Evaluation of Performance Based Appraisal System in Higher Education Sector using DEA and AHP

Dr. Neeta Saxena
Assistant Professor
Amity University
Madhya Pradesh, Gwalior.

Dr. Neha Jain
Assistant Professor
IITM College, Janakpuri
New Delhi.

Abstract: There is a broad interest in the study of schemes for the measurement of the efficiency of the higher education sector, which generates demand but at the same time is controversial because of the complexity of the problem. Performance evaluation in Higher Education institutions is one of the essential activities in teaching and learning procedure. This problem is associated with the highly combinatorial characteristics that occur when facing the selection of the proper combination of the attributes, namely inputs and outputs. This study proposes an integrated approach to measure performance based appraisal system (PBAS) in higher educational institutions combining Analytic Hierarchy Process (AHP) with Data Envelopment Analysis (DEA).The AHP allows consideration of the varying importance of each criterion of teaching performance, while DEA enables to the comparison of teachers on teaching as perceived by students with a view to identifying the scope for improvement by each teacher.

Key Words: *PBAS, DEA, AHP, Higher education sector.*

*****

I. Introduction:

In this period of knowledge economy, higher education sector plays an important role in the progress of a country. As government subsidies to universities have been decreasing, more efficient use of resources becomes important for university administrators. One of the key conditions for achieving a high performance of organization is the high performance of its own employees. Therefore, great efforts were spent in order to develop most objective and effective system by which would be their performance evaluated. Company management would respond, on the basis of obtained results, either by the remuneration or promotion for good performance or by encouraging employees to achieve performance improvements. Performance based Appraisal System (PBAS) is an important management tool to assess employees' efficiency in the workplace, and may be defined (Pearce & Porter 1986), as a structured formal interaction between a subordinate and supervisor that usually takes the form of a periodic interview (annual or semi annual) to evaluate the work performance. PA(Performance Appraisal) is proposed to engage, line up, and combine individual and group effort to constantly improve overall organisational mission accomplishment (Grubb 2007).

With globalization of higher education, university and institutes have become a part of the service industry and in order to remain competitive higher education institute and university management have become more and more concerned with the student's satisfaction. Student's satisfaction with teaching and learning is considered as one of major content for ranking (Dougals et al, 2006). Therefore Performance Appraisal partially based on Student's evaluation plays an important role to assess the performance of a faculty. It is also very important to evaluate the performance of faculties, in areas of research, teaching and administration through indicators and performance models that are of similar complexity with today's educational demands. There are already performance indicators in place in certain areas and their results have impacted the decisions of students and employers Colbert *et al.* (2000).

One of the most difficult features of higher education to be evaluated is that of academic staff, this is because it involves a large number of qualitative criteria, which must be quantified in a rather objective manner. The evaluation of teaching is multidimensional: Research projects and publications, quality of teaching, community services, student's satisfaction etc and major reasons for evaluation are to support decision –making on rewarding, awarding or promotion as well as to improve teaching quality. Assessment of teaching plays an important role of feedback both to faculties in order to improve their performance and to student in order to choose courses or supervisor.(Badri and Abdulla 2004 and Crumbley, Reichlet 2009)

Higher education Institutes are preparing reports or profiles at regular intervals for each employee. The profiles include detailed information regarding wages/salaries costs, utilisation of resources, and outcome quality (e.g., cost per product, and reworking rates). These indicators are compared against performance in other Institutes. Multiple

factors involved profiling can effectively identify underutilisation of inputs, uncover problems with the efficiency and quality of work, and assess an individual's performance (Sherman 1984). These profiles are designed to generate a specification, if the performance indicators for a particular employee differ from the average by a certain amount. And appraisal results are used, either directly or indirectly, to determine reward outcomes (Colby & Wallace 1975) as well as to identify the poor performers who may require some form of counselling, or training, or in extreme cases, demotion, dismissal or a decrease in pay. Since employees consume sizable portions of investment, the better management of employees can have a significant impact on the overall efficiency of the organisation.

