Benchmarking: An International Journal

A performance evaluation framework for technical institutions in one of the states of India

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Received 8 February 2013
Revised 20 September 2013
Accepted 22 November 2013

Abstract

Purpose – Technical education plays an important role in the development of a country in this age of knowledge economy. Indian technical education system is facing many opportunities and challenges, one of which is how to assess the performance of technical institutions based on multiple criteria. The purpose of this paper is to describe and illustrate an application of a structured approach to determine relative efficiency and ranking of a set of private engineering colleges under multi-criteria environment.

Design/methodology/approach – To cater to the increasing need of technical manpower, a very large number of private engineering colleges have been established in the state of West Bengal of eastern India within a very short period. Uniform and acceptable quality of the graduates from many of these private engineering colleges is a concern today and therefore the need for performance evaluation and ranking of these colleges is paramount. For the proposed framework a comparatively new multiple criteria decision-making tool, multiple objective optimization on the basis of simple ratio analysis (MOOSRA) is applied for performance evaluation of eight private engineering colleges taking into account some selected criteria. The subjective weights of the criteria are determined using fuzzy analytic hierarchy process (AHP).

Findings – For the analysis, the required data have been provided by the management of the colleges for the academic year of 2011-2012. Based on request of the management identities of these institutes are not disclosed. The institutes are considered as anonymous institute and coded as A, B, C, D, E, F, G and H, respectively. The result of the study reveals that E is the best and the ranking the authors get is in the order of E > F > A > H > D > C > G > B. The result shows that composite performance scores of institutions A, E and F are above the mean performance score value. Therefore these three institutions can be considered as the benchmark or peer group for the remaining five institutions which lie below the mean line of the performance score value.

Originality/value – This paper provides a comprehensive yet detailed methodology for performance evaluation of academic institutions. The novelty in the approach is that fuzzy AHP and MOOSRA are being used as a benchmarking technique in a simple methodology which is generic in nature. It is one of the few studies that evaluate the performance of technical institutions in India.

Keywords Performance evaluation, Sensitivity analysis, Fuzzy AHP, Ranking, MOOSRA, Private engineering college

Paper type Research paper

Benchmarking: An International Journal
Vol. 22 No. 5, 2015
pp. 773-790

1463-5771
DOI 10.1108/BIJ-02-2013-0019

1. Introduction

The core of human resource development is education, which plays an important role in developing the socioeconomic framework of the country. In a lecture at Central Hall of Parliament, New Delhi, on July 25, 2012 the President of India said "Education is the true alchemy that can bring India its next golden age. Our motto is unambiguous: All for knowledge, and knowledge for all."

The primary objective of education is to enable us to know things we did not know earlier, so as to improve the quality of life. In 1993 United Nations development programs (UNDP) under the leadership of Professor Amartya Sen and Professor M. Haque devised a composite index called human development index (HDI) to measure the quality of life. The components of HDI are life expectancy, literacy rate and gross domestic product (GDP) of the country. According to 1997 HDI value India ranks 139th out of 174 countries. Education can substantially improve the HDI value. Indian patriotic monk Swami Vivekananda said, "we want that education by which character is formed, strength of mind is increased, the intellect is expanded and by which one can stand on one's own feet." To ensure education for all (EFA), Government of India implements a number of programs for the achievement of the EFA goals, including, inter alia, Sarva Shiksha Abhiyan (SSA), Mid-day Meal Scheme (MDM) and National Literacy Mission (NLM).

Indian technical education system is one of the largest educational systems in the world. Engineering education in India started during the British colonial rule and it focussed mainly on civil engineering. Gradually few engineering colleges, namely, the Engineering College at Roorkee, Poona Civil Engineering College at Pune, Bengal Engineering College at Shibpur, etc., came up in the mid 1850s. Gradually to meet the growing need of a rapidly expanding economy the enrollments in technical education sector begin to increase. As a result of this a number of universities and colleges those offer technical education have been set up both by government and private initiatives all over the country including West Bengal, a state of eastern India.

There are many debates on the role and potential benefits of privately provided technical education. The most frequently advanced economic arguments in favor of greater private provision in technical education are that it improves efficiency, giving greater accountability and increased diversity of choice and access from the increased resources flowing into education. (World Bank, 1994, 1995; Sanyal, 1998). From the financial point of view, the burden on government expenditure and resources is reduced.

Other studies give a different picture suggesting that private institutions tend mainly to offer programs that have high private benefits but fewer social benefits. Many have argued, for example, that the role of research and the broad educational needs of society are less important to private sector institutions (Johnstone, 1998). The private sector is only likely to offer professional subjects, such as engineering and medicine if the potential for economic profit is high (Tilak, 1991) and, in most cases, private sector institutions offer subjects that are mainly of low capital intensive (James, 1991).

