple models of a different combination of inputs and outputs is required to know what is the area of excellence of different HEIs.

(iv) A correlation and regression analysis of all the input variables and output variables is required so that the extent of dependency of dependent variables on independent variables can be known.

(v) Weights assigned to different performance indicators may not be appropriate.

(vi) Resource constraints may be a major factor for the different HEIs. All the government-funded HEIs do not have the same level of resource availability.

(vii) Many HEIs in India do have sufficient funding and resources for research and development activities.

2.10 Research Gaps and Objectives

Based on the literature review and the critiques of the university ranking systems following research gaps have been identified:

(i) The universities with higher levels of research funding tended to be more efficient in their research activities, while those with more teaching staff tended to be more efficient in their teaching activities. However, the performance measurement parameters for both types of the universities are same Jamaludin and Jusoff, (2012).

(ii) Most universities are not efficient in all three areas (Teaching, Research, and Administration), and there is a need to improve their resource allocation and management practices to enhance their efficiency Thakur and Singh, (2015).

(iii) Private universities are generally efficient in their teaching activities but less efficient in their research and community service activities. Research and community service activities need to be enhanced Meeampol and Tongurai, (2019).

Research objectives: Based on the literature review and the critiques of different university ranking systems, the following research objectives have been determined for the study:

(i) To formulate different models of input and output variables based on statistical analysis.

(ii) To find the relative efficiency of HEIs for all the models formulated and areas of excellence of the top 50 HEIs in India.

CHAPTER 3

RESEARCH METHODOLOGY

In this study, the performance indicators of the University ranking system are analysed statistically using correlation and regression analysis and various models of dependent and independent variables are formed to check the relative efficiency of the top 50 HEIs ranked by NIRF India. It has been observed that all the indicators of performance criteria may not be very influential and all the criteria of evaluation may not be relevant for all the institutions, therefore, different models of dependent and independent variables are required to find the certain area of excellence of the individual institution. To find the relative efficiency of the institutions for all the models Data Envelopment Analysis (DEA) is used. Titko et al. (2014) have already used such type of research methodology for the efficiency analysis of Latvian banks.

3.1 Statistical Analysis of Performance Indicators

Data Envelopment Analysis is based on the linear regression analysis and linear programming model. In a regression analysis, all the independent variables must be independent or weakly correlated with each other. Thus, correlation analysis and multi-collinearity are required for both inputs and outputs of DEA models. Also, regression analysis is required to know the extent of dependency of the dependent variables on the corresponding independent variables. In this study, correlation and regression analysis is used and 15 models are prepared based on the higher coefficient of determination. Finally, DEA is used to find the relative efficiency of the institutions for all 15 models.

3.2 Data Envelopment Analysis

The input-oriented BCC model of the DEA model is used for finding the relative efficiency of the institutions. The BCC model was first proposed by Banker, Charnes, and Cooper in 1984 as an improvement over the original DEA model proposed by Charnes et al. (1978). It is a non-parametric linear programming model that allows for variable returns to scale. Unlike other DEA models, the BCC model uses both input-oriented and output-oriented measures of efficiency, which allows for a more comprehensive analysis of DMUs. The BCC model also allows for the inclusion of multiple inputs and outputs making it suitable for analyzing complex systems. Singh et al. (2022) also used DEA for the performance improvement of educational systems in the Indian context. However, they have not analyzed the dependent and independent variables using correlation and regression statistical methodology which may be useful to formulate several models.

Many researchers used the Various models of DEA to measure the performance of the HEIs Kumar and Thakur, (2019); Debnath et al., (2008); Singh et al., (2022). DEA has been modified for its multidimensional data handling capability. DEA has been widely applied in measuring the efficiency of banking units and supplier efficiency measurement in supply chain management Azadi et al., (2015); Fukuyama and Matousek, (2017); Stewart et al., (2016); Zhou et al., (2016). Applicability and capability to measure efficiency for multidimensional nonparametric data have prompted us to use DEA to measure the efficiency of HEI.

To improve the methodology of measuring the efficiency of the higher education system in India, this study employs the non-parametric frontier technique called Data Envelopment Analysis (DEA) to calculate efficiency scores. An input-oriented DEA model under variable returns to scale (VRS) is used to derive relative efficiency measures and rankings. The study addresses the relatively less-researched area of utilizing National Institutional Ranking Framework (NIRF) data with DEA. The study's sample includes the top 50 engineering educational institutions in India, as ranked by the National Institutional Ranking Framework (NIRF). The secondary data of these Institutions have been retrieved from the NIRF website. To ensure the

selection of appropriate variables for the DEA models, the retrieved data is processed using methods like correlation analysis, linear regression analysis, and analysis of mean values.

Let there be *m* input and *n* output variables for all the DMUs. The efficiency (θ_k) of the k^{th} DMU can be represented as:

$$\theta_k = \max\left\{\left(BY_j\right)/\left(AX_i\right)\right\} \quad (1)$$

subject to the constraints:

$$AX_i \geq BY_j, \qquad for\ all\ i = 1, 2, ..., m\ and\ j = 1, 2, ..., n \quad (2)$$

$$AX_i = 1 \quad (3)$$

Where $X_i = x_1, x_2, ..., x_m$ are *m* number of input variables and $Y_j = y_1, y_2, ..., y_n$ are *n* number of output variables. $A = a_1, a_{2,...,} a_m$ are the coefficients of input variables and $B = b_1, b_2, ..., b_n$ are the coefficients of output variables.

The BCC model allows for variable returns to scale by introducing a weight for the overall scale of production. This weight is denoted as λ and is included in the objective function as a separate variable:

$$\theta_k = \max\left\{\left(BY_j\right)/\left(AX_i\right)\right\}\lambda \quad (4)$$

subject to the constraints:

$$AX_i \geq BY_j, \qquad for\ all\ i = 1, 2, ..., m\ and\ j = 1, 2, ..., n \quad (5)$$

$$AX_i = 1 \quad (6)$$

$$\lambda\left(BY_j - AX_i\right) \geq 0, \qquad for\ all\ i = 1, 2, ..., m\ and\ j = 1, 2, ..., n \quad (7)$$

$$\lambda \geq 0 \quad (8)$$

The third and seventh constraint ensures that the scale of production is not less than the scale of production of any other DMU in the set, while the fourth constraint ensures that λ is non-negative.

CHAPTER 4

DATA ANALYSIS AND RESULT DISCUSSION

The study is based on the analysis of secondary data. The data has been gathered from the NIRF (2023) website. The top 50 engineering institutions according to the NIRF ranking are taken as Decision-Making Units (DMUs). This study incorporates seventeen variables from the NIRF data. Data from the NIRF ranking is divided into 5 major indicators which then are bifurcated into 17 variables as shown in Figure (1). These variables are divided into two groups dependent and independent variables. The list of these variables is shown in Table 3.

The variables Student Strength (SS), Faculty-Student Ratio (FSR), Faculty Qualification and Strength (FQE), Financial Resources and Utilization (FRU), Students' Regional Diversity (RD), Percentage of Women Diversity (WD), Economically and Socially Challenged Students (ESCS), and Physically Challenged Students (PCS) appear to be influential factors in determining the performance of the institute. Conversely, the performance of the institute can be evaluated based on the variables Research Paper Publications (PU), Quality of Publications (QP), Intellectual Property Right (Published and granted) (IPR), Footprint of Projects and Professional Practices (FPPP), Combined Metrics for Placement and Higher Studies (GPH), (Metrics for University Examination (GUE), Median Salary (GMS), and Metrics for Ph.D. Students Graduated (GPHD), as indicated. Among the parameters, only Peer Perception (PR) can function as both an input and output. A higher peer perception is indicative of better outcomes, and this is likely due to the presence of superior inputs that contribute to an improved perception among peers.

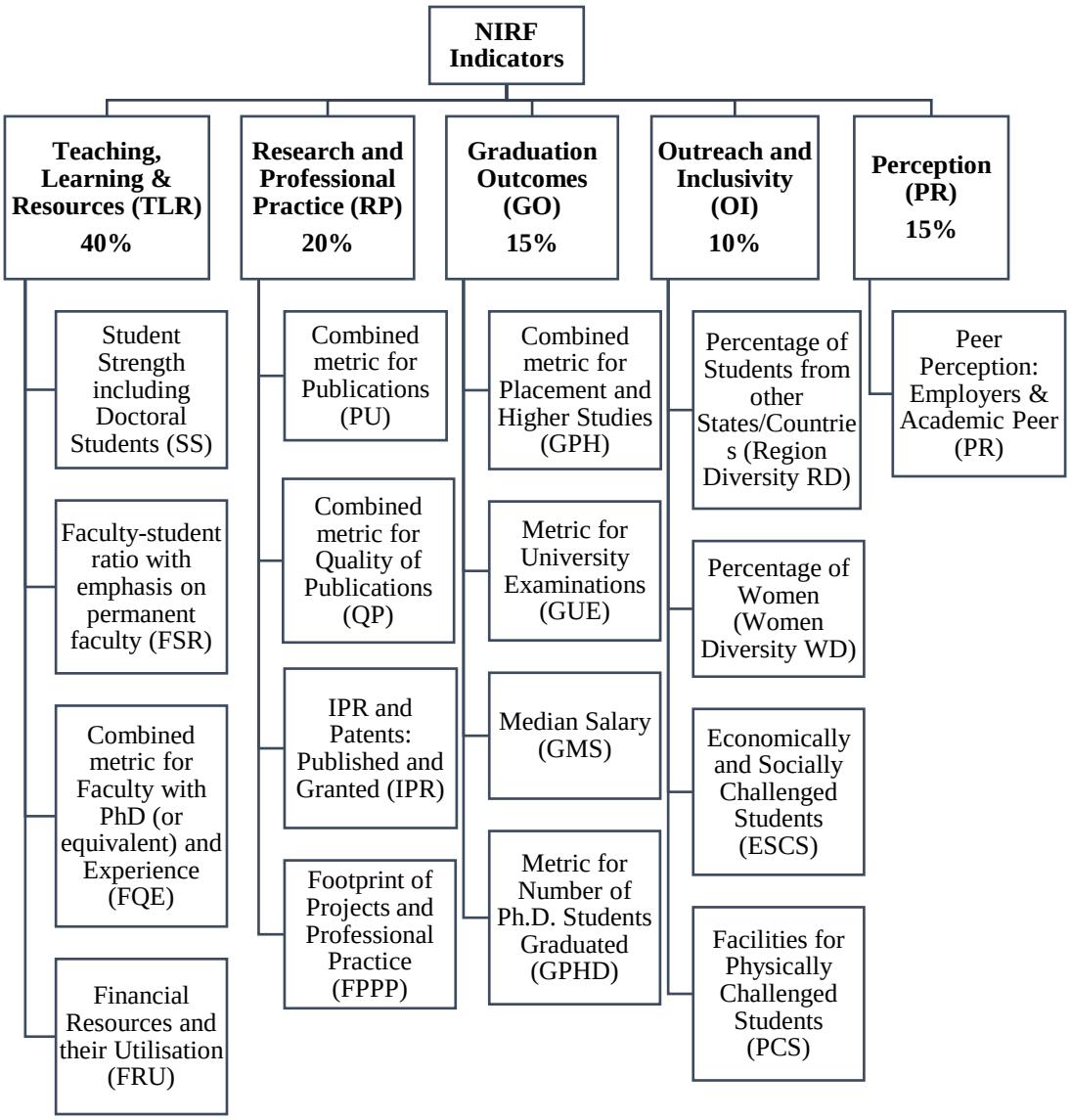

Fig 4.1. Performance Indicators structure of the NIRF framework

Table 4.1: Input and Output Variables list

Input Variables	Output Variables
• Student Strength including Doctoral Students (SS) • Faculty-student ratio with emphasis on permanent faculty (FSR) • Combined metric for Faculty with PhD (or equivalent) and Experience (FQE) • Financial Resources and their Utilisation (FRU) • Percentage of Students from other States/Countries (Region Diversity RD) • Percentage of Women (Women Diversity WD) • Economically and Socially Challenged Students (ESCS) • Facilities for Physically Challenged Students (PCS) • Peer Perception: Employers & Academic Peer (PR)	• Combined metric for Publications (PU) • Combined metric for Quality of Publications (QP) • IPR and Patents: Published and Granted (IPR) • Footprint of Projects and Professional Practice (FPPP) • Combined metric for Placement and Higher Studies (GPH) • Metric for University Examinations (GUE) • Median Salary (GMS) • Metric for Number of Ph.D. Students Graduated (GPHD) • Peer Perception: Employers & Academic Peer (PR)

The next step is to find the appropriate variables to be included in the DEA model as inputs and outputs, statistical analysis was employed on the data. To enhance the accuracy of evaluating input-output variables, many researchers discuss this issue, and various methods for the selection of variables were proposed. The simplified method to determine relevant variables is to omit highly correlated ones as in the case of multi-collinearity Jenkins and Anderson (2003); Luo, Liang (2012). The correlation coefficients and their significance values for input variables are shown in Table 4.

Data for the analysis of the specific DMUs was collected from the NIRF 2023 website and is present in the Appendix I.

Table 4.2: Correlation coefficients for Input Variables

		SS	FSR	FQE	FRU	RD	WD	ESCS
SS	Pearson Correlation	1	-.136	-.237	-.245	.117	.226	-.198
	Sig. (2-tailed)		.346	.097	.087	.419	.114	.169
FSR	Pearson Correlation	-.136	1	.732**	.078	-.080	.523**	-.178
	Sig. (2-tailed)	.346		.000	.591	.582	.000	.216
FQE	Pearson Correlation	-.237	.732**	1	.404**	-.016	.264	.087
	Sig. (2-tailed)	.097	.000		.004	.910	.064	.549
FRU	Pearson Correlation	-.245	.078	.404**	1	.296*	-.424**	.340*
	Sig. (2-tailed)	.087	.591	.004		.037	.002	.016
RD	Pearson Correlation	.117	-.080	-.016	.296*	1	-.178	.023
	Sig. (2-tailed)	.419	.582	.910	.037		.217	.876
WD	Pearson Correlation	.226	.523**	.264	-.424**	-.178	1	-.403**
	Sig. (2-tailed)	.114	.000	.064	.002	.217		.004
ESCS	Pearson Correlation	-.198	-.178	.087	.340*	.023	-.403**	1
	Sig. (2-tailed)	.169	.216	.549	.016	.876	.004	

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

*. Correlation is significant at the 0.05 level (2-tailed).

The correlations analysis is used to avoid the multi-collinearity in regression analysis. For example, the correlation between FQE and FSR is relatively strong and significant. It means that both the highly correlated variables must not be used at a time as input variables or both can be used separately as input variables for different output variables. Similarly, the correlation analysis is used for the output variables as shown in Table 5.

Table 4.3: Correlation coefficients for output variables.