This study describes the use of DEA to improve methods of measuring employees' efficiency for a higher education institute. The objectives of current study are fivefold.

- Evaluate and rank the employees based on their performance using the DEA
- Determine the peer for each underperforming employee
- Identify the weak factors of each inefficient employee
- Set target values for all the output factors for the inefficient employees
- Formulate recommendations and suggestions to the management, which should lead to enhancing employee efficiency

The evaluation of study is carried out by the authorities of higher education institute based on a combination of judgement and quantitative criteria such as number of publications, indexing and impact factor of journals, number of national and international conference participations etc. (Marsh and Roche 1997 and Crumbley, Reichlet 2009). The evaluation of faculty is normally carried out using student's perception on content, delivery of course and independent remark of student. This study mainly concern with evaluation of teaching performance, for this AHP method uses to derive the relative importance of each criteria of performance of teaching and DEA for deriving performance targets for each faculty.

II. Data Envelopment Analysis as a performance measure:

Data envelopment analysis is a decision making tool based on linear programming for measuring the relative efficiency of a set of comparable units. Besides the identification of relatively efficient and inefficient units, DEA identifies the sources and level of inefficiency for each of inputs and outputs.

In recent times the DEA method is becoming a trendy field in operation research for assessing the relative efficiency of various entities (Emrouznejad et al., to appear; Seiford, 1997).since the seminal work of Charnes, Cooper and Rhodes(1978) and since 1995, there was literally exponential growth in the number of publications. Between 1995 and 2003, the number of relevant publications stabilized at about 225 per year. However in the last four years (2004-2007) the number increased to approximately 360 per year. In this study DEA is a method for assessing the comparative performance of unit setting a set of inputs against a corresponding set of outputs, based on certain assumptions.

Let us have n mutually compared decision making units (DMU) producing outputs y_{rj} (r = 1,2, ..., s), using inputs x_{ij} (i = 1, 2 , ..., m). If we use output-oriented model DEA with constant returns to scale for evaluation of decision making unit DMU, then we are solving the following linear programming Problem:

Objective function: $\emptyset_0^* = max\emptyset_0$

Subject to: $\sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{i0}$ where i = 1, 2, 3,------m.

$$-\phi y_{r0} + \sum y_{rj}\lambda_j \geq 0, \quad \lambda_j \geq 0$$ Where j =1, 2, 3----n and r = 1,2,3,------s

Where:
x_{ij} is i input of j employee;
y_{rj} is r output of j employee;
x_{io} is i input of evaluated employee;
y_{ro} is r output of evaluated employee;
λ_j is intensity variable of j employee;
$\emptyset_0$ is the coefficient of expansion of output, the technical efficiency score of the evaluated employee.
The result of thus formulated linear programming task is technical efficiency score $\emptyset_0$ of evaluated decision making unit, in this case, the employee, which is defined as the aptitude to achieve maximum outputs at a given level of inputs. This measurement indicates how many times level of outputs has to be proportionally increased, maintaining the unchanged level of inputs, for employee to be technically efficient. If $\emptyset_0$ equals one and a variable λ_j is equal one for rated employee and zero for all other employees, the employee is technically efficient. Otherwise, if the technical efficiency measurement $\emptyset_0$ is greater than 1, the employee is not technically efficient in comparison with others and must

increase outputs while level of inputs remains the same. If employee is rated inefficient, non-zero variables λ_j points to the elements of referential set. Convex combination of outputs and inputs of efficient employees' reference set with coefficients λj indicates so called target values, i.e. values of inputs and outputs of a virtual efficient reference employee on the frontier. Model assumes constant returns to scale, which means the proportional change in outputs due to the change of inputs. Therefore, if the inputs increase by 1%, outputs also increase by 1%.