In order to cater to the increasing need of technical manpower, a very large number of engineering colleges under private management has been establish in the state of West Bengal within a very short period of a decade or so. Different studies and views expressed by industry and academic experts highlight lower employability of the engineering graduates coming out of these institutes. In this paper we have considered eight private engineering colleges of the state for study. Based on request of the management identities of these institutes are not disclosed. The institutes are considered as anonymous institute and coded as A, B, C, D, E, F, G and H, respectively.

In this paper we suggest an integrated fuzzy multi-criteria decision-making (MCDM) model consisting of fuzzy analytic hierarchy process (AHP) and multiple objective optimization on the basis of simple ratio analysis (MOOSRA) to assess the relative performance of the private engineering colleges in West Bengal. The contribution of the present work is that, this model is robust; it is easy to deal with; complex mathematics is not required and the evaluation criteria encompass stakeholders' preference. Computation of the degree of relative importance for evaluation criteria is made through fuzzy AHP. Finally MOOSRA method is used to aggregate performance scores under different criteria into an overall performance score for each institution and ranking the colleges according to their overall performance score.

This paper is organized as follows: Section 1 provides the background and outlines the purpose of this paper. Section 2 reviews the earlier literature. Section 3 discusses the higher education system in the country and the state of West Bengal, section 4 describes the proposed model used in the paper. Section 5 gives information about data and computation. Section 6 describes the sensitivity analysis. The last section summarizes discussion and conclusion.

2. Review of the literature

Uniform and acceptable quality of the graduates from many of these private engineering colleges is a concern today and therefore the need for performance evaluation and ranking of these colleges is paramount. All the stakeholders want to get optimum benefits at shortest period of time and at an economical cost to improve the quality of life. Therefore, this is high time to do performance evaluation of the technical institutions. During the past two decades considerable volume of research has been conducted worldwide regarding performance evaluation of universities, libraries, research institutes, etc. Most of the studies have focussed on UK or Australia. The use of league table (Herbert and Thomas, 1998; Yorke, 1997, 1998) is found to rank academic institutions in UK. League tables are generally used to compare academic performance of various institutions by considering a set of well-defined criteria such as – student satisfaction, research assessment/quality, entry standards, student-staff ratio, academic services spend, facilities spend, good honors, graduate prospects and completion rate. A statistical technique known as *Z*-transformation is applied to each criterion to create a score for that criterion. Weighted *Z*-scores on each criterion help to determine the final rank of the institution.

Apart from the concept of league table, researches on universities in UK include those by Athanassopoulos and Shale (1997), Glass *et al.* (1995), Johnes (1996, 2006), Casu and Thanassoulis (2006), Flegg *et al.* (2004). In UK Portela and Thanassoulis (2001) have investigated the efficiency of schools also. Plenty of studies have been reported on efficiency analysis of Australian universities. Among the authors that have written about it we can mention Avkiran (2001), Abbott and Doucouliagos (2003), Worthington and Lee (2008), etc. Kao and Hung (2008) have concentrated on performance evaluation of academic departments in Tiwan. Fandel (2007) makes a study on German Universities. Korhonen *et al.* (2001) analyze 18 research units at Helsinki school of Finland. Elsewhere Hashimoto and Cohn (1997) have investigated Japanese universities, McMillan and Datta (1998) have investigated Canadian universities. Nicholls and Cargill (2011) develop a model for university research funding. Simon *et al.* (2011) concentrate on changes in productivity of Spanish university libraries. In India, Tyagi *et al.* (2009) have done similar study dealing with assessment of academic departments of IIT Roorkee. All the study mentioned above use various DEA models for the purpose. Apart from DEA models, literatures on application of MCDM tools for performance evaluation of academic institutions (Das *et al.*, 2012a, b) are also available.

Apart from performance evaluation some research works of different kind are also found in the literature. Wilkinson and Yussof (2005) presented a comparative analysis on public and private provision of higher education in Malaysia. They compared a sample of public universities and private colleges in terms of their enrollments, costs, facilities and quality of provision. The purpose was to illuminate an important policy issue for Malaysia and to contribute to the general debate on the role of the private sector in the provision of higher education. The general findings were that public universities appear to be more efficient in satisfying public demand in terms of quality of provision. Diamantis and Benos (2007) proposed a methodology called multi-criteria satisfaction analysis (MUSA) to measure students' satisfaction of a university department in International and European studies (IES). According to them student satisfaction was dependent on factors such as curriculum, range of academic subjects taught, the academic staff training, the teaching materials, the social and intellectual experience furnished by the institution. The study showed that the IES department enjoyed a high rate of student satisfaction compared to rest of the academic department in the university. Healey (2008) presented the aspect of internationalization of higher education. He showed that due to globalization, higher education became an export sector for many countries. He showed that licensing production, in the form of franchising degree provision to international partners, began to mutate into foreign direct investment as many universities set up campuses in other countries. The paper examined the supply- and demand-side drivers within the university sector. It concluded that current trends of commercialization and internationalization of higher education were unsustainable in the medium term. In Indian context Varma and Kapur (2010) examined whether various aspects of undergraduate education at the Indian Institutes of Technology (IITs) such as – students' access, satisfaction and attitude toward their future plans were influenced by their socioeconomic status. Findings of the survey conducted with nearly 260 students at two out of five original IITs in 2007-2008, revealed that access to the IITs, satisfaction at the IITs, and future plans after the IITs are strongly correlated to students' socioeconomic status.