		PU	QP	IPR	FPPP	GPH	GMS	GPHD
PU	Pearson Correlation	1	.925**	.477**	.562**	.114	.403**	.720**
	Sig. (2-tailed)		.000	.000	.000	.429	.004	.000
QP	Pearson Correlation	.925**	1	.566**	.401**	.003	.321*	.760**
	Sig. (2-tailed)	.000		.000	.004	.986	.023	.000
IPR	Pearson Correlation	.477**	.566**	1	.393**	-.347*	.026	.532**
	Sig. (2-tailed)	.000	.000		.005	.013	.855	.000
FPPP	Pearson Correlation	.562**	.401**	.393**	1	.181	.655**	.530**
	Sig. (2-tailed)	.000	.004	.005		.209	.000	.000
GPH	Pearson Correlation	.114	.003	-.347*	.181	1	.380**	.046
	Sig. (2-tailed)	.429	.986	.013	.209		.006	.750
GMS	Pearson Correlation	.403**	.321*	.026	.655**	.380**	1	.477**
	Sig. (2-tailed)	.004	.023	.855	.000	.006		.000
GPHD	Pearson Correlation	.720**	.760**	.532**	.530**	.046	.477**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.750	.000	

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

*. Correlation is significant at the 0.05 level (2-tailed).

It has been observed that QP and PU, PU, and GPHD are strongly correlated with each other. Thus, during the selection of input variables for out variables both the highly correlated variables cannot be used simultaneously. Based on the correlation analysis (Tables 4 and 5) and the Regression analysis (Table 6), Fifteen DEA models have been developed to calculate efficiency scores of 50 DMUs using different combinations of variables. The list is quite big, but only those combinations of input-output variables are considered in which the values of R^2 are relatively higher. As per the DEA restrictions, it is assumed that the total number of the DMUs should be three times larger than the sum of variables Jenkins and Anderson (2003); Ruggiero (2005), in our case, it is possible to employ a maximum of 16 inputs and outputs in the model. Besides, some variables cannot be used in one model even in the case they are not correlated.

Table 4.4. Results of the regression analysis: models with different dependent variables

Regression model with the dependent variable	**R Square adjusted**	**Sig.**	**Statistics on coefficients**	
			Predictors	**Sig.**
Combined metric for Publications (PU)	0.559	0.000	Faculty Education (with Ph.D.) and Experience (FQE)	0.138
			Faculty Resources and their Utilization (FRU)	0.071
			Regional Diversity of Students (RD)	0.134
			Women Diversity in percentage (WD)	0.000
			Peer Perception (PR)	0.000
Combined metric for Quality of Publications (QP)	0.566	0.000	Student Strength (SS)	0.007
			Faculty Education (with Ph.D.) and Experience (FQE)	0.446
			Faculty Resources and their Utilization (FRU)	0.298
			Regional Diversity of Students (RD)	0.307
			Women Diversity in percentage (WD)	0.003
			Peer Perception (PR)	0.004
IPR and Patents: Published and Granted (IPR)	0.332	0.001	Student Strength (SS)	0.038
			Faculty Education (with Ph.D.) and Experience (FQE)	0.587
			Faculty Resources and their Utilization (FRU)	0.712
			Regional Diversity of Students (RD)	0.884
			Women Diversity in percentage (WD)	0.430
			Peer Perception (PR)	0.070
Footprint of Projects and Professional Practice (FPPP)	0.791	0.000	Faculty-student ratio (FSR)	0.221
			Faculty Resources and their Utilization (FRU)	0.000
			Women Diversity in percentage (WD)	0.093
			Peer Perception (PR)	0.018
Combined metric for Placement and Higher Studies (GPH)	0.112	0.111	Student Strength (SS)	0.351
			Faculty Education (with Ph.D.) and Experience (FQE)	0.891
			Faculty Resources and their Utilization (FRU)	0.219
			Regional Diversity of Students (RD)	0.508
			Women Diversity in percentage (WD)	0.140
			Peer Perception (PR)	0.129
			Economically and Socially Challenged Students (ESCS)	0.090
Median Salary (GMS)	0.696	0.000	Faculty Resources and their Utilization (FRU)	0.001
			Regional Diversity of Students (RD)	0.172
			Women Diversity in percentage (WD)	0.000
			Peer Perception (PR)	0.138
Metric for Number of Ph.D. Students	0.654	0.000	Student Strength (SS)	0.004
			Faculty-student ratio (FSR)	0.001
			Faculty Resources and their Utilization (FRU)	0.270
			Faculty Education (with Ph.D.) and Experience (FQE)	0.056
			Regional Diversity of Students (RD)	0.314

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Table4.4 (continued

Graduated (GPHD)			Peer Perception (PR)	0.003
Peer Perception: Employers & Academic Peer (PR)	0.687	0.000	Student Strength (SS)	0.000
			Faculty-student ratio (FSR)	0.178
			Faculty Education (with Ph.D.) and Experience (FQE)	0.190
			Faculty Resources and their Utilization (FRU)	0.000
			Women Diversity in percentage (WD)	0.082

The regression analysis indicates that the ESCS variable has less significance value in all models. Similarly, the value of adjusted R^2 for GPH is insignificant as an output variable. Thus, ESCS and GPH are not very useful to be included in the analysis. To achieve the established research goals, fifteen different combinations of variables have been used to develop DEA models for measuring the relative efficiency of Engineering Higher education institutes in India. Models differ in the number of incorporated variables: 1 model with 10 variables, 1- model with 9 variables, 2- models each with 8 variables, 5 models each with 7 variables, 3 models each with 6 variables, 2 models each with 5 variables, and one model with 4-variables as shown in Table 7. The developed M1-M15 models were applied to measure the relative efficiency of Engineering Higher education institutes. Efficiency measurement has been conducted using the DEA Frontier software, with the received data processed within the SPSS 20.0 environment. The relative efficiencies of all the models are shown in Table 8. The Maximum, minimum, mean, median, and standard deviation of the efficiencies have also been analyzed and discussed in the study.

Table 4.5. DEA models with different input-output combinations

Model No.	Inputs	Outputs
M1	1. FQE 2. FRU 3. RD 4. WD 5. PR	1. GMS
M2	1. FQE 2. FRU 3. RD 4. WD 5. PR	1. PU
M3	1. FQE 2. FRU 3. WD 4. PR	1. FPPP
M4	1. SS 2. FRU 3. WD	1. GPHD
M5	1. SS 2. FQE 3. WD 4. FSR 5. FRU 6. RD	1. PR
M6	1. SS 2. FQE 3. FRU 4. WD 5. PR	1. PU 2. IPR 3. GMS 4. GPHD
M7	1. SS 2. FQE 3. FRU 4. RD 5. WD 6. PR	1. QP 2. IPR 3. GMS 4. GPHD
M8	1. FQE 2. FRU 3. RD 4. WD 5. PR	1. PU 2. GMS
M9	1. FQE 2. FRU 3. WD 4. PR	1. IPR
M10	1. FQE 2. FRU 3. WD	1. QP 2. IPR 3. GMS 4. PR
M11	1. SS 2. FQE 3. FRU 4. FSR 5. RD 6. PR	1. GMS 2. GPHD
M12	1. SS 2. FQE 3. FRU 4. RD 5. WD 6. PR	1. FPPP 2. GMS
M13	1. FQE 2. FRU 3. RD 4. WD	1. PR 2. FPPP 3. GMS
M14	1. SS 2. FQE 3. FRU 4. RD 5. WD	1. GMS 2. PR
M15	1. SS 2. FQE 3. FRU 4. WD	1. PU 2. PR

The comprehensive results and in-depth scores obtained by each DMU in models, from M1 to M15 are present in the Appendix II.

Table 4.6: Relative efficiencies of All the DMUs for 15 models of DEA.

Code	Name	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15
U01	IIT Madras	0.758	1	1	0.8664	1	1	1	1	0.9539	1	0.8797	1	1	1	1
U02	IIT Delhi	0.8249	1	0.8832	0.8689	0.9821	1	1	1	0.9437	1	0.946	0.9403	1	1	1
U03	IIT Bombay	0.8101	0.9469	1	0.8845	0.9723	1	1	0.9552	1	1	0.9198	1	1	1	0.9865
U04	IIT Kanpur	1	0.924	1	0.9153	0.9735	1	1	1	1	1	1	1	1	1	0.9735
U05	IIT Roorkee	0.8822	0.9505	0.9181	0.884	0.8957	0.9965	1	0.9694	0.94	0.9385	0.9287	0.9181	0.9305	0.9344	0.9216
U06	IIT Kharagpur	0.974	1	0.9692	1	1	1	1	1	1	1	1	0.974	1	1	1
U07	IIT Guwahati	1	1	1	0.9101	1	1	1	1	1	1	1	1	1	1	1
U08	IIT Hyderabad	1	0.7434	0.7681	0.8287	0.9672	1	1	1	0.7021	0.7054	1	1	1	1	0.9987
U09	NIT Trichy	0.7454	0.7795	0.7373	0.7377	0.9152	0.8102	0.8137	0.7795	0.7324	0.8447	0.8312	0.7868	0.8447	0.9196	0.9188
U10	Jadavpur University	1	1	0.8472	0.8744	0.6791	1	1	1	0.7665	0.8655	1	1	1	1	0.9158
U11	VIT, Vellore	0.9714	1	0.9163	1	0.8869	1	1	1	0.9165	1	1	0.9714	1	1	1
U12	NIT Surathkal	0.7972	0.8484	0.8193	0.7289	0.8742	0.8368	0.8632	0.8484	0.8126	0.8417	0.8637	0.8631	0.8732	0.8742	0.8742
U13	Anna University	1	1	0.9563	0.9163	1	1	1	1	0.9493	1	1	1	1	1	1
U14	IIT Indore	0.9788	0.8402	0.9499	1	0.8986	1	1	1	0.841	0.8125	1	1	0.8797	0.9618	0.9688
U15	IIT Varanasi	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
U16	NIT Rourkela	0.888	1	0.8658	0.8186	0.7144	1	1	1	0.9114	0.8309	1	0.888	0.8639	0.8639	0.8157
U17	IIT Dhanbad	0.987	1	0.9798	0.988	0.9734	1	1	1	1	0.9984	1	0.987	0.9806	0.9806	1
U18	IIT Gandhinagar	0.5969	0.604	1	0.9556	0.8061	0.9556	0.9557	0.604	0.5851	0.6042	0.9557	1	0.7975	0.8388	0.9039
U19	Amritha Vidyapeeth	0.8144	0.837	0.7965	0.767	0.6762	0.7934	0.8261	0.837	0.7314	0.7532	0.8446	0.846	0.8502	0.8418	0.8257
U20	Thapar Institute	1	1	1	0.7676	0.7556	1	1	1	1	0.8264	1	1	0.7902	0.8669	0.8456
U21	NIT Warangal	0.8337	0.8008	0.7645	0.7053	0.7536	0.8451	0.8924	0.8343	0.7867	0.7741	0.8761	0.8719	0.8305	0.8688	0.8107
U22	IIT Ropar	0.7584	0.7323	0.7721	0.8701	0.884	0.9112	0.9112	0.7584	0.7357	0.7019	0.8831	0.9267	0.757	0.9029	0.8918
U23	NIT Calicut	0.8113	0.7659	0.7016	0.7905	0.7246	0.8812	0.903	0.8113	0.6916	0.7175	0.9039	0.862	0.7802	0.8697	0.7972
U24	ICT, Mumbai	0.8781	0.8673	1	0.9967	0.8155	1	1	0.8781	1	0.7994	1	1	1	1	0.8458
U25	BITS Pilani	1	0.948	0.926	0.8243	0.8764	1	1	1	0.926	1	1	1	1	1	0.9434

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Table 4.6 (continued)

Code	Name	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15
U26	Jamia Millia	1	1	1	1	0.9748	1	1	1	1	1	1	1	1	1	1
U27	Siksha Anusandhan	0.7778	0.7778	0.7774	0.6835	0.7584	0.866	0.866	0.7778	0.7955	0.774	0.825	0.8222	0.7651	0.8205	0.8063
U28	SRM, Chennai	0.9427	1	0.9289	0.8126	0.8749	1	1	1	0.9289	0.9646	0.975	0.9446	0.9154	0.9407	0.9791
U29	DTU, New Delhi	1	1	1	0.7901	0.9927	1	1	1	1	1	1	1	1	1	1
U30	IIT Jodhpur	1	0.9521	1	0.7593	0.7946	1	1	1	0.9521	0.6286	1	1	0.7541	0.8695	0.8018
U31	Amity University, UP	1	1	1	0.9094	0.7948	1	1	1	1	0.8613	1	1	0.8939	0.9651	0.9602
U32	Aligarh Muslim Uni	1	1	0.9476	0.9639	0.9505	1	1	1	1	0.9887	1	1	1	1	0.9937
U33	IIT Mandi	1	0.7757	0.8094	1	0.9612	1	1	1	0.7716	0.9214	1	1	0.9611	1	0.9851
U34	SASTRA, Thanjavur	1	1	1	0.7844	0.7033	1	1	1	0.9922	0.7321	1	1	0.841	0.8738	0.8154
U35	IIEST, Shibpur	0.8916	0.8963	0.8286	0.926	0.8587	0.9779	1	0.8963	0.8251	0.834	1	0.9531	0.8964	0.952	0.9241
U36	KARE, Srivilliputtur	0.9108	0.9108	0.9109	0.832	0.6726	0.9565	0.9565	0.9108	0.9108	0.7054	0.9565	0.9277	0.7449	0.851	0.8077
U37	MNIT, Jaipur	1	1	1	0.8094	0.7503	1	1	1	0.994	0.8023	1	1	0.9137	0.9378	0.8586
U38	Chandigarh Uni.	0.7607	0.7607	0.7418	0.7768	0.7159	0.8302	0.8302	0.7607	0.7418	0.7484	0.8216	0.8038	0.7447	0.8164	0.8105
U39	KIIT, Bhubaneshwar	0.8994	0.8994	0.8994	0.7438	0.7262	1	1	0.8994	0.9179	0.7732	1	0.8994	0.7648	0.7914	0.7848
U40	NIT, Silchar	1	1	1	0.7935	0.8313	1	1	1	1	0.8807	1	1	0.9258	0.9712	0.9275
U41	IIT Patna	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
U42	VNIT, Nagpur	0.968	0.9279	0.9772	0.7415	0.7827	1	1	0.968	1	0.8221	0.9791	1	0.8994	0.9299	0.8668
U43	NIT Durgapur	0.9377	0.9377	0.9088	0.8629	0.8235	0.9939	1	0.9377	0.9088	0.9012	1	0.9377	0.9271	0.9335	0.907
U44	K L college of Engg.	1	1	1	1	0.6831	1	1	1	1	0.8736	1	1	1	1	1
U45	SSCNE, Kalavakkam	1	1	0.891	0.882	0.8074	0.9785	1	1	0.8875	0.7577	1	1	0.911	1	0.8971
U46	NIT Jalandhar	0.9673	0.9656	0.8842	0.8749	0.8392	0.9607	0.9979	0.9673	0.8842	0.8761	0.9979	0.9921	0.9067	0.9884	0.9415
U47	IIT Bhubaneshwar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
U48	IISST, Kerala	0.6822	0.6822	0.682	1	1	1	1	0.6822	0.682	0.7068	1	1	0.7118	1	1
U49	MNIT, Prayagaj	1	1	1	0.9132	1	1	1	1	1	1	1	1	1	1	1
U50	LPU, Punjab	1	1	1	1	0.907	1	1	1	1	1	1	1	1	1	1

Application of input-oriented DEA models under VRS assumption yielded efficiency scores for DMUs. In the M1 model graduates' medium salary is defined by faculty qualification and experience, financial resources utilization, women diversity, regional diversity, and peer perception up to 69.3% (adjusted R square). Thus, these variables do not fully define the graduates' salaries. Some other variables are also responsible for it which are to be explored and tested. Considering this model, it has been observed that many IITs and NITs are not the frontier organizations, however, some of the state Govt. institutions and private institutions are the frontier organizations. In the M2 model Metrics of publication are defined by the Metric of faculty with Ph.D., Financial resource utilization regional diversity, percentage of women, and peer perception up to 55%. It has been observed that most of the IITs are frontier organizations or have efficiencies close to 1. Many private institutions and state government institutions are having poor publication efficiencies. The reasons may be poor faculty qualification and experience, lack of financial resource availability, and poor utilization.