In this study **four input and four output** variables are used. **Inputs** were faculty and student ratio, salary (median salary range stated in employees' questionnaire), working conditions and environment, working time (ordinary scale of 1 - really poor and 5- definitely suitable) and benefits (employee can identify benefits that the employer provides). As an **output** we have chosen four things that, according to several published studies, have a positive effect on it – Teaching, Number of students placed, jab satisfaction and commitment to the organization and research. Their level can be determined by the attitudes of employees to 20 questions in the questionnaire on a 6-level Likert-type scale from strongly disagree to strongly agree. The first 10 propositions ascertained the level of working motivation of employees.

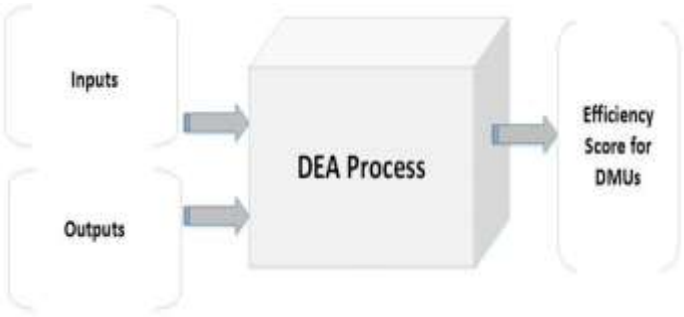

Figure 1: DEA Model

III. The Analytic Hierarchy Process (AHP):

The Analytic Hierarchy Process (AHP), introduced by Thomas Saaty (1980), is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process. Given two criteria i and j the DMU is asked to return a value for (aij) in the form of a digit from 1 to 9 to reflect the degree to which i is preferred to j (if that is the case) or vice versa. The responses lead to the creation of a hierarchy matrix (A), for the relative importance between criteria i and j for $i > j$,i.e. i is preferred to j. The reciprocals are calculated for $i < j$ such that $aji = aij^{-1}$ while aij equals 1 for i = j. The data in the matrix are manipulated to derive relative weights for the criteria, and measures of the stability of the decision-maker preferences expressed.

Required steps in AHP:

Establishment of a structural Hierarchy: A complex decision is to be structured in to a hierarchy descending from an overall objective to various criteria, sub criteria till the lowest level. The overall goal of the decision is represented at the top level of the hierarchy. The criteria and the sub criteria, which contribute to the decision, are represented at the intermediate levels. Finally the decision alternatives are laid down at the last level of the hierarchy. According to Saaty (2000), a hierarchy can be constructed by creative thinking, recollection and using people's perspectives.

Establishment of comparative judgments: Once the hierarchy has been structured, the next step is to determine the priorities of elements at each level. A set of comparison matrices of all elements in a level with to respect to an element of the immediately higher level are constructed. The pair wise comparisons are given in terms of how much element A is more important than element B.

Synthesis of priorities and measurement of consistency: The pair wise comparisons generate the matrix of rankings for each level of the hierarchy after all matrices are developed and all pair wise comparisons are obtained, Eigen vectors (relative weights) are obtained.

Eigen Vector Method: Suppose we wish to compare a set of 'n' objects in pairs according to their relative weights. Denote the objects by $A_1, A_2, ...A_n$ and their weights by $w_1, w_2, ...w_n$. The pair wise comparisons may be represented by a matrix as given in Table

	A_1	A_2	.....	.....	A_n
A_1	w_1/w_1	w_1/w_2			w_1/w_n
A_2	w_2/w_1	w_2/w_1			w_2/w_1
...					
...					
A_n	w_n/w_1	w_n/w_1			w_n/w_1

Table 1: Matrix containing weights

The matrix shown in Table-1 has positive entries everywhere and satisfies the reciprocal property aji = 1/aij. It is called a reciprocal matrix.