3. Higher education system in the country and in the state of West Bengal

India is the second most populous country in the world. Despite the world's largest number of people in the working age group, there is a shortage of employable talent and skill. The biggest challenge before the country today is to make the available manpower employable by imparting proper education so that they can meet the growing need of a rapidly expanding economy. The government is committed to improve the quality of education in view of the fast changing domestic and global scenario. For this purpose, the government has taken/proposed a number of major initiatives during the XIth Five-Year-Plan.

In Indian education system a three-level hierarchy is observed (Figure 1). The first level is the elementary or primary education in which the children enter into the education system at the age of six. Prior to that, they may be admitted into kindergartens (KG) at the age four to six to prepare them for primary school. After completing the secondary education in schools, students enter into the colleges and universities for higher education. Up to the secondary education level all the students go through generalized courses. After this level, students may opt a specialized professional course out of a lot of diverse courses. The taxonomy of higher education is shown in Figure 2.

There has been an impressive growth in the area of university and higher education. According to University Grant Commission (UGC) enrollment in various courses at all levels in universities/colleges and other institutions of higher education in 2010-2011 was 16.97 million. Out of this the number of women students was 7.05 million constituting 41.5 percent. There has been a significant increase in the students' enrollment under open and distance education system. At present, 568 university level institutions, nearly 2,300 engineering colleges are running in India and 600,000 students are passing out in each year (Biswas *et al.*, 2010).

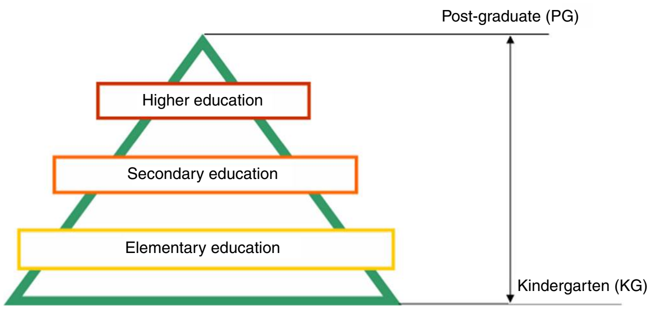

Figure 1.
Hierarchy of Indian education system

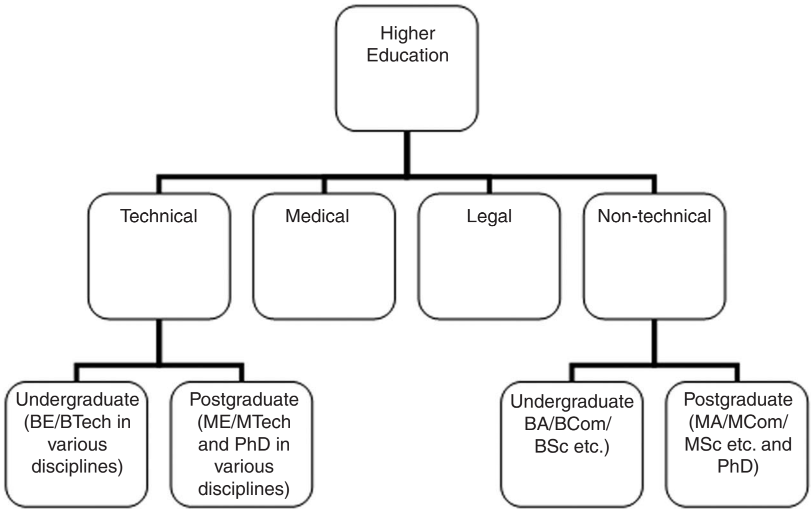

Figure 2.
Taxonomy of higher education

3.1 Technical and higher education system in West Bengal

There are 23 universities catering to all the branches of higher education in the state of West Bengal. Out of these only five universities are covering engineering education in bachelors and masters level. Most of them are funded by the state government. Almost all the engineering colleges (82 in number) of the state are affiliated to West Bengal University of Technology (WBUT). Apart from five government colleges under WBUT, all the remaining colleges are being run by private management. These private colleges are located in cities, hilly areas and remote villages. There are wide varieties in the resources, infrastructures and facilities in these private colleges. At this juncture the objective of this paper is to propose an exotic, simple and robust model for performance evaluation of these colleges. The contribution of the present work is that the proposed model is easy to deal with; complex mathematics is not required and it the evaluation criteria encompass stakeholders' requirements.