In the M3 model, the Footprint of Projects, Professional practice, and executive development programs are taken as the sole output, which is defined, by faculty qualification and experience, financial resources utilization, women diversity, and peer perception up to 79.2%. For this model, it is observed that there are a few institutes that have their output less than the projected values as per the DEA model. For example, the actual values differ from the projected values for VIT Vellore (U11), SRM Chennai (U28), BITS Pilani (U25), and IIST Kerala (U48) by 26.84%, 213.09%, 121.87%, and 117.07% respectively. If FPPP is considered as the Output and FQE, FRU, WD, and PR as input variables many top leading institutes stated by NIRF ranking hold a lower rank in relative efficiency. For example, IIT Delhi (U02), IIT Kharagpur (U06), IIT Hyderabad (U08), NIT Trichy (U09), NIT Surathkal (U12) have relative efficiencies of 88.32%, 96.92%, 76.81%, 73.73%, and 81.93% respectively. On the other hand, some higher education institutes lie on the frontier in the DEA model but they are ranked lower in the NIRF ranking. Some examples of these universities are JMI New Delhi (U26), DTU Delhi (U29), SASTRA Thanjavur (U24), etc.

In the M4 model, the number of Ph.D. Students produced are used as the output and Student Strength including Doctoral Students, Financial Resources and their Utilization, and Percentage of Women are used as input. Projection difference has been seen in a few institutes such as Amrita Vishwa Vidyapeetham Coimbatore (U19) by 134.19%, and Aligarh Muslim University (U32) by 20.45%. GPHD is defined by SS, FRU, and WD by 54.6%. It means that some other important variables contributing to the production of Ph.D. have not been considered by the NIRF ranking. Some of the top-ranking institutes lag in the relative efficiency (DEA model) considering the produced Ph.D. examples IIT Madras (U01), IIT Delhi (U02), IIT Mumbai (U03), NIT Trichy (U09), etc. There are not many institutes giving the required output as Ph.D. produced according to resources utilized but some of them are producing a good number of Ph.D. using the limited resources at their disposal for example VIT Vellore (U11) and IIST Kerala (U48). Similarly, in the M5 model, Peer Perception has been taken as the output variable. Student Strength including Doctoral Students, a Combined metric for Faculty with Ph.D. (or equivalent) Experience., Faculty-student ratio with emphasis on permanent faculty, Financial Resources and their Utilization, Region Diversity, and Percentage of Women are the inputs that define 63.9% of the output variable. The institutes have very little deviation from their projected values except for IIT Jodhpur (U30), and MNIT Jaipur (U46) which deviate by 52.356% and 50.436% respectively. However, there are not more than 14 Universities that are frontier institutes in relative efficiencies when PR is taken as output and SS, FQE, and WD as input variables. Examples of frontier institutes are IIT Madras (U01), IIT Kanpur (U04), Institute of Chem. Tech, Mumbai (U18), JMI New Delhi (U26), DTU Delhi (U35), NIT Kurukshetra (U50).

In the M6 model, the institutes' efficiencies are calculated considering multiple outputs and multiple inputs. As the institutes are already the leading institutes in India, most of them lie on the frontier except a few institutions like NIT Trichy (U08), NIT Surathkal (U10), A V Vidyapeetham Coimbatore (U19), NIT Warangal (U21), IIT Ropar (U22), IIT Bhubaneshwar (U36), etc. The relative efficiency in model M6 is calculated with variables of Student Strength including Doctoral Students, the Combined metric for Faculty with a Ph.D. (or equivalent) and Experience, Financial

Resources and their Utilization, Percentage of Women, Peer Perception as input variables, and Combined metric for Publications, IPR and Patents: Filed, Published, Granted and Licensed, Median Salary and Metric for Number of Ph.D. Students Graduated as output variables. The analysis shows some institutes deviate from the projection values in almost every output variable such as A V Vidyapeetham Coimbatore (U19), IIT Ropar (U22), IIT Bhubaneshwar (U36), KARE Srivilliputtur (U39), SASTRA Thanjavur (U41). In the M7 model, ten variables are taken to estimate the relative efficiency of the Higher engineering institutions in India. The Input variables are Student Strength including Doctoral Students, Combined metric for Faculty with Ph.D. (or equivalent) and Experience, Financial Resources and their Utilisation, Region Diversity, Percentage of Women, and Peer Perception and output variables are Combined metric for Quality of Publications, IPR, and Patents: Filed, Published, Granted, and Licensed, Median Salary, Metric for Number of Ph.D. Students Graduated. The results are similar to the M6 model as most of the institutes are on the frontier except for a few that are mentioned in M6 as well. The projection results have shown improvement as compared to M6 but some still show a deviation in all the output variables such as), IIT Bhubaneshwar (U36), and KARE Srivilliputtur (U39).

In the M8 model, seven variables are used where the Combined metric for Faculty with Ph.D. (or equivalent) and Experience, Financial Resources and their Utilization, Region Diversity, Percentage of Women, and Peer Perception are taken as Input variables, and Combined metric for Publications and Median Salary are taken as output variables. Some institutes deviated from the projection values in both the output variables such institutes are IIT Gandhinagar (U23), SOA Bhubaneshwar (U27), KARE Srivilliputtur (U39), SASTRA Thanjavur (U41). There are 30 out of 50 institutes whose relative efficiencies with PU and GMS as output are at the frontier. Some institutes are relatively efficient but ranked very low in the NIRF ranking such as NIT Kurukshetra (U50), MNNIT Prayagraj (U47), MNIT Jaipur (U46), DTU Delhi (U35), JMI New Delhi (U26). In the M9 Model, Combined metric for Faculty with Ph.D. (or equivalent) and Experience, Financial Resources and their Utilisation, Percentage of Women have been considered as input variables; and IPR and Patents:

Filed, Published, Granted and Licensed, Combined metric for Placement, Higher Studies, and Entrepreneurship have been considered as the output variables. Only sixteen out of fifty institutes lie on the frontier. This shows that very few institutes focus on the IPRs patents Publishing side of higher education. Some of the frontier institutes that are ranked low in the NIRF ranking are NIT Kurukshetra (U50), MNNIT Prayagraj (U47), KLCE Vaddeswaram (U44), DTU Delhi (U35), VNIT Nagpur (U32), etc. The institute that lacks the projection value of one of the outputs generally lacks the other output as well. IIT Ropar (U22), IIT Bhubaneshwar (U36), and SSNCE Kancheepuram (U48) differ highly from the projection values of the output variables.

In the M10 Model, seven variables are taken to perform the Data envelopment analysis. The inputs for the analysis are Combined metrics for Faculty with Ph.D. (or equivalent) and Experience, Financial Resources, and their Utilisation, Percentage of Women, and the outputs for the model are IPR and Patents: Filed, Published, Granted and Licensed, the Combined metric for Placement, Peer Perception, and medium salary. Twenty out of fifty institutes performed relatively well on these parameters. Some institutes are on the frontier yet hold lower positions in NIRF ranking for example NIT Kurukshetra (U50), MNNIT Prayagraj (U47), KLCE Vaddeswaram (U44), IIT Jodhpur (U30), Amity University U.P. (U25), etc. In the M11 model, Combined metrics for Placement, Higher Studies, and Entrepreneurship and Metrics for the Number of Ph.D. Students who Graduated are the outputs and the Combined metric for Faculty with a Ph.D. (or equivalent) and Experience, Financial Resources and their Utilisation, Percentage of Women, Region Diversity, and Peer Perception are taken as the input variables. The model shows that most of the universities lie on the frontier i.e., thirty-four institutes out of fifty institutes, however, the top institutes in NIRF such as IIT Madras (U01), IIT Delhi (U02), IIT Mumbai (U03) are not at their full efficiency. This may suggest that the number of Ph.D. students graduating is less from these institutes as compared to their resources or that the level of research is so intense that it only produces a limited amount of Ph.D. students. This model requires more data to draw concrete conclusions from the results. Projection difference is seen in very few institutes and it is observed that the institutes have projection difference in both of the output variables or in none.

In the M12 Model, Footprint of Projects, Professional Practice and Executive Development Programs, and Median Salary are taken outputs, whereas Student Strength including Doctoral Students, Combined metric for Faculty with Ph.D. (or equivalent), and Experience, Financial Resources and their Utilisation, Percentage of Women, Region Diversity, Peer Perception are taken as inputs for relative efficiency calculation. In this model, some institutes are ranked higher in the NIRF ranking but are not relatively as efficient as some of the lower-ranked universities. Examples of frontier institutes are NIT Kurukshetra (U50), VTU Belgaum (U49), DTU Delhi (U35), JMI New Delhi (U26), Institute of Chem. Tech, Mumbai (U18), IIT ISM (U14), IIT Madras (U01) etc. Some universities have a high deviation in FPPP values such as Chandigarh University (U45) and NIT Silchar (U38) with 315.382% and 101.368% of projection deviation respectively. This shows that these institutes have less focus on Projects, Professional Practice, and Executive Development Programs. In the M13 Model, Peer perception is now taken as an Output Variable. The input variables are Combined metrics for Faculty with Ph.D. (or equivalent) and Experience, Financial Resources and their Utilisation, Percentage of Women, and Region Diversity. Only twenty institutes out of fifty institutes are on the frontier. IIST, Kerala (U43) is the worst-performing institute. This model coincides with the NIRF ranking for the top institutes however, there are institutes with high relative efficiency ranked low, these institutes are NIT Kurukshetra (U50), KLCE Vaddeswaram (U44), AMU Aligarh (U37), BITS Pilani (U29) and more. The deviation in projection values highlights the institutes lacking in every discipline such as VTU Belgaun (U49), SSNCE Kancheepuram (U48), and NIT Silchar (U38).

M14 Model focuses on Graduates' median salary and peer perception of that institute as outputs and Student Strength including Doctoral Students, the Combined metric for Faculty with Ph.D. (or equivalent) and Experience, Financial Resources and their Utilisation, Percentage of Women, and Region Diversity as the inputs. In this model, twenty-seven out of the institutes are lying on the frontier line whereas SOA Bhubaneshwar (U27) is the least relatively efficient institute. The top-ranked institutes are frontier; however, there are institutes in the lower ranks that perform relatively as efficiently as higher institutes. It has been observed that if the lower-ranked institutes

are provided with the same inputs, they may outperform the high-ranked institutes in the given output parameters such institutes are NIT Kurukshetra (U50), MNNIT Prayagraj (U47), KLCE Vaddeswaram (U44), DTU Delhi (U35), JMI New Delhi (U26), Anna University Chennai (U17), etc. In the M15 Model, Combined metrics for Placement, Higher Studies, Entrepreneurship, and Peer Perception are the output parameters, and Student Strength including Doctoral Students, the Combined metric for Faculty with a Ph.D. (or equivalent) and Experience, Financial Resources and their Utilisation, Percentage of Women are taken as the input parameters. The model shows that about 50% of the institutes lie on the frontier. NIT Rourkela (U15) has the least relative efficiency of 78.76%. There are institutes with high deviations from the projected value of both the output variables for example KIIT Bhubaneshwar (U42), and MNIT Jaipur (U46).

There have been some institutes that have performed consistently on either side of their NIRF ranking. For example, NIT Trichy (U08), NIT Surathkal (U10), A V Vidyapeetham Coimbatore (U19), NIT Warangal (U21), IIT Ropar (U22) are the institutes that have not been frontier even in a single DEA model are in the top 25 ranking of NIRF. On the other hand, JMI New Delhi (U26) has been frontier in every model of DEA been placed at 26^{th} rank in NIRF. There are institutes such as DTU Delhi (U35), KLCE Vaddeswaram (U44), and NIT Kurukshetra (U50) that have been frontier in 14 of the 15 DEA models presented in the research.

Based on the above analysis, some of the recommendations made for the ranking organizations are mentioned below:

(i) The DEA analysis shows that the indicators considered for the performance measurement must be revisited. Some of the inputs may not influence the outputs sufficiently. Thus, correlation and regression analysis is required before fixing the output and input variables.

(ii) In addition, the ranking of the institutions should be based on the different output parameters, not on the overall ranking. Thus, the performance ranking can be presented in different clusters. Many institutions in India are teaching-oriented and performing well, they should not be ignored due

to weak research performance. The level of availability of resources for the different institutes is different, thus, the scale efficiency will be more appropriate to measure the performance.

(iii) The performance measuring parameters should be very broad which must be concerned with most of the institutions participating in NIRF ranking processes.

(iv) The weights assigned to different measuring parameters should be optimal and should fit most of the institutions.

(v) Peer perception and outreach have high weightage as 15% and 10% respectively. The institutes funded by govt. and public sectors have a high level of resources and findings and they have excellent peer perception compared to the other institutions. Due to a lack of resources and findings, many institutions have weak outreach programs. The weightage of peer perception and outreach may be normalized.

(vi) Some mathematical models like DEA may be used to make the clusters of performance ranking.

4.1 Managerial/Policy Implications: This study may bring the attention of the performance ranking organizations to reconsider the performance evaluation criteria and toward the limitations of the institutions situated in remote locations and having a lack of resources and facilities like internet and communication facilities. Many institutions that are performing well but not participating in the ranking processes should be motivated to participate in the ranking and share the related information. All the fifteen models developed based on the different combinations of inputs and outputs using correlation regression analysis may help in diving the performance ranking in different clusters.

4.2 Academic Implications: The DEA model proposed in this study may help the researcher explore some more performance measurement criteria so that the coefficient of determination of the dependent variables may be maximized. In addition, different models of DEA may be employed to test the result of the study. The scale of the availability of resources and inputs used is very important. Thus, the performance ranking may also be represented in the form of scale efficiency.

CHAPTER 5

CONCLUSION, FUTURE SCOPE AND SOCIAL IMPACT

This study was focused on the micro-analysis of the performance indicators considered for the performance ranking of the Higher Engineering Institutions in India by NIRF. Before the analysis, the world's top university ranking bodies were considered for the review of ranking methodologies adopted by them. Some critiques of those methodologies have also been presented in this study including the NIRF ranking and its critiques. Secondary data available on the NIRF website has been considered as the base for the analysis. Different combinations of DEA models were prepared using correlation and regression analysis. It has been observed that the results of these fifteen models are quite different from the NIRF ranking. The reasons for the deviation have also been discussed in detail.