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the property
3	Moderate importance of one over another	Experience and judgment slightly favour one over the other
5	Essential or strong importance	Experience and judgment strongly favour one over another
7	Very strong important	An element is strongly favoured and its dominance is demonstrated in practice.
9	Extreme important	The evidence favouring one element over another is one of the highest possible order of affirmation
2,4,6,8	Intermediate values between two adjacent judgments	Comprise is needed between two judgments
Reciprocals	When activity i compared to j is assigned one of the above numbers, the activity j compared to i is assigned its reciprocal	
Rational	Ratios arising from forcing consistency of judgments	

Table 2: Saaty's Ratio scale for pair wise comparison of importance of weights of criteria/ alternatives

Calculation of consistency: When many pair wise comparisons are performed, some inconsistencies may typically arise. The consistency ratio is calculated as per the following steps:

(i) Calculate the relative weights each matrix of order n.

(ii) Compute the consistency index for each matrix of order n by the formulae

$$CI = \frac{x-m}{m-1}$$

A perfectly consistent decision maker should always obtain CI=0, but small values of inconsistency may be tolerated. In particular, if

$$\frac{CI}{RI} < 0.1$$

the inconsistencies are tolerable, and a reliable result may be expected from the AHP, where RI is the Random Index, i.e. the consistency index when the entries of matrix are completely random.

.

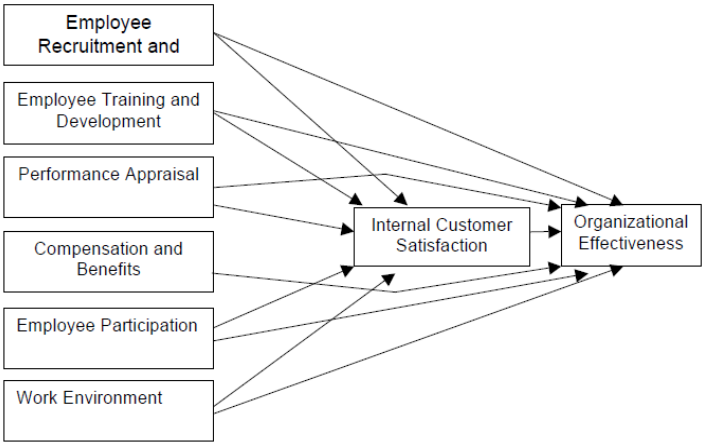

Figure 2: Theoretical model of Evaluation Process

Combination of AHP and DEA to evaluate teaching Performance:

The considered AHP hierarchy consists of goal, criteria and sub-criteria At the higher level, the ultimate goal of the problem is placed which is the overall evaluation of teaching from the student perspective. At the next level, there are two criteria—course and teacher. At this level, we are interested in measuring the extent to which the students' satisfaction depends on the nature of the course itself or on the teacher's performance.

In the evaluation of performance the following category may be considered:

(i) Course content
(ii) Course delivery
(iii) Field connectivity and relevance
(iv) Continuous evaluation/ Internal assessment
(v) Personality and behaviour

Also on the bases of above category following questions can be asked to the students:

(i) Has the faculty uploaded the session plan on the first day of the class?
(ii) Has the faculty uploaded attendance within 24 hours of the class held?
(iii) Would you like to do another course with this faculty or recommended this faculty to other students for doing the course?
(iv) Remark to the faculty from the student.

The following paragraphs provide the definitions of the sub-criteria as clearly explained to students before they completed the questionnaire:

Preparation: Preparation stands for the whole organization and presentation of the course (the course curriculum, the selection of the relative teaching material, etc.) as well as the preparation of the teacher before each class.

Professionalism: Professionalism reflects the conduct of the teacher in terms of punctuality, access for students, timing of feedback and responsiveness to student requests.

Presence: This reflects the teacher's ability to communicate concepts to students, eagerness, encouraging participation, fostering questions and so on.

Teaching Aid: Teaching aid comprises all the means that either helps the teacher in delivering his/her lesson or accompany teaching, such as suggested literature, handouts, presentations used, exercises given, papers presented as well as supporting classes (delivered by teaching or technical assistants).

Questionnaire can be used to capture from the student perspective the relative importance of criteria. This was done through pair wise comparisons of criteria using the AHP framework (Saaty,1996)

''When evaluating the Teacher, what is the level of importance of his/her Preparation when compared to his/her Presence in class?'' The student answers using the 9-point scale, e.g. the student scores say 7 at the appropriate place to indicate that Preparation by the teacher is significantly more important than his/her Presence in class. Clearly, all possible pairs of questions are asked at each hierarchical level (in total, n *(n-1)/2, where n denotes the number of criteria of the particular level of the hierarchy). The responses are then used within the AHP framework as outlined next

The faculties are regarded as decision-making units (DMUs) in the context of DEA. Faculties for the purposes of this illustration are seen as delivering two broad types of service, Teaching and Research. In the context of DEA, these are outputs. Their attainments on teaching from the student perspective are captured in the manner outlined in the preceding section, using the AHP. Their attainments in research are reflected in research outputs such as refereed papers and contributed chapters. Attainments in teaching and research are set against two parameters that would reflect the expectation of attainment in teaching and research.

These are Salary and Experience in a faculty position, which constitute inputs in the context of DEA.

Data for inputs and outputs of the DEA model are considered as above discussion in The output on Teaching is the AHP-based weighted evaluation of the tutors and their course. We use within the DEA model the aggregate of ''Course Interest+ Course Usefulness+ faculty's Professionalism+ faculty's level of Preparation+ faculty's Presence in class+ Teaching aid'' as one of our four outputs. An alternative measure that was used for research output is the number of papers published by the faculty to date. Therefore, the final DEA model is:

•Inputs: Salary, Faculty student's ratio, working conditions and environment, working time
•Outputs: Teaching, no. of students placed, job satisfaction, Research.
•Teaching was the aggregate weighted scores for: Course Interest+ Course Usefulness+ faculty's Professionalism + faculty's level of Preparation+ faculty's Presence in Class +Teaching Aid.
•Research was number of refereed publications.

•No of students placed it is a quantitative data can be collected form training and placement cell of the institute.
• Job satisfaction was again aggregate of salary on time + HR policy of the institute + facilities provided by the institute.

As can be seen, the benchmark faculties (i.e. with 100% efficiency) are so whether teaching is given sole priority or teaching and research are given equal priority to improve. These would be good benchmarks for a institute to seek for other faculty to emulate. In fact, all faculties have very similar efficiency in both scenarios on priority to improve. In very few occasions is the efficiency on teaching slightly higher when teaching and research are given equal priority. In those few cases, a person's slightly higher efficiency in teaching when research is also prioritized to improve suggests he/she would have higher scope to improve in teaching if they diverted effort from research.

Teaching performance evaluation, when used appropriately and findings are implemented can significantly enhance student experience. PBAS has been developed to capture student perceptions of teaching quality and have been used to assess the performance of faculties. However, the PBAS returns need to be used with caution. Their analysis needs to reflect the varying preferences of students depending on the nature of their program of study, the stage in a student's education, whether a course is compulsory or optional and so on. This study has addressed these issues in the context of teaching evaluation. Using the approach in this study, the institution can identify at an aggregate level any features that may be common among the best attaining faculties. This type of information can in turn affect both how teachers are

advised to improve their performance and also the recruitment policy of the institution in terms of features sought in candidates in future. the study opens an avenue of research whereby using AHP and DEA in combination the teaching evaluations by students can be assessed in a manner that is more reflective of student preferences while teachers are set targets of attainment appropriate to the stage of their career. Performance evaluation through an integrated application of the AHP and the DEA methods provides more objective results and more reliable solutions to the observed problem, thus creating a valuable information base for high-quality strategic decision making in higher education institutions, both at the national level and at the level of individual institutions. The idea was to take on a new, comprehensive approach and, through the integrated and combined use of the DEA and the AHP methods, obtain a more complete and objective evaluation of faculty performance and perform their ranking. The ultimate goal of this study was to improve the evaluation process of higher education institutions.