The ranking organizations need to explore the limitations of the universities and all aspects of a university's performance. Some factors such as location, program offerings, faculty expertise, research opportunities, and personal preferences should also be considered when making decisions about higher education options. The inclusion of relative efficiency as a factor in the NIRF ranking framework may enhance the accuracy and relevance of the rankings. It also helps to find of the weightage to be assigned to the different inputs and outputs. The findings can be used to enhance the ranking procedures of HEIs, enabling society to make more informed decisions when choosing the appropriate educational institution.

Limitations and future scope of the research: This study is based on the secondary data collected from the website of the NIRF. The primary data directly collected from the institutions and some interviews of the academic experts of these institutions may give

better results and more inputs for the analysis. Based on the DEA analysis some most important inputs and outputs may be selected that are applicable for all the institutions for common acceptability of the ranking results or a cluster of performance ranking may be provided.

Social Impact: This revised ranking system for higher education institutions (HEIs) has the potential to significantly impact society. Students will benefit from clearer, more focused information. Defined outputs highlight aspects like graduate success rates and program strengths, empowering them to choose institutions that align with their goals. This can lead to a more informed and successful student body.

For HEIs, the system could spark a competitive environment. With a focus on areas highlighted by the ranking, institutions may strive to improve teaching quality, research output, and graduate employability. This could lead to an overall enhancement of the higher education landscape. Furthermore, a transparent and informative ranking system can foster public trust.

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APPENDIX I

Table I.1 Data for Models

DMU	Institute Name	SS	FSR	FQE	FRU	PU	QP	IPR	FPPP	MS	GPHD	RD	WD	PR	GUE	PCS	ESCS	GPH
U01	Indian Institute of Technology Madras	18.5	30	17.3	29.4	35	36.41	15	10	20	16.75	21.29	14.11	100	14.6	20	7.86	28.54
U02	Indian Institute of Technology Delhi	18.43	26.2	17.05	23.21	34.09	38.72	15	6.94	21.18	16.73	22.94	16.65	94.07	13.5	20	8.33	33.59
U03	Indian Institute of Technology Bombay	18.5	24	16.09	20.53	31.5	34.4	15	7.04	19.5	17.2	19.03	13.46	85.36	13.89	20	4.41	31.34
U04	Indian Institute of Technology Kanpur	18.5	25.29	17.36	23.2	28.45	30.39	14	7.32	21.93	16.02	19.94	11.35	76.15	15	20	7.53	36.04
U05	Indian Institute of Technology Roorkee	17.61	23.7	15.5	17.74	29.63	34.04	10	4.68	20.78	15.54	23.08	11.96	59.37	15	20	5.38	37.59
U06	Indian Institute of Technology Kharagpur	18.45	20.07	14.03	14.71	30.59	37.26	8	2.44	20.33	20	19.62	10.55	75.51	13.14	20	5.88	31.21
U07	Indian Institute of Technology Guwahati	18.5	20.99	12.01	16.2	28.74	30.97	10	5.29	22.09	15.61	22.6	11.4	50.09	15	20	0.95	32.31
U08	Indian Institute of Technology Hyderabad	12.65	30	18.32	22.89	24.53	24.25	7	5.35	21.12	8.43	17.08	15.41	60.04	15	20	3.46	31.37
U09	National Institute of Technology Tiruchirappalli	17.5	23.39	15.86	16.99	25.69	27.48	6	2.28	17.02	11.57	16.68	20.76	67.98	15	20	8.41	35.23
U10	Jadavpur University	17.35	29.25	18.97	11.32	27.98	29.01	6	2.91	15.95	12.06	6.54	18.03	35.84	15	20	8.24	33.67
U11	Vellore Institute of Technology	20	21.54	13.65	7.16	26.96	37.21	11	0.24	13.38	14.11	19.65	21.86	50.21	15	20	0.12	27.9
U12	NIT Karnataka, Surathkal	17.5	22.17	14.23	18.9	23.14	23.44	6	3.51	16.87	11.49	16.65	16.32	48.38	15	20	9.99	33.87
U13	Anna University	17.59	23.2	13.15	9.98	27.4	32.94	12	2.14	11.72	12.25	0.59	25.29	65.5	14.37	20	4.14	21.6
U14	Indian Institute of Technology Indore	10.88	29.99	17.79	17.23	25.55	26.3	5	4.04	20.37	9.84	19.96	13.81	24.73	15	20	5.76	27.17
U15	Indian Institute of Technology (BHU), VAranasi	16.8	17.7	12.35	14.27	23.48	27.98	6	2.56	20.27	11.51	16.77	10.22	53.31	15	20	9.17	35.44
U16	National Institute of Technology Rourkela	17.5	25.7	17.05	13.71	25.91	27.98	6	1.81	14.52	11.61	15.95	14.41	18.85	15	20	8.69	30.41
U17	Indian Institute of Technology (ISM), Dhanbad	15	21.48	14.7	15.19	26.91	30.33	4	2.35	17.91	11.22	19.16	10.32	30.85	12.64	20	7.76	31.15
U18	Indian Institute of Technology Gandhinagar	10	30	19.48	23.32	18.05	16.61	2	6.19	16.71	7.91	21.18	20.24	35.84	14.57	20	4.71	29.68
U19	Amrita Vishwa Vidyapeetham	18	30	18.21	10.22	23.06	21.55	8	1.94	10.21	2.28	17.66	21.95	33.77	15	20	5.44	34.36
U20	Thapar Institute of Engineering and Technology	17.16	26.57	15.41	11.81	21.75	30.02	9	0.69	15	9.28	17.31	24.97	10.79	15	20	0.79	31.32
U21	National Institute of Technology Warangal	16.5	24.79	16.34	14.95	20.81	21.81	7	1.23	17.42	9.18	15.94	16.52	34.99	15	20	4.73	32.81
U22	Indian Institute of Technology Ropar	11.05	28.28	18.13	19.81	17.96	18.73	4	3.84	18.96	5.54	22.29	14.74	32.7	15	20	7.91	31.57

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U23	National Institute of Technology Calicut	16	27.3	17.41	13.33	17.11	17.44	5	1.27	16.24	10.21	15.32	22.89	33.06	15	20	9.76	37.17
U24	Institute of Chemical Technology	10.82	26.74	18.02	17.36	17.54	19.84	14	4.93	13.54	9.7	7.65	24.91	17.57	15	20	1.1	30.76
U25	Birla Institute of Technology & Science -Pilani	18.84	20.2	13.36	11.77	21.38	26.68	4	0.81	19.66	6.76	19.93	14.43	32.88	15	20	0.02	36.98
U26	Jamia Millia Islamia,New Delhi	10.5	26.85	14.78	9.77	26.86	26.71	3	3.03	13.02	7.35	22.91	11.78	18.34	15	20	9.16	37.84
U27	Siksha Anusandhan	17.36	30	15.42	13.74	16.01	19.12	8	1	9.54	8.31	20.88	30	24.07	15	20	1.3	32.61
U28	S.R.M. Institute of Science and Technology	17.55	23.15	13.16	9.93	24.14	29.73	6	0.31	9.54	7.82	18.31	22.49	22.01	14.81	20	0.8	32.83
U29	Delhi Technological University	18.9	30	11.96	9.57	18.33	21.47	0.5	0.83	17.44	5.09	14.24	19.6	43.22	15	20	3.19	36.74
U30	Indian Institute of Technology Jodhpur	11.04	30	18.58	21.34	15.51	16.58	1.5	4.64	18.42	3.97	19.01	20.42	11.7	15	20	5.42	35.69
U31	Amity University	15.5	27.54	14.73	8.52	24.9	24.96	11	0.61	10.18	5.73	15.99	23.28	13.75	15	20	0.16	27.37
U32	Aligarh Muslim University	11	30	16.17	12.9	24.95	25.86	7	2.03	11.43	5.66	5.38	11.59	24.51	12.61	20	3.23	29.42
U33	Indian Institute of Technology Mandi	9.24	22.26	15.21	15.92	17.72	18.13	4	2.62	21.25	7.45	20.74	16.29	24.73	13.57	20	9.31	37.04
U34	Shanmugha Arts Science Technology & Research Academy	16.47	30	16.75	10.82	16.25	20.99	5	1.9	12.41	6.82	11.72	25.81	11.4	15	20	0.44	34.85
U35	Indian Institute of Engineering Science and Technology, Shibpu	13.44	22.64	14.55	12.83	20.81	20.29	3	1.58	13.52	10.72	11.94	17.14	31.97	14.88	20	9.83	32.35
U36	Kalasalingam Academy of Research and Education	16.47	30	17.59	10.07	13.85	17.78	4	0.6	10.62	8	17.53	30	13.46	15	20	7.8	34.88
U37	Malaviya National Institute of Technology	15.25	23.51	15.72	11.22	21.18	23.22	5	1.86	14.4	8.08	12.94	19.12	11.7	15	20	7.5	29.41
U38	Chandigarh University	18.95	30	16.64	10.11	8.41	13.28	9	0.35	12.56	7.94	25	30	33.77	15	20	4.56	23.69
U39	Kalinga Institute of Industrial Technology	20	25.27	15.82	11.51	13.84	18.03	10	0.46	11.15	10.44	25.66	29.86	14.59	15	20	1.86	20.69
U40	National Institute of Technology Silchar	13.34	21.04	14.23	12.25	22.65	23.74	7	1.19	14.72	6.79	14	15.33	11.4	15	20	4.02	33.26
U41	Indian Institute of Technology Patna	10.99	17.84	11.84	16.27	22.35	22.3	3	3.75	19.77	8.34	18.76	10.37	24.73	13.68	20	7.02	30.46
U42	Visvesvaraya NIT, Nagpur	14.04	22.45	15.13	13.51	17.12	17.29	10	2.62	15.58	7.12	12.63	17.29	14.88	15	20	3.48	35.07
U43	National Institute of Technology Durgapur	14.42	22.14	14.27	13.11	18.64	19.06	2	1.62	13.99	9.38	14.54	13.1	19.1	15	20	8.16	35.84
U44	K L E F, Andra Pradesh	17.43	30	17.2	6.3	19.9	19.87	6	0.37	11.36	7.29	10.15	25.8	13.46	15	20	0.48	24.27
U45	Sri Sivasubramaniya Nadar College of Engineering	12.5	28.32	16.13	10.73	18.75	18.42	3	0.91	12.25	6.22	3.89	25.52	15.43	15	20	3.81	33.47
U46	Dr. B R Ambedkar NIT, Jalandhar	15.59	29.21	13.96	9.23	14.88	18.38	3	0.5	13.59	6.44	14.24	25.14	24.73	15	20	8.38	25.83
U47	Indian Institute of Technology Bhubaneswar	10.95	20.18	13.92	15.3	15.66	16.86	2	2.82	19.01	6.41	21.19	10	24.95	15	20	6.48	33.73
U48	Indian Institute of Space Science and Technology	7.19	30	16.85	19.03	11.1	10.45	2	0.89	16.27	2.95	19.62	17.72	39.39	13.86	20	4.38	30.33
U49	Motilal Nehru National Institute of Technology	16.01	16.61	11.34	13.18	16.27	18.2	4	1.9	16.84	9	12.93	12.04	16.51	15	20	9.82	36.73
U50	Lovely Professional University	18	23.53	12.72	5.39	14.69	21.73	13	0.1	11.19	2.79	24.43	19.08	25.39	15	20	0	20.21

APPENDIX II

Detailed DMU rankings

Table-II.1. Model- M1

Input(1) = FQE Input(2) = FRU Input(3) = RD Input(4) = WD Input(5) = PR

Output(1) = GMS

No.	DMU	Score	Rank		Reference(Lambda)								
1	U01	0.758	47	U10	0.061	U15	0.938						
2	U02	0.8249	39	U04	0.354	U07	0.177	U15	0.469				
3	U03	0.8101	42	U10	0.075	U13	0.002	U15	0.874	U32	0.048		
4	U04	1	1	U04	1								
5	U05	0.8822	36	U07	0.28	U15	0.719	U41	0.001				
6	U06	0.974	26	U07	0.034	U15	0.962	U25	0.004				
7	U07	1	1	U07	1								
8	U08	1	1	U08	1								
9	U09	0.7454	48	U13	0.116	U15	0.207	U29	0.103	U49	0.574		
10	U10	1	1	U10	1								
11	U11	0.9714	27	U29	0.347	U44	0.126	U50	0.527				
12	U12	0.7972	43	U07	0.006	U49	0.994						
13	U13	1	1	U13	1								
14	U14	0.9788	25	U30	0.019	U33	0.49	U41	0.457	U49	0.034		
15	U15	1	1	U15	1								
16	U16	0.888	35	U26	0.21	U32	0.151	U40	0.267	U49	0.372		
17	U17	0.987	24	U15	0.195	U32	0.09	U47	0.715				
18	U18	0.5969	50	U13	0.011	U15	0.05	U32	0.045	U49	0.894		
19	U19	0.8144	40	U13	0.021	U32	0.354	U44	0.196	U50	0.429		
20	U20	1	1	U20	1								
21	U21	0.8337	38	U10	0.079	U15	0.155	U29	0.203	U49	0.562		
22	U22	0.7584	46	U15	0.083	U25	0.027	U33	0.034	U41	0.55	U49	0.307
23	U23	0.8113	41	U10	0.187	U25	0.13	U29	0.19	U44	0.167	U49	0.326

24	U24	0.8781	37	U30	0.021	U40	0.043	U45	0.706	U49	0.23		
25	U25	1	1	U25	1								
26	U26	1	1	U26	1								
27	U27	0.7778	44	U31	0.066	U44	0.009	U49	0.652	U50	0.273		
28	U28	0.9427	30	U13	0.017	U44	0.079	U49	0.491	U50	0.413		
29	U29	1	1	U29	1								
30	U30	1	1	U30	1								
31	U31	1	1	U31	1								
32	U32	1	1	U32	1								
33	U33	1	1	U33	1								
34	U34	1	1	U34	1								
35	U35	0.8916	34	U13	0.177	U32	0.231	U49	0.45	U50	0.143		
36	U36	0.9108	32	U20	0.465	U31	0.14	U44	0.395				
37	U37	1	1	U37	1								
38	U38	0.7607	45	U13	0.077	U44	0.054	U49	0.243	U50	0.625		
39	U39	0.8994	33	U31	0.532	U40	0.376	U49	0.092				
40	U40	1	1	U40	1								
41	U41	1	1	U41	1								
42	U42	0.968	28	U30	0.096	U37	0.224	U40	0.079	U45	0.152	U49	0.449
43	U43	0.9377	31	U26	0.211	U32	0.202	U40	0.117	U49	0.47		
44	U44	1	1	U44	1								
45	U45	1	1	U45	1								
46	U46	0.9673	29	U13	0.09	U29	0.069	U44	0.28	U49	0.332	U50	0.229
47	U47	1	1	U47	1								
48	U48	0.6822	49	U26	0.038	U32	0.003	U49	0.951	U50	0.009		
49	U49	1	1	U49	1								
50	U50	1	1	U50	1								