IV. Conclusion

The proposed approach of combining the Analytic Hierarchy Process, as a method for decision-making support in terms of complexity and uncertainty, and robust non-parametric methods, such as the Data Envelopment Analysis, provides a flexible, systematic, and objective framework for a comprehensive (absolute and relative) efficiency measurement and performance evaluation, and, implicitly, stands for a reliable basis for making high-quality strategic decisions in higher education institutions. Through the simultaneous use of the non-financial indicators and the possibility of including not only the quantitative but also the qualitative factors and their combination (through the AHP), the proposed approach significantly reduces the subjectivity and bias frequently present in the measurement and evaluation of organizational performance. In fact, the given process of efficiency evaluation and performance measurement of the observed faculties has had certain limitations, the most important ones being related to the fact that the analysis included a relatively small number of the model inputs and outputs, and omitted those relating to scientific research and the financial component, as extremely important dimensions for the functioning of the observed higher education institutions. By including these factors into the analysis, a more realistic, multidimensional evaluation of faculty performance would be obtained, which makes room for a new interpretation of the results obtained, a correlation analysis, a solution sensitivity analysis, and further research in this direction.

References

[1] Emmanuel Thanassoulis, Prasanta Kumar Dey, Konstantinos Petridis, Ioannis Goniadis and Andreas C. Georgiou, Journal of the Operational Research Society(2017) 68(4). “Evaluating higher education teaching performance using combined analytic hierarchy process and data envelopment analysis”

[2] Michał Pietrzak, Piotr Pietrzak, Joanna Baran, Online Journal of Applied Knowledge Management.volume 4, Issue 2, 2016. “Efficiency assessment of public higher education with the application of Data Envelopment Analysis: The evidence from Poland.”

[3] Predrag Mimovic* and Ana Krstic, Economic Horizons,January - April 2016, Volume 18.”The Integrated Application of the AHP and the DEA Methods in Evaluating the Performances of Higher Education Institutions in the Republic of Serbia.”

[4] Dariush Akbarian, Hindawi Publishing Corporation Journal of Optimization Volume 2015, Article ID 594727, “Ranking All DEA-Efficient DMUs Based on Cross Efficiency andAnalytic Hierarchy Process Methods.”

[5] A. Altamirano-Corro, R. Peniche-VeraMeasuring, Journal of Applied Research and Technology. Vol.12, February 2014 “The Institutional Efficiency Using DEA and AHP: the Case of a Mexican University.”

[6] R.V. Pranesh, A. John Rajan, Kaja Bantha Navas, Proceedings of the World Congress on Engineering July 3 - 5, 2013, London, U.K. Vol I. “Evaluating the Performance of State University, National Important Institute and Private Deemed Universities in Chennai (India) by using Data Envelopment Analysis.”

[7] Peter Zbranek, Acta Oeconomica et Informatica. XVI (Number 1, 2013), “Data Envelopment Analysis as a tool for evaluation of employees’ performance.”

[8] Hadi Shirouyehzad,F. Hosseinzadeh Lotfi, Mir. B. Aryanezhad & Reza Dabestani

[9] South African Journal of Industrial,Engineering May 2012 Vol 23(1) “A Data Envelopment Analysis Approach for Measuring the Efficiency of Employees: a case study.”

[10] P. Kousalya,G.Mahender, Reddy,S. Supraja, Matematica Aterena, Vol.2, 2012. “Analytical Hierarchy Process approach–An Application of Engineering Education.”

[11] Salah R. Agha, Ibrahim Kuhail, Nader Abdelnabi, Mahmoud Salem, Ahmed Ghanim. Journal of Industrial Engineering and Management. 2011 Volume 4(2). “Assessment of academic departments’ efficiency using data envelopment analysis.”

[12] Chin-Yen A. Liu, Wen – Hsing Liu, Proceedings of the 2010 industrial Engineering Research Conference. “Performance Evaluation on Private Higher Education Using Data Envelopment Analysis.”