Table-II.2. Model- M2

Input(1) = FQE Input(2) = FRU Input(3) = RD Input(4) = WD Input(5) = PR
Output(1) = PU

No.	DMU	Score	Rank		Reference(Lambda)										
1	U01	1	1	U01	1										
2	U02	1	1	U02	1										
3	U03	0.9469	30	U01	0.34	U06	0.529	U13	0.062	U32	0.069				
4	U04	0.924	33	U06	0.693	U15	0.279	U32	0.028						
5	U05	0.9505	28	U01	0.124	U06	0.471	U17	0.083	U26	0.322				
6	U06	1	1	U06	1										
7	U07	1	1	U07	1										
8	U08	0.7434	47	U06	0.011	U07	0.06	U13	0.048	U15	0.559	U32	0.323		
9	U09	0.7795	42	U07	0.368	U11	0.02	U13	0.333	U15	0.126	U49	0.153		
10	U10	1	1	U10	1										
11	U11	1	1	U11	1										
12	U12	0.8484	38	U07	0.223	U13	0.187	U15	0.192	U41	0.104	U49	0.295		
13	U13	1	1	U13	1										
14	U14	0.8402	39	U26	0.569	U32	0.312	U41	0.089	U49	0.03				
15	U15	1	1	U15	1										
16	U16	1	1	U16	1										
17	U17	1	1	U17	1										
18	U18	0.604	50	U13	0.034	U15	0.065	U32	0.054	U41	0.076	U49	0.771		
19	U19	0.837	40	U11	0.211	U26	0.155	U32	0.25	U44	0.255	U50	0.129		
20	U20	1	1	U20	1										
21	U21	0.8008	41	U13	0.085	U26	0.194	U32	0.184	U49	0.509	U50	0.029		
22	U22	0.7323	48	U15	0.041	U32	0.147	U41	0.131	U47	0.434	U49	0.247		
23	U23	0.7659	45	U13	0.147	U32	0.095	U44	0.18	U49	0.42	U50	0.159		

24	U24	0.8673	37	U32	0.091	U40	0.254	U45	0.651	U49	0.005				
25	U25	0.948	29	U07	0.089	U11	0.091	U15	0.184	U26	0.185	U49	0.282	U50	0.168
26	U26	1	1	U26	1										
27	U27	0.7778	43	U31	0.066	U44	0.009	U49	0.652	U50	0.273				
28	U28	1	1	U28	1										
29	U29	1	1	U29	1										
30	U30	0.9521	27	U20	0.427	U40	0.573								
31	U31	1	1	U31	1										
32	U32	1	1	U32	1										
33	U33	0.7757	44	U07	0.045	U11	0.01	U26	0.087	U49	0.781	U50	0.079		
34	U34	1	1	U34	1										
35	U35	0.8963	36	U13	0.197	U26	0.06	U31	0.015	U32	0.199	U49	0.437	U50	0.092
36	U36	0.9108	34	U20	0.465	U31	0.14	U44	0.395						
37	U37	1	1	U37	1										
38	U38	0.7607	46	U13	0.077	U44	0.054	U49	0.243	U50	0.625				
39	U39	0.8994	35	U31	0.532	U40	0.376	U49	0.092						
40	U40	1	1	U40	1										
41	U41	1	1	U41	1										
42	U42	0.9279	32	U32	0.055	U40	0.582	U45	0.157	U49	0.206				
43	U43	0.9377	31	U26	0.211	U32	0.202	U40	0.117	U49	0.47				
44	U44	1	1	U44	1										
45	U45	1	1	U45	1										
46	U46	0.9656	26	U13	0.119	U44	0.266	U49	0.351	U50	0.264				
47	U47	1	1	U47	1										
48	U48	0.6822	49	U26	0.038	U32	0.003	U49	0.951	U50	0.009				
49	U49	1	1	U49	1										
50	U50	1	1	U50	1										

Table-II.3. Model- M3

Input(1) = FQE Input(2) = FRU Input(3) = WD Input(4) = PR

Output(1) = FPPP

No.	DMU	Score	Rank		Reference(Lambda)						
1	U01	1	1	U01	1						
2	U02	0.8832	36	U01	0.14	U03	0.565	U07	0.294		
3	U03	1	1	U03	1						
4	U04	1	1	U04	1						
5	U05	0.9181	29	U04	0.008	U07	0.585	U41	0.407		
6	U06	0.9692	23	U15	0.997	U26	0.003				
7	U07	1	1	U07	1						
8	U08	0.7681	45	U01	0.232	U07	0.223	U26	0.263	U41	0.282
9	U09	0.7373	48	U07	0.197	U49	0.642	U50	0.16		
10	U10	0.8472	38	U26	0.959	U50	0.041				
11	U11	0.9163	30	U29	0.28	U50	0.72				
12	U12	0.8193	40	U07	0.475	U49	0.525				
13	U13	0.9563	24	U07	0.362	U26	0.055	U50	0.583		
14	U14	0.9499	25	U01	0.043	U26	0.246	U30	0.223	U41	0.488
15	U15	1	1	U15	1						
16	U16	0.8658	37	U26	0.341	U40	0.159	U49	0.5		
17	U17	0.9798	21	U15	0.195	U26	0.039	U47	0.766		
18	U18	1	1	U18	1						
19	U19	0.7965	42	U26	0.628	U50	0.372				
20	U20	1	1	U20	1						
21	U21	0.7645	46	U26	0.297	U49	0.608	U50	0.095		
22	U22	0.7721	44	U01	0.038	U26	0.265	U30	0.049	U41	0.648
23	U23	0.7016	49	U07	0.065	U26	0.042	U49	0.395	U50	0.498
24	U24	1	1	U24	1						
25	U25	0.926	28	U26	0.221	U49	0.583	U50	0.196		
26	U26	1	1	U26	1						
27	U27	0.7774	43	U31	0.08	U49	0.647	U50	0.273		

28	U28	0.9289	27	U31	0.071	U49	0.463	U50	0.465		
29	U29	1	1	U29	1						
30	U30	1	1	U30	1						
31	U31	1	1	U31	1						
32	U32	0.9476	26	U15	0.066	U26	0.544	U47	0.39		
33	U33	0.8094	41	U07	0.06	U26	0.253	U41	0.125	U49	0.563
34	U34	1	1	U34	1						
35	U35	0.8286	39	U07	0.048	U26	0.073	U49	0.565	U50	0.314
36	U36	0.9109	31	U20	0.367	U31	0.071	U40	0.117	U44	0.446
37	U37	1	1	U37	1						
38	U38	0.7418	47	U29	0.092	U49	0.222	U50	0.687		
39	U39	0.8994	33	U31	0.532	U40	0.376	U49	0.092		
40	U40	1	1	U40	1						
41	U41	1	1	U41	1						
42	U42	0.9772	22	U26	0.226	U30	0.174	U37	0.321	U49	0.279
43	U43	0.9088	32	U26	0.382	U47	0.018	U49	0.6		
44	U44	1	1	U44	1						
45	U45	0.891	34	U31	0.728	U37	0.085	U40	0.068	U49	0.12
46	U46	0.8842	35	U31	0.045	U49	0.338	U50	0.617		
47	U47	1	1	U47	1						
48	U48	0.682	50	U26	0.041	U49	0.951	U50	0.008		
49	U49	1	1	U49	1						
50	U50	1	1	U50	1						

Table-II.4. Model- M4

Input(1) = SS Input(2) = FRU Input(3) = WD

Output(1) = GPHD

No.	DMU	Score	Rank		Reference(Lambda)						
1	U01	0.8664	29	U06	0.68	U14	0.32				
2	U02	0.8689	28	U06	0.678	U14	0.322				
3	U03	0.8845	22	U06	0.724	U14	0.276				
4	U04	0.9153	18	U06	0.707	U47	0.293				
5	U05	0.884	23	U06	0.614	U14	0.027	U41	0.359		
6	U06	1	1	U06	1						
7	U07	0.9101	20	U06	0.604	U15	0.194	U47	0.202		
8	U08	0.8287	32	U14	0.224	U33	0.276	U41	0.501		
9	U09	0.7377	47	U06	0.332	U26	0.485	U33	0.183		
10	U10	0.8744	26	U06	0.198	U11	0.326	U26	0.476		
11	U11	1	1	U11	1						
12	U12	0.7289	48	U06	0.265	U14	0.282	U26	0.362	U41	0.092
13	U13	0.9163	17	U06	0.129	U11	0.483	U26	0.388		
14	U14	1	1	U14	1						
15	U15	1	1	U15	1						
16	U16	0.8186	34	U06	0.315	U11	0.04	U26	0.645		
17	U17	0.988	13	U06	0.315	U15	0.103	U47	0.581		
18	U18	0.9556	15	U14	0.192	U33	0.807				
19	U19	0.767	43	U26	0.559	U50	0.441				
20	U20	0.7676	42	U06	0.004	U11	0.278	U26	0.718		
21	U21	0.7053	49	U06	0.145	U26	0.846	U33	0.01		
22	U22	0.8701	27	U41	0.189	U47	0.454	U48	0.357		
23	U23	0.7905	38	U06	0.19	U11	0.067	U26	0.743		
24	U24	0.9967	12	U14	0.941	U33	0.059				
25	U25	0.8243	33	U26	0.984	U50	0.016				
26	U26	1	1	U26	1						
27	U27	0.6835	50	U11	0.142	U26	0.856	U44	0.002		

28	U28	0.8126	35	U11	0.094	U26	0.495	U44	0.379	U50	0.032
29	U29	0.7901	39	U11	0.004	U26	0.494	U50	0.502		
30	U30	0.7593	44	U26	0.275	U47	0.075	U48	0.65		
31	U31	0.9094	21	U26	0.51	U44	0.136	U50	0.353		
32	U32	0.9639	14	U26	0.537	U47	0.435	U48	0.028		
33	U33	1	1	U33	1						
34	U34	0.7844	40	U26	0.66	U44	0.227	U50	0.113		
35	U35	0.926	16	U06	0.265	U26	0.605	U33	0.13		
36	U36	0.832	31	U11	0.099	U26	0.574	U44	0.326		
37	U37	0.8094	36	U11	0.109	U26	0.774	U44	0.116		
38	U38	0.7768	41	U11	0.092	U26	0.425	U44	0.483		
39	U39	0.7438	45	U11	0.457	U26	0.538	U44	0.005		
40	U40	0.7935	37	U26	0.989	U50	0.011				
41	U41	1	1	U41	1						
42	U42	0.7415	46	U26	0.973	U48	0.027				
43	U43	0.8629	30	U06	0.109	U15	0.168	U26	0.678	U47	0.045
44	U44	1	1	U44	1						
45	U45	0.882	24	U26	0.93	U50	0.07				
46	U46	0.8749	25	U26	0.563	U44	0.241	U50	0.196		
47	U47	1	1	U47	1						
48	U48	1	1	U48	1						
49	U49	0.9132	19	U15	0.503	U26	0.497				
50	U50	1	1	U50	1						

Table-II.5. Model- M5

Input(1) = SS Input(2) = FQE Input(3) = WD

Output(1) = PR

No.	DMU	Score	Rank		Reference(Lambda)						
1	U01	1	1	U01	1						
2	U02	0.9821	11	U01	0.88	U13	0.076	U41	0.044		
3	U03	0.9723	15	U01	0.545	U06	0.352	U13	0.041	U41	0.061
4	U04	0.9735	13	U01	0.149	U06	0.791	U47	0.06		
5	U05	0.8957	22	U01	0.082	U06	0.559	U41	0.181	U47	0.178
6	U06	1	1	U06	1						
7	U07	1	1	U07	1						
8	U08	0.9672	16	U01	0.385	U47	0.185	U48	0.431		
9	U09	0.9152	19	U01	0.423	U13	0.281	U41	0.297		
10	U10	0.6791	48	U01	0.136	U41	0.804	U48	0.06		
11	U11	0.8869	23	U07	0.666	U15	0.3	U41	0.033		
12	U12	0.8742	27	U06	0.018	U13	0.265	U15	0.417	U41	0.3
13	U13	1	1	U13	1						
14	U14	0.8986	21	U47	0.688	U48	0.312				
15	U15	1	1	U15	1						
16	U16	0.7144	45	U15	0.261	U41	0.64	U47	0.1		
17	U17	0.9734	14	U15	0.208	U47	0.792				
18	U18	0.8061	34	U41	0.229	U48	0.771				
19	U19	0.6762	49	U01	0.06	U13	0.11	U41	0.829		
20	U20	0.7556	39	U41	0.606	U49	0.394				
21	U21	0.7536	40	U01	0.04	U06	0.039	U13	0.129	U41	0.792
22	U22	0.884	24	U01	0.031	U47	0.593	U48	0.376		
23	U23	0.7246	43	U01	0.102	U41	0.854	U48	0.043		
24	U24	0.8155	32	U41	0.43	U48	0.57				
25	U25	0.8764	25	U07	0.457	U41	0.126	U49	0.417		
26	U26	0.9748	12	U41	0.034	U47	0.776	U48	0.19		

27	U27	0.7584	38	U07	0.077	U41	0.605	U49	0.318		
28	U28	0.8749	26	U07	0.118	U41	0.189	U49	0.693		
29	U29	0.9927	10	U07	0.795	U49	0.205				
30	U30	0.7946	36	U41	0.416	U48	0.584				
31	U31	0.7948	35	U41	0.735	U49	0.265				
32	U32	0.9505	18	U47	0.868	U48	0.132				
33	U33	0.9612	17	U41	0.445	U48	0.555				
34	U34	0.7033	46	U41	0.882	U49	0.118				
35	U35	0.8587	28	U01	0.09	U41	0.878	U48	0.033		
36	U36	0.6726	50	U41	0.982	U49	0.018				
37	U37	0.7503	41	U41	0.91	U49	0.09				
38	U38	0.7159	44	U07	0.314	U15	0.038	U41	0.648		
39	U39	0.7262	42	U41	0.296	U49	0.704				
40	U40	0.8313	30	U41	0.98	U49	0.02				
41	U41	1	1	U41	1						
42	U42	0.7827	37	U41	1						
43	U43	0.8235	31	U41	0.824	U49	0.176				
44	U44	0.6831	47	U41	0.818	U49	0.182				
45	U45	0.8074	33	U41	0.764	U48	0.236				
46	U46	0.8392	29	U07	0.091	U41	0.628	U49	0.281		
47	U47	1	1	U47	1						
48	U48	1	1	U48	1						
49	U49	1	1	U49	1						
50	U50	0.907	20	U07	0.25	U41	0.061	U49	0.69		

Table-II.6. **Model- M6**

Input(1) = SS Input(2) = FQE Input(3) = FRU Input(4) = WD Input(5) = PR

Output(1) = IPR Output(2) = GMS Output(3) = PU Output(4) = GPHD

No.	DMU	Score	Rank		Reference(Lambda)												
1	U01	1	1	U01	1												
2	U02	1	1	U02	1												
3	U03	1	1	U03	1												
4	U04	1	1	U04	1												
5	U05	0.9965	36	U01	0.12	U03	0.069	U04	0.017	U06	0.145	U07	0.529	U14	0.064	U26	0.057
6	U06	1	1	U06	1												
7	U07	1	1	U07	1												
8	U08	1	1	U08	0.999												
9	U09	0.8102	49	U06	0.189	U07	0.011	U13	0.263	U26	0.085	U41	0.452				
10	U10	1	1	U10	1												
11	U11	1	1	U11	1												
12	U12	0.8368	47	U06	0.015	U07	0.392	U11	0.01	U41	0.482	U49	0.101				
13	U13	1	1	U13	1												
14	U14	1	1	U14	1												
15	U15	1	1	U15	1												
16	U16	1	1	U16	1												
17	U17	1	1	U17	1												
18	U18	0.9556	42	U14	0.192	U33	0.807										
19	U19	0.7934	50	U11	0.068	U26	0.445	U31	0.208	U50	0.279						
20	U20	1	1	U20	1												
21	U21	0.8451	46	U07	0.297	U20	0.004	U26	0.259	U33	0.216	U40	0.071	U49	0.014	U50	0.139
22	U22	0.9112	43	U32	0.154	U33	0.429	U41	0.372	U48	0.045						

23	U23	0.8812	44	U06	0.017	U07	0.321	U26	0.473	U33	0.05	U44	0.139				
24	U24	1	1	U24	1												
25	U25	1	1	U25	1												
26	U26	1	1	U26	1												
27	U27	0.866	45	U07	0.06	U11	0.059	U24	0.058	U31	0.402	U41	0.169	U49	0.251		
28	U28	1	1	U28	1												
29	U29	1	1	U29	1												
30	U30	1	1	U30	1												
31	U31	1	1	U31	1												
32	U32	1	1	U32	1												
33	U33	1	1	U33	1												
34	U34	1	1	U34	1												
35	U35	0.9779	39	U06	0.224	U24	0.097	U26	0.467	U41	0.068	U49	0.144				
36	U36	0.9565	41	U20	0.214	U26	0.123	U37	0.351	U44	0.312						
37	U37	1	1	U37	1												
38	U38	0.8302	48	U11	0.269	U24	0.006	U26	0.232	U31	0.198	U41	0.075	U50	0.219		
39	U39	1	1	U39	1												
40	U40	1	1	U40	1												
41	U41	1	1	U41	1												
42	U42	1	1	U42	1												
43	U43	0.9939	37	U06	0.007	U16	0.287	U24	0.043	U26	0.244	U41	0.11	U49	0.308		
44	U44	1	1	U44	1												
45	U45	0.9785	38	U26	0.509	U40	0.409	U44	0.082								
46	U46	0.9607	40	U11	0.057	U25	0.072	U26	0.392	U29	0.024	U49	0.142	U50	0.314		
47	U47	1	1	U47	1												
48	U48	1	1	U48	1												
49	U49	1	1	U49	1												
50	U50	1	1	U50	1												

Table-II.7. **Model- M7**

Input(1) = SS Input(2) = FQE Input(3) = FRU Input(4) = RD Input(5) = WD Input(6) = PR

Output(1) = QP Output(2) = IPR Output(3) = GMS Output(4) = GPHD

No.	DMU	Score	Rank		Reference(Lambda)																
1	U01	1	1	U01	1																
2	U02	1	1	U02	1																
3	U03	1	1	U03	1																
4	U04	1	1	U04	1																
5	U05	1	1	U05	1																
6	U06	1	1	U06	1																
7	U07	1	1	U07	1																
8	U08	1	1	U08	1																
9	U09	0.8137	50	U06	0.174	U13	0.275	U26	0.03	U33	0.012	U35	0.072	U41	0.437						
10	U10	1	1	U10	1																
11	U11	1	1	U11	1																
12	U12	0.8632	47	U06	0.101	U07	0.137	U13	0.219	U41	0.366	U49	0.176								
13	U13	1	1	U13	1																
14	U14	1	1	U14	1																
15	U15	1	1	U15	1																
16	U16	1	1	U16	1																
17	U17	1	1	U17	1																
18	U18	0.9557	42	U14	0.166	U24	0.028	U33	0.806												
19	U19	0.8261	49	U13	0.065	U26	0.177	U32	0.233	U44	0.251	U50	0.273								
20	U20	1	1	U20	1																
21	U21	0.8924	45	U06	0.008	U10	0.133	U13	0.013	U15	0.304	U32	0.014	U33	0.115	U40	0.19	U42	0.211	U50	0.013
22	U22	0.9112	43	U32	0.154	U33	0.429	U41	0.372	U48	0.045										

23	U23	0.903	44	U06	0.07	U10	0.321	U11	0.045	U24	0.003	U26	0.178	U33	0.154	U45	0.086	U49	0.143		
24	U24	1	1	U24	1																
25	U25	1	1	U25	1																
26	U26	1	1	U26	1																
27	U27	0.866	46	U07	0.06	U11	0.059	U24	0.058	U31	0.402	U41	0.169	U49	0.251						
28	U28	1	1	U28	1																
29	U29	1	1	U29	1																
30	U30	1	1	U30	1																
31	U31	1	1	U31	1																
32	U32	1	1	U32	1																
33	U33	1	1	U33	1																
34	U34	1	1	U34	1																
35	U35	1	1	U35	1																
36	U36	0.9565	41	U20	0.214	U26	0.123	U37	0.351	U44	0.312										
37	U37	1	1	U37	1																
38	U38	0.8302	48	U11	0.269	U24	0.006	U26	0.232	U31	0.198	U41	0.075	U50	0.219						
39	U39	1	1	U39	1																
40	U40	1	1	U40	1																
41	U41	1	1	U41	1																
42	U42	1	1	U42	1																
43	U43	1	1	U43	1																
44	U44	1	1	U44	1																
45	U45	1	1	U45	1																
46	U46	0.9979	40	U13	0.048	U26	0.166	U29	0.171	U44	0.125	U45	0.179	U49	0.14	U50	0.171				
47	U47	1	1	U47	1																
48	U48	1	1	U48	1																
49	U49	1	1	U49	1																
50	U50	1	1	U50	1																

Table-II.8. Model- M8

Input(1) = FQE Input(2) = FRU Input(3) = RD Input(4) = WD Input(5) = PR

Output(1) = PU Output(2) = GMS

No.	DMU	Score	Rank		Reference(Lambda)										
1	U01	1	1	U01	1										
2	U02	1	1	U02	1										
3	U03	0.9552	35	U01	0.288	U06	0.584	U10	0.088	U13	0.041				
4	U04	1	1	U04	1										
5	U05	0.9694	32	U01	0.128	U06	0.156	U07	0.609	U17	0.042	U26	0.065		
6	U06	1	1	U06	1										
7	U07	1	1	U07	1										
8	U08	1	1	U08	1										
9	U09	0.7795	45	U07	0.368	U11	0.02	U13	0.333	U15	0.126	U49	0.153		
10	U10	1	1	U10	1										
11	U11	1	1	U11	1										
12	U12	0.8484	41	U07	0.223	U13	0.187	U15	0.192	U41	0.104	U49	0.295		
13	U13	1	1	U13	1										
14	U14	1	1	U14	1										
15	U15	1	1	U15	1										
16	U16	1	1	U16	1										
17	U17	1	1	U17	1										
18	U18	0.604	50	U13	0.034	U15	0.065	U32	0.054	U41	0.076	U49	0.771		
19	U19	0.837	42	U11	0.211	U26	0.155	U32	0.25	U44	0.255	U50	0.129		
20	U20	1	1	U20	1										
21	U21	0.8343	43	U10	0.216	U15	0.134	U25	0.133	U26	0.024	U29	0.05	U49	0.442
22	U22	0.7584	48	U15	0.083	U25	0.027	U33	0.034	U41	0.55	U49	0.307		
23	U23	0.8113	44	U10	0.187	U25	0.13	U29	0.19	U44	0.167	U49	0.326		
24	U24	0.8781	40	U30	0.021	U40	0.043	U45	0.706	U49	0.23				

25	U25	1	1	U25	1										
26	U26	1	1	U26	1										
27	U27	0.7778	46	U31	0.066	U44	0.009	U49	0.652	U50	0.273				
28	U28	1	1	U28	1										
29	U29	1	1	U29	1										
30	U30	1	1	U30	1										
31	U31	1	1	U31	1										
32	U32	1	1	U32	1										
33	U33	1	1	U33	1										
34	U34	1	1	U34	1										
35	U35	0.8963	39	U13	0.197	U26	0.06	U31	0.015	U32	0.199	U49	0.437	U50	0.092
36	U36	0.9108	37	U20	0.465	U31	0.14	U44	0.395						
37	U37	1	1	U37	1										
38	U38	0.7607	47	U13	0.077	U44	0.054	U49	0.243	U50	0.625				
39	U39	0.8994	38	U31	0.532	U40	0.376	U49	0.092						
40	U40	1	1	U40	1										
41	U41	1	1	U41	1										
42	U42	0.968	33	U30	0.096	U37	0.224	U40	0.079	U45	0.152	U49	0.449		
43	U43	0.9377	36	U26	0.211	U32	0.202	U40	0.117	U49	0.47				
44	U44	1	1	U44	1										
45	U45	1	1	U45	1										
46	U46	0.9673	34	U13	0.09	U29	0.069	U44	0.28	U49	0.332	U50	0.229		
47	U47	1	1	U47	1										
48	U48	0.6822	49	U26	0.038	U32	0.003	U49	0.951	U50	0.009				
49	U49	1	1	U49	1										
50	U50	1	1	U50	1										

Table-II.9. Model- M9

Input(1) = FQE Input(2) = FRU Input(3) = WD Input(4) = PR

Output(1) = IPR

No.	DMU	Score	Rank		Reference(Lambda)								
1	U01	0.9539	22	U03	1								
2	U02	0.9437	25	U03	1								
3	U03	1	1	U03	1								
4	U04	1	1	U04	1								
5	U05	0.94	26	U04	0.105	U06	0.111	U07	0.734	U15	0.05		
6	U06	1	1	U06	1								
7	U07	1	1	U07	1								
8	U08	0.7021	47	U04	0.042	U07	0.523	U15	0.069	U41	0.045	U47	0.322
9	U09	0.7324	45	U07	0.121	U49	0.737	U50	0.141				
10	U10	0.7665	42	U06	0.031	U26	0.685	U50	0.285				
11	U11	0.9165	30	U29	0.084	U49	0.105	U50	0.811				
12	U12	0.8126	38	U07	0.333	U49	0.667						
13	U13	0.9493	24	U07	0.333	U50	0.667						
14	U14	0.841	36	U32	0.412	U47	0.118	U49	0.47				
15	U15	1	1	U15	1								
16	U16	0.9114	31	U26	0.072	U32	0.31	U40	0.38	U49	0.238		
17	U17	1	1	U17	1								
18	U18	0.5851	50	U41	0.118	U49	0.882						
19	U19	0.7314	46	U26	0.341	U49	0.076	U50	0.583				
20	U20	1	1	U20	1								
21	U21	0.7867	40	U07	0.256	U26	0.246	U32	0.054	U49	0.272	U50	0.172
22	U22	0.7357	44	U15	0.006	U26	0.126	U32	0.25	U41	0.597	U47	0.02
23	U23	0.6916	48	U29	0.049	U49	0.465	U50	0.486				

24	U24	1	1	U24	1								
25	U25	0.926	28	U26	0.221	U49	0.583	U50	0.196				
26	U26	1	1	U26	1								
27	U27	0.7955	39	U31	0.135	U49	0.525	U50	0.339				
28	U28	0.9289	27	U31	0.071	U49	0.463	U50	0.465				
29	U29	1	1	U29	1								
30	U30	0.9521	23	U20	0.427	U40	0.573						
31	U31	1	1	U31	1								
32	U32	1	1	U32	1								
33	U33	0.7716	41	U26	0.084	U49	0.838	U50	0.078				
34	U34	0.9922	21	U20	0.805	U44	0.195						
35	U35	0.8251	37	U26	0.072	U49	0.626	U50	0.301				
36	U36	0.9108	32	U20	0.465	U31	0.14	U44	0.395				
37	U37	0.994	20	U20	0.197	U40	0.633	U44	0.17				
38	U38	0.7418	43	U29	0.092	U49	0.222	U50	0.687				
39	U39	0.9179	29	U31	0.775	U40	0.192	U49	0.033				
40	U40	1	1	U40	1								
41	U41	1	1	U41	1								
42	U42	1	1	U42	1								
43	U43	0.9088	33	U26	0.382	U47	0.018	U49	0.6				
44	U44	1	1	U44	1								
45	U45	0.8875	34	U31	0.756	U40	0.142	U49	0.101				
46	U46	0.8842	35	U31	0.045	U49	0.338	U50	0.617				
47	U47	1	1	U47	1								
48	U48	0.682	49	U26	0.041	U49	0.951	U50	0.008				
49	U49	1	1	U49	1								
50	U50	1	1	U50	1								

Table-II.10. Model- M10

Input(1) = FQE Input(2) = FRU Input(3) = WD

Output(1) = QP Output(2) = IPR Output(3) = GMS Output(4) = PR

No.	DMU	Score	Rank		Reference(Lambda)						
1	U01	1	1	U01	1						
2	U02	1	1	U02	1						
3	U03	1	1	U03	1						
4	U04	1	1	U04	1						
5	U05	0.9385	20	U03	0.1	U04	0.097	U06	0.443	U07	0.361
6	U06	1	1	U06	1						
7	U07	1	1	U07	1						
8	U08	0.7054	46	U04	0.032	U06	0.332	U07	0.427	U15	0.209
9	U09	0.8447	28	U06	0.454	U07	0.134	U13	0.412		
10	U10	0.8655	26	U06	0.333	U11	0.078	U25	0.182	U50	0.407
11	U11	1	1	U11	1						
12	U12	0.8417	29	U07	0.931	U29	0.023	U49	0.046		
13	U13	1	1	U13	1						
14	U14	0.8125	34	U07	0.123	U15	0.674	U25	0.203		
15	U15	1	1	U15	1						
16	U16	0.8309	31	U06	0.368	U15	0.054	U26	0.478	U50	0.1
17	U17	0.9984	17	U06	0.253	U15	0.747				
18	U18	0.6042	50	U07	0.358	U15	0.135	U29	0.088	U49	0.419
19	U19	0.7532	41	U06	0.186	U26	0.132	U50	0.682		
20	U20	0.8264	32	U07	0.267	U11	0.38	U29	0.195	U50	0.158
21	U21	0.7741	37	U15	0.633	U25	0.043	U26	0.066	U50	0.258
22	U22	0.7019	48	U15	0.919	U26	0.081				
23	U23	0.7175	44	U15	0.253	U25	0.12	U29	0.278	U50	0.349

24	U24	0.7994	36	U03	0.5	U50	0.5				
25	U25	1	1	U25	1						
26	U26	1	1	U26	1						
27	U27	0.774	38	U07	0.12	U29	0.01	U49	0.502	U50	0.369
28	U28	0.9646	19	U07	0.157	U11	0.43	U29	0.413		
29	U29	1	1	U29	1						
30	U30	0.6286	49	U07	0.218	U15	0.101	U29	0.148	U49	0.533
31	U31	0.8613	27	U07	0.115	U11	0.142	U29	0.11	U50	0.634
32	U32	0.9887	18	U06	0.664	U26	0.268	U50	0.068		
33	U33	0.9214	21	U07	0.654	U25	0.346				
34	U34	0.7321	43	U29	0.489	U49	0.062	U50	0.448		
35	U35	0.834	30	U15	0.296	U29	0.061	U49	0.312	U50	0.332
36	U36	0.7054	46	U29	0.41	U50	0.59				
37	U37	0.8023	35	U15	0.263	U26	0.076	U49	0.121	U50	0.54
38	U38	0.7484	42	U07	0.072	U13	0.031	U29	0.3	U50	0.597
39	U39	0.7732	39	U07	0.111	U49	0.296	U50	0.593		
40	U40	0.8807	23	U15	0.351	U26	0.122	U49	0.224	U50	0.303
41	U41	1	1	U41	1						
42	U42	0.8221	33	U06	0.015	U07	0.266	U15	0.303	U50	0.415
43	U43	0.9012	22	U15	0.068	U26	0.422	U49	0.51		
44	U44	0.8736	25	U29	0.027	U50	0.973				
45	U45	0.7577	40	U29	0.636	U49	0.01	U50	0.353		
46	U46	0.8761	24	U29	0.645	U50	0.355				
47	U47	1	1	U47	1						
48	U48	0.7068	45	U07	0.156	U15	0.36	U29	0.164	U49	0.32
49	U49	1	1	U49	1						
50	U50	1	1	U50	1						

Table-II.11. Model- M11

Input(1) = SS Input(2) = FQE Input(3) = FRU Input(4) = RD Input(5) = WD Input(6) = FSR

Input(7) = PR

Output(1) = GMS Output(2) = GPHD

No.	DMU	Score	Rank		Reference(Lambda)												
1	U01	0.8797	44	U06	0.698	U08	0.085	U14	0.135	U24	0.062	U33	0.021				
2	U02	0.946	39	U04	0.466	U06	0.421	U33	0.113								
3	U03	0.9198	41	U06	0.724	U08	0.05	U10	0.087	U24	0.066	U41	0.073				
4	U04	1	1	U04	1												
5	U05	0.9287	40	U06	0.441	U07	0.29	U33	0.061	U41	0.208						
6	U06	1	1	U06	1												
7	U07	1	1	U07	1												
8	U08	1	1	U08	1												
9	U09	0.8312	48	U06	0.189	U13	0.244	U41	0.461	U49	0.106						
10	U10	1	1	U10	1												
11	U11	1	1	U11	1												
12	U12	0.8637	46	U06	0.14	U07	0.086	U13	0.19	U41	0.348	U49	0.236				
13	U13	1	1	U13	1												
14	U14	1	1	U14	1												
15	U15	1	1	U15	1												
16	U16	1	1	U16	1												
17	U17	1	1	U17	1												
18	U18	0.9557	38	U14	0.166	U24	0.028	U33	0.806								
19	U19	0.8446	47	U13	0.139	U26	0.113	U32	0.162	U45	0.128	U49	0.026	U50	0.431		
20	U20	1	1	U20	1												
21	U21	0.8761	45	U10	0.229	U15	0.044	U26	0.069	U33	0.222	U44	0.008	U45	0.008	U49	0.42
22	U22	0.8831	43	U33	0.105	U41	0.619	U48	0.276								
23	U23	0.9039	42	U06	0.077	U10	0.3	U11	0.046	U26	0.172	U33	0.152	U45	0.099	U49	0.154
24	U24	1	1	U24	1												
25	U25	1	1	U25	1												

26	U26	1	1	U26	1												
27	U27	0.825	49	U11	0.037	U13	0.005	U26	0.353	U49	0.553	U50	0.051				
28	U28	0.975	36	U11	0.101	U44	0.161	U49	0.509	U50	0.229						
29	U29	1	1	U29	1												
30	U30	1	1	U30	1												
31	U31	1	1	U31	1												
32	U32	1	1	U32	1												
33	U33	1	1	U33	1												
34	U34	1	1	U34	1												
35	U35	1	1	U35	1												
36	U36	0.9565	37	U20	0.214	U26	0.123	U37	0.351	U44	0.312						
37	U37	1	1	U37	1												
38	U38	0.8216	50	U11	0.221	U13	0.019	U26	0.349	U44	0.039	U49	0.112	U50	0.26		
39	U39	1	1	U39	1												
40	U40	1	1	U40	1												
41	U41	1	1	U41	1												
42	U42	0.9791	35	U30	0.087	U33	0.042	U40	0.323	U45	0.195	U49	0.353				
43	U43	1	1	U43	1												
44	U44	1	1	U44	1												
45	U45	1	1	U45	1												
46	U46	0.9979	34	U13	0.048	U26	0.166	U29	0.171	U44	0.125	U45	0.179	U49	0.14	U50	0.171
47	U47	1	1	U47	1												
48	U48	1	1	U48	1												
49	U49	1	1	U49	1												
50	U50	1	1	U50	1												

Table-II.12. Model- M12

Input(1) = SS Input(2) = FQE Input(3) = FRU Input(4) = RD Input(5) = WD Input(6) = PR

Output(1) = FPPP Output(2) = GMS

No.	DMU	Score	Rank		Reference(Lambda)										
1	U01	1	1	U01	1										
2	U02	0.9403	37	U01	0.291	U04	0.231	U07	0.324	U14	0.154				
3	U03	1	1	U03	1										
4	U04	1	1	U04	1										
5	U05	0.9181	41	U04	0.008	U07	0.585	U41	0.407						
6	U06	0.974	33	U07	0.034	U15	0.962	U25	0.004						
7	U07	1	1	U07	1										
8	U08	1	1	U08	1										
9	U09	0.7868	50	U13	0.222	U26	0.016	U29	0.155	U41	0.541	U45	0.066		
10	U10	1	1	U10	1										
11	U11	0.9714	34	U29	0.347	U44	0.126	U50	0.527						
12	U12	0.8631	45	U01	0.053	U07	0.147	U13	0.196	U41	0.342	U49	0.261		
13	U13	1	1	U13	1										
14	U14	1	1	U14	1										
15	U15	1	1	U15	1										
16	U16	0.888	43	U26	0.21	U32	0.151	U40	0.267	U49	0.372				
17	U17	0.987	32	U15	0.195	U32	0.09	U47	0.715						
18	U18	1	1	U18	1										
19	U19	0.846	47	U13	0.141	U26	0.482	U32	0.025	U44	0.345	U50	0.007		
20	U20	1	1	U20	1										
21	U21	0.8719	44	U10	0.289	U26	0.057	U29	0.176	U32	0.041	U41	0.399	U49	0.039
22	U22	0.9267	40	U18	0.199	U33	0.1	U41	0.601	U48	0.099				
23	U23	0.862	46	U10	0.043	U26	0.104	U29	0.32	U33	0.232	U45	0.301		
24	U24	1	1	U24	1										
25	U25	1	1	U25	1										
26	U26	1	1	U26	1										
27	U27	0.8222	48	U13	0.031	U26	0.328	U41	0.035	U49	0.507	U50	0.099		

28	U28	0.9446	36	U13	0.007	U26	0.005	U45	0.091	U49	0.443	U50	0.454		
29	U29	1	1	U29	1										
30	U30	1	1	U30	1										
31	U31	1	1	U31	1										
32	U32	1	1	U32	1										
33	U33	1	1	U33	1										
34	U34	1	1	U34	1										
35	U35	0.9531	35	U13	0.216	U26	0.194	U32	0.132	U41	0.258	U45	0.146	U49	0.053
36	U36	0.9277	39	U26	0.013	U40	0.504	U44	0.483						
37	U37	1	1	U37	1										
38	U38	0.8038	49	U13	0.1	U26	0.346	U29	0.048	U45	0.008	U49	0.067	U50	0.432
39	U39	0.8994	42	U31	0.532	U40	0.376	U49	0.092						
40	U40	1	1	U40	1										
41	U41	1	1	U41	1										
42	U42	1	1	U42	1										
43	U43	0.9377	38	U26	0.211	U32	0.202	U40	0.117	U49	0.469				
44	U44	1	1	U44	1										
45	U45	1	1	U45	1										
46	U46	0.9921	31	U26	0.106	U29	0.227	U44	0.02	U45	0.323	U49	0.078	U50	0.246
47	U47	1	1	U47	1										
48	U48	1	1	U48	1										
49	U49	1	1	U49	1										
50	U50	1	1	U50	1										

Table-II.13. Model- M13

Input(1) = FQE Input(2) = FRU Input(3) = RD Input(4) = WD

Output(1) = FPPP Output(2) = GMS Output(3) = PR

No.	DMU	Score	Rank		Reference(Lambda)										
1	U01	1	1	U01	1										
2	U02	1	1	U02	1										
3	U03	1	1	U03	1										
4	U04	1	1	U04	1										
5	U05	0.9305	24	U04	0.109	U06	0.247	U07	0.597	U15	0.047				
6	U06	1	1	U06	1										
7	U07	1	1	U07	1										
8	U08	1	1	U08	1										
9	U09	0.8447	38	U06	0.454	U07	0.134	U13	0.412						
10	U10	1	1	U10	1										
11	U11	1	1	U11	1										
12	U12	0.8732	35	U01	0.052	U07	0.295	U13	0.202	U15	0.21	U49	0.241		
13	U13	1	1	U13	1										
14	U14	0.8797	34	U04	0.07	U07	0.398	U10	0.172	U15	0.36				
15	U15	1	1	U15	1										
16	U16	0.8639	36	U15	0.343	U26	0.066	U32	0.416	U50	0.176				
17	U17	0.9806	22	U15	0.543	U47	0.457								
18	U18	0.7975	41	U03	0.8	U07	0.029	U13	0.13	U26	0.04				
19	U19	0.8502	37	U13	0.308	U26	0.401	U32	0.006	U44	0.095	U50	0.19		
20	U20	0.7902	42	U13	0.135	U29	0.656	U49	0.075	U50	0.135				
21	U21	0.8305	40	U10	0.095	U15	0.457	U29	0.253	U32	0.179	U50	0.016		
22	U22	0.757	46	U04	0.008	U07	0.494	U15	0.225	U32	0.25	U41	0.023		
23	U23	0.7802	43	U10	0.13	U15	0.022	U29	0.671	U32	0.165	U50	0.012		
24	U24	1	1	U24	1										
25	U25	1	1	U25	1										
26	U26	1	1	U26	1										
27	U27	0.7651	44	U29	0.739	U49	0.261								

28	U28	0.9154	27	U29	0.885	U50	0.115								
29	U29	1	1	U29	1										
30	U30	0.7541	47	U04	0.282	U07	0.329	U13	0.29	U15	0.036	U32	0.04	U49	0.022
31	U31	0.8939	33	U13	0.361	U32	0.075	U44	0.007	U50	0.557				
32	U32	1	1	U32	1										
33	U33	0.9611	23	U07	0.54	U15	0.455	U25	0.005						
34	U34	0.841	39	U07	0.054	U10	0.013	U13	0.481	U26	0.155	U44	0.179	U50	0.119
35	U35	0.8964	32	U13	0.196	U15	0.077	U32	0.224	U49	0.365	U50	0.138		
36	U36	0.7449	48	U13	0.452	U44	0.042	U50	0.506						
37	U37	0.9137	28	U10	0.148	U13	0.137	U26	0.175	U29	0.332	U32	0.16	U50	0.048
38	U38	0.7447	49	U13	0.047	U29	0.46	U50	0.493						
39	U39	0.7648	45	U29	0.817	U50	0.183								
40	U40	0.9258	26	U15	0.074	U29	0.177	U32	0.298	U49	0.298	U50	0.153		
41	U41	1	1	U41	1										
42	U42	0.8994	31	U07	0.109	U10	0.162	U13	0.2	U26	0.118	U32	0.039	U49	0.371
43	U43	0.9271	25	U26	0.195	U32	0.242	U49	0.526	U50	0.038				
44	U44	1	1	U44	1										
45	U45	0.911	29	U10	0.113	U13	0.616	U29	0.024	U32	0.085	U44	0.162		
46	U46	0.9067	30	U13	0.321	U29	0.356	U44	0.016	U50	0.307				
47	U47	1	1	U47	1										
48	U48	0.7118	50	U13	0.072	U15	0.479	U29	0.065	U49	0.384				
49	U49	1	1	U49	1										
50	U50	1	1	U50	1										

Table-II.14. Model- M14

Input(1) = SS Input(2) = FQE Input(3) = FRU Input(4) = RD Input(5) = WD

Output(1) = GMS Output(2) = PR

No.	DMU	Score	Rank		Reference(Lambda)										
1	U01	1	1	U01	1										
2	U02	1	1	U02	1										
3	U03	1	1	U01	0.001	U03	0.997	U06	0.001						
4	U04	1	1	U04	1										
5	U05	0.9344	33	U04	0.153	U06	0.46	U07	0.135	U33	0.073	U41	0.179		
6	U06	1	1	U06	1										
7	U07	1	1	U07	1										
8	U08	1	1	U08	1										
9	U09	0.9196	36	U01	0.103	U06	0.41	U13	0.295	U41	0.013	U48	0.179		
10	U10	1	1	U10	1										
11	U11	1	1	U11	1										
12	U12	0.8742	38	U06	0.018	U13	0.265	U15	0.417	U41	0.3				
13	U13	1	1	U13	1										
14	U14	0.9618	29	U08	0.079	U10	0.01	U32	0.009	U33	0.41	U41	0.492		
15	U15	1	1	U15	1										
16	U16	0.8639	44	U15	0.343	U26	0.066	U32	0.416	U50	0.176				
17	U17	0.9806	26	U15	0.543	U47	0.457								
18	U18	0.8388	47	U08	0.011	U13	0.03	U32	0.104	U33	0.204	U41	0.002	U48	0.648
19	U19	0.8418	46	U13	0.276	U26	0.274	U32	0.093	U44	0.056	U50	0.301		
20	U20	0.8669	43	U13	0.128	U26	0.339	U29	0.392	U41	0.069	U45	0.072		
21	U21	0.8688	42	U10	0.067	U15	0.268	U26	0.018	U29	0.218	U32	0.228	U33	0.202
22	U22	0.9029	37	U08	0.105	U33	0.046	U41	0.558	U48	0.291				
23	U23	0.8697	40	U13	0.133	U26	0.119	U29	0.292	U33	0.273	U45	0.184		
24	U24	1	1	U24	1										
25	U25	1	1	U25	1										
26	U26	1	1	U26	1										
27	U27	0.8205	48	U13	0.201	U26	0.102	U41	0.415	U50	0.282				

28	U28	0.9407	31	U13	0.168	U41	0.144	U49	0.207	U50	0.481				
29	U29	1	1	U29	1										
30	U30	0.8695	41	U24	0.209	U32	0.091	U33	0.635	U48	0.064				
31	U31	0.9651	28	U13	0.079	U26	0.156	U45	0.335	U50	0.43				
32	U32	1	1	U32	1										
33	U33	1	1	U33	1										
34	U34	0.8738	39	U13	0.146	U26	0.129	U29	0.064	U45	0.48	U50	0.181		
35	U35	0.952	30	U13	0.266	U26	0.207	U32	0.145	U41	0.283	U45	0.1		
36	U36	0.851	45	U26	0.25	U44	0.103	U45	0.373	U50	0.274				
37	U37	0.9378	32	U10	0.091	U26	0.228	U29	0.319	U32	0.129	U33	0.01	U45	0.223
38	U38	0.8164	49	U11	0.097	U13	0.184	U26	0.361	U29	0.064	U50	0.294		
39	U39	0.7914	50	U13	0.102	U26	0.008	U41	0.296	U50	0.594				
40	U40	0.9712	27	U13	0.121	U26	0.255	U29	0.154	U32	0.198	U41	0.226	U45	0.045
41	U41	1	1	U41	1										
42	U42	0.9299	35	U26	0.029	U29	0.242	U32	0.26	U33	0.064	U41	0.225	U45	0.181
43	U43	0.9335	34	U13	0.03	U26	0.252	U32	0.217	U41	0.024	U49	0.478		
44	U44	1	1	U44	1										
45	U45	1	1	U45	1										
46	U46	0.9884	25	U13	0.085	U26	0.188	U29	0.279	U45	0.254	U50	0.195		
47	U47	1	1	U47	1										
48	U48	1	1	U48	1										
49	U49	1	1	U49	1										
50	U50	1	1	U50	1										

Table-II.15. Model- M15

Input(1) = SS Input(2) = FQE Input(3) = FRU Input(4) = WD

Output(1) = PU Output(2) = PR

No.	DMU	Score	Rank		Reference(Lambda)								
1	U01	1	1	U01	1								
2	U02	1	1	U02	1								
3	U03	0.9865	19	U01	0.189	U02	0.316	U06	0.477	U48	0.018		
4	U04	0.9735	22	U01	0.149	U06	0.791	U47	0.06				
5	U05	0.9216	29	U01	0.03	U06	0.665	U07	0.026	U26	0.28		
6	U06	1	1	U06	1								
7	U07	1	1	U07	1								
8	U08	0.9987	17	U01	0.417	U26	0.22	U48	0.363				
9	U09	0.9188	30	U01	0.159	U06	0.199	U13	0.46	U41	0.017	U48	0.165
10	U10	0.9158	31	U06	0.292	U11	0.323	U26	0.385				
11	U11	1	1	U11	1								
12	U12	0.8742	36	U06	0.018	U13	0.265	U15	0.417	U41	0.3		
13	U13	1	1	U13	1								
14	U14	0.9688	23	U01	0.05	U26	0.841	U48	0.109				
15	U15	1	1	U15	1								
16	U16	0.8157	42	U07	0.116	U15	0.19	U26	0.651	U50	0.043		
17	U17	1	1	U17	1								
18	U18	0.9039	33	U01	0.062	U26	0.347	U48	0.591				
19	U19	0.8257	41	U13	0.28	U26	0.403	U50	0.317				
20	U20	0.8456	40	U13	0.194	U26	0.218	U41	0.253	U50	0.335		
21	U21	0.8107	44	U13	0.149	U15	0.227	U26	0.362	U41	0.225	U50	0.038
22	U22	0.8918	35	U01	0.034	U41	0.494	U47	0.107	U48	0.366		
23	U23	0.7972	49	U13	0.292	U26	0.559	U41	0.133	U50	0.016		
24	U24	0.8458	39	U26	0.426	U41	0.145	U48	0.429				
25	U25	0.9434	25	U07	0.143	U15	0.435	U26	0.071	U50	0.352		
26	U26	1	1	U26	1								
27	U27	0.8063	47	U26	0.072	U41	0.494	U50	0.434				

28	U28	0.9791	21	U11	0.067	U13	0.592	U29	0.072	U41	0.11	U50	0.159
29	U29	1	1	U29	1								
30	U30	0.8018	48	U26	0.104	U41	0.347	U48	0.549				
31	U31	0.9602	24	U11	0.327	U26	0.501	U44	0.02	U50	0.152		
32	U32	0.9937	18	U01	0.015	U06	0.034	U26	0.569	U41	0.344	U48	0.039
33	U33	0.9851	20	U26	0.286	U41	0.255	U48	0.46				
34	U34	0.8154	43	U26	0.504	U41	0.113	U50	0.383				
35	U35	0.9241	28	U13	0.246	U26	0.436	U41	0.315	U50	0.003		
36	U36	0.8077	46	U26	0.626	U50	0.374						
37	U37	0.8586	38	U26	0.464	U41	0.203	U50	0.333				
38	U38	0.8105	45	U13	0.266	U26	0.323	U41	0.015	U50	0.395		
39	U39	0.7848	50	U41	0.325	U49	0.014	U50	0.661				
40	U40	0.9275	27	U13	0.021	U26	0.392	U41	0.383	U50	0.205		
41	U41	1	1	U41	1								
42	U42	0.8668	37	U26	0.376	U41	0.43	U50	0.195				
43	U43	0.907	32	U15	0.015	U26	0.433	U41	0.121	U49	0.404	U50	0.026
44	U44	1	1	U44	1								
45	U45	0.8971	34	U26	0.867	U41	0.04	U50	0.093				
46	U46	0.9415	26	U13	0.035	U26	0.274	U41	0.178	U50	0.513		
47	U47	1	1	U47	1								
48	U48	1	1	U48	1								
49	U49	1	1	U49	1								
50	U50	1	1	U50	1								

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Signature

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ANNEXURE-IV

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S. No. 347751

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

STATEMENT OF GRADES

Master of Technology in Industrial Engineering and Management

(Department of Mechanical Engineering)

Name : LAKSHYA SAINI Roll No. : 2K22/IEM/08

Month & Year of Examination : NOVEMBER , 2022 Semester : FIRST

Subject Code	Subject Title	Credits	Credits Secured	Grade
IEM501	DATA ANALYTICS	4	4	O
IEM503	PRODUCTION & OPERATION MANAGEMENT	4	4	A
IEM5407	PRODUCT DESIGN & DEVELOPMENT	4	4	A+
IEM5305	TOTAL QUALITY MANAGEMENT	3	3	A+
IEM5205	PRINCIPLES OF MANAGMENT	2	2	A+
		17	17	

AB : Absent DT : Detained

Credits Secured / Total : 17 / 17 SGPA : 9.00

Dated : Feb 14, 2023

Date of Declaration of Result Jan 11, 2023

CONTROLLER OF EXAMINATIONS

S. No. 374224

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

STATEMENT OF GRADES

Master of Technology in Industrial Engineering and Management

(Department of Mechanical Engineering)

Name : LAKSHYA SAINI Roll No. : 2K22/IEM/08

Month & Year of Examination : MAY , 2023 Semester : SECOND

Subject Code	Subject Title	Credits	Credits Secured	Grade
IEM502	OPERATIONS RESEARCH	4	4	A+
IEM504	SUPPLY CHAIN MANAGEMENT	4	4	A
IEM5404	INDUSTRY 4.0 & SMART MANUFACTURING	4	4	A
IEM5304	INTERNATIONAL LOGISTICS AND WAREHOUSE MANAGEMENT	3	3	A+
IEM5210	CONTEMPORARY ISSUES IN INDUSTRIAL ENGINEERING AND MANAGEMENT	2	2	A+
		17	17	

AB : Absent DT : Detained

Credits Secured / Total : 17 / 17 SGPA : 8.53

Dated : Aug 4, 2023

Date of Declaration of Result Jun 20, 2023

CONTROLLER OF EXAMINATION

Delhi Technological University

(Formerly Delhi College of Engineering)

THE RESULT OF THE CANDIDATE WHO APPEARED IN THE FOLLOWING EXAMINATION HELD IN NOV 2023 IS DECLARED AS UNDER:-

Master of Technology(Industrial Engineering and Management), III-SEMESTER

Result Declaration Date : 04-03-2024 **Notification No: 1660**

IEM601 : MAJOR PROJECT I IEM6201 : E- Commerce IEM6303 : Knowledge Management IEM6405 : Advanced Operation Research

Sr.No	Roll No.	Name of Student	IEM601	IEM6201	IEM6303	IEM6405	SGPA	TC	Failed Courses
			3.00	2.00	3.00	4.00			
1	2K22/IEM/02	AMAN MAAN	B+	O	A	A+	8.42	12	
2	2K22/IEM/03	ANIKET MODI	B+	A	B+	A	7.5	12	
3	2K22/IEM/04	ASHISH MALHOTRA	B+	A	C	B	6.33	12	
4	2K22/IEM/05	HAMISH ALI	B+	A+	B	B+	7.08	12	
5	2K22/IEM/06	KAMALDEEP SAHU	B+	A+	B	A+	7.75	12	
6	2K22/IEM/07	KUMAR AMIT	A+	O	O	O	9.75	12	
7	2K22/IEM/08	LAKSHYA SAINI	A+	A+	B+	A+	8.5	12	
8	2K22/IEM/09	SAMIR KUMAR	B+	A+	A	A	7.92	12	
9	2K22/IEM/10	SHEETAL SHARMA	B+	A+	B	A	7.42	12	
10	2K22/IEM/11	SHUBHAM SAURABH	B+	A	B	A	7.25	12	
11	2K22/IEM/12	SUBADEEP DAS	A	A+	B	A	7.67	12	
12	2K22/IEM/13	VATAN SINGH	A	O	A	A+	8.67	12	

OIC (Results)

Controller of Examination

Note: Any discrepancy in the result in r/o name/roll no/registration/marks/grades/course code/title should be brought to the notice of Controller of Examination/OIC(Results) within 15 days of declaration of result in the prescribed proforma.

e-Receipt for State Bank Collect Payment

REGISTRAR, DTU (RECEIPT A/C)

BAWANA ROAD, SHAHABAD DAULATPUR, , DELHI-110042
Date: 29-May-2024

SBCollect Reference Number :	DUM6843256
Category :	Miscellaneous Fees from students
Amount :	₹2000
University Roll No :	2K22/IEM/08
Name of the student :	LAKSHYA SAINI
Academic Year :	2023-2024
Branch Course :	MASTERS OF TECHNOLOGY
Type/Name of fee :	Others if any
Remarks if any :	M.TECH THESIS FEE
Mobile No. of the student :	9540294749
Fee Amount :	2000
Transaction charge :	0.00
Total Amount (In Figures) :	2,000.00
Total Amount (In words) :	Rupees Two Thousand Only
Remarks :	M.TECH THESIS FEE
Notification 1:	Late Registration fee Rs.50 per day, Hostel Room Rent for internship Rs.1000 per month, Hostel Cooler Rent Rs.1000 per year, I card Rs.200, Character certificate Rs.200, Migration certificate Rs.200, Bonafide certificate Rs.200, Special certificate Rs.500, Provisional certificate Rs.200, Duplicate Mark sheet Rs.500, Training Diary Rs.70
Notification 2:	Fee Structure Rs.200, Admit Card Rs.50. Transcript fee and other fee rates has to be confirmed from the Academic Cell prior to remit the fees online by the student.

ANNEXURE-VII

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)
Shahbad Daulatpur, Main Bawana Road, Delhi-110042, India

CERTIFICATE OF FINAL THESIS SUBMISSION

(Submitted in duplicate)

1. Name: LAKSHYA SAINI
2. Roll No: 2K22/IEM/08
3. Thesis title: Microanalysis of NIRF ranking of Top-fifty engineering institutions in India: An integrated approach of DEA and Statistical Analysis
4. Degree for which the thesis is submitted: Masters of Technology
5. Faculty (of the University to which the thesis is submitted)

6. Thesis Preparation Guide was referred to for preparing the thesis.	YES ☑	NO ☐
7. Specifications regarding thesis format have been closely followed.	YES ☑	NO ☐
8. The contents of the thesis have been organized based on the guidelines.	YES ☑	NO ☐
9. The thesis has been prepared without resorting to plagiarism.	YES ☑	NO ☐
10. All sources used have been cited appropriately.	YES ☑	NO ☐
11. The thesis has not been submitted elsewhere for a degree.	YES ☑	NO ☐
12. All the correction has been incorporated.	YES ☑	NO ☐
13. Submitted 2 hard bound copies plus one CD.	YES ☑	NO ☐

(Signature of the Supervisor)
Name: Dr. Pravin Kumar.

(Signature of Candidate)
Name: LAKSHYA SAINI
Roll No: 2K22/IEM/08

LAKSHYA SAINI

+91 9540294749 lakshyasaini_2k22iem08@dtu.ac.in
2K22/IEM/08 lakshya.shakti15@gmail.com

EDUCATION

M.TECH (IEM)	2022-2024	Delhi technological University, New Delhi	Pursuing (8.765)
B.TECH (Mechanical Engineering)	2018-2022	UIET, Kurukshetra University, Kurukshetra	78.6%
CISCE (ISC) (Class XII)	2018	Lord Jesus Public School, Gurgaon	86.2 %
CISCE (ICSE) (Class X)	2016	Lord Jesus Public School, Gurgaon	91.5 %

INTERNSHIPS

Data Analyst, TRENDPHORIA PVT. LMT, Gurgaon June 2020-July 2020

- Excelled in data analysis and interpretation using MS-Excel.

Summer Intern, GAIL (INDIA) LMT, Jaipur July 2021-Aug 2021

- Provided administrative support and wrote clear and concise communications.

Data Entry Specialist, AIMDATASOFT, Delhi Jan 2021-June 2021

- Ensured the accuracy of data through compilation, review, and verification.

ACADEMIC PROJECT

Python — *Self projects*

- Used linear regression to predict the base auction price of wicketkeepers in the IPL | Link.
- Walmart store sales forecast using different machine learning models and their error comparison | Link

Tableau — *Dashboards*

- Used super store datasets to create interactive dashboards, illustrating comparable sales amount via timeline. | Link
- Used level of detail expressions to calculate data at different levels of granularity, which allowed me to infer useful insights from the FIFA player rating dataset, showcasing positioning of valued players at granularity of nationality.| Link

ACADEMIC ACHIEVEMENTS AND AWARDS

- GATE (Mechanical) 2022 qualified
- Qualified Internal Smart India Hackathon 2022, Kurukshetra University
- Google Business Intelligence Specialization

TECHNICAL SKILLS

Prog. Languages – Python (Data Analysis), SQL.	MS Excel – Macros and VBA, Tableau, PostgreSQL	Microsoft Suite, Data Analysis, Data Visualization

SOFT SKILLS

- Management | Operations-Research | Problem Solving | Skill Management | Adaptability
- Leadership | Planning | Time Management | Business Intelligence

POSITIONS OF RESPONSIBILITY

- As Media Head in Google developers Club, UIET, KUK
  - Managed social media accounts to maintain interaction with users, create awareness, and engage in creative content.
- Media Head in Entrepreneurship cell, UIET, KUK.
  - Created engaging and interactive content for students, and lead backend team to ensure smooth execution.
  - Played a vital role in management and media team at Kuk University events.
- Internship coordinator at IIC, UIET, KUK

EXTRA-CURRICULAR ACTIVITIES

- Head coordinator at milaap'2019 Kurukshetra university
- Volunteer at Next Step to Sunrise (NGO)

OTHER INFORMATION

- LinkedIn - linkedin.com/in/lakshya-saini-dtu