4. The proposed model

4.1 Selection of evaluation criteria

The performance of technical institutions in absolute sense is very difficult to measure. There are lot of factors/criteria/attributes/objectives relating to the performance of the institutions and the evaluation result is very much sensitive to the selection of the criteria.

For our study we formed an expert committee consisting of 15 experts in the field of teaching at UG/PG level, academic planning and administration and industry management responsible for providing employment. We prepared a questionnaire containing 50 questions related to criteria selection and the same was circulated among the experts. Aggregating their views by doing pareto analysis following criteria are short listed for the study. Also, the expert committee helped us to determine the relative importance of criteria through fuzzy AHP:

- student intake (SI);
- faculty strength (FS);
- number of books in library (BOOKS);
- percentage of students getting degree grade point average 7 and above (DGPA);
- percentage of students placed on campus (PLACEMENT); and
- annual drop out (DO).

In our study we classify the criteria as either beneficial (i.e. higher the better) or non-beneficial criteria (i.e. lower the better). To simplify the analysis above six criteria are reduced to five criteria by computing faculty strength per student intake, number of books in the library per student intake and annual drop out per student intake. Thus the final five criteria for analysis becomes:

(1) faculty strength per student intake (FS/SI);

(2) number of books in library per student intake (BOOKS/SI);

(3) percentage of students getting degree grade point average 7 and above (DGPA);

(4) percentage of students placed on campus (PLACEMENT); and

(5) annual drop out per student intake (DO/SI).

All the criteria mentioned above are self-explanatory. Out of five criteria listed above, first four criteria are considered as beneficial and the last one is considered as non-beneficial criteria. The data used in this paper have been provided by the management of the institutes.

4.2 The methods

Multiple criteria decision making is not an esoteric subject. Irrespective of field, it can be employed to select and prioritize the alternatives in the set. Lot of multiple criteria analysis tools like – AHP (Saaty, 1980), TOPSIS (Hwang and Yoon, 1981), DEA (Charnes *et al.*, 1978), MOORA (Brauers and Zavadskas, 2006), etc., are available for performance evaluation and ranking of alternatives. In this paper we use fuzzy AHP to determine the weights of the evaluation criteria and MOOSRA (Das *et al.*, 2012c) method for performance evaluation of technical institutions. The output of the fuzzy AHP is the input to the MOOSRA method. Fuzzy AHP has been chosen because assessment of relative importance of criteria is made according to the perception and understanding of set of experts. For the study we use MOOSRA method because of its several advantages (Das *et al.*, 2012c) (Like – Less computational time, very simple and stable, high robustness, etc.) over other MCDM methods such as MOORA, AHP, TOPSIS, VIKOR, ELECTRE, etc. Figure 3 presents schematic view of the proposed model which can be divided into three phases. The Phase-I deals with team working. The weights of the criteria are determined in Phase-II and finally the alternatives are ranked in Phase-III.

4.2.1 Fuzzy AHP. The AHP is a MCDM tool to render subjective judgment on one criteria over another. This tool which is first introduced by Saaty (1980) works on eigenvalue approach to the pairwise comparison. In this method the relative preference of the qualitative factors are expressed in terms of Saaty's nine-point scale. The AHP method is based on three principles: first, structure of the model; second, comparative judgment of the alternatives and the criteria; third, synthesis of the priorities. In the literature, AHP has been widely used in solving many complicated decision-making problems.

Though the AHP is very much able to deal with the expert's knowledge and experiences by perception or preference, it still cannot reflect the human thought totally with the crisp numbers. Therefore, the fuzzy AHP that integrates the fuzzy theory (Zadeh, 1965) into AHP environment is applied here to solve the performance evaluation problem of technical institutions of the state of West Bengal.

Fuzzy set which is an extension of crisp set deals with ambiguous or imprecise data. It was first introduced by Zadeh (1965). A fuzzy set is characterized by a membership function which assigns to each object a grade of membership ranging between zero and one. Triangular and trapezoidal fuzzy numbers are normally used to capture the vagueness of the parameters related to select the alternatives. The triangular fuzzy number (TFN) is very simple to use and calculate. It helps in decision-making problems where the information available is subjective and imprecise. In practical applications, the triangular form of the membership function is used most often for representing fuzzy numbers (Ding and Liang, 2005; Xu and Chen, 2007) that can be defined by a triplet $M = (l, m, u)$, m is the median value of fuzzy number M. l and u is the left and right side of fuzzy number M, respectively, as shown in Figure 4. Some basic important definitions of fuzzy sets can be found in Zimmerman (1996), Raj and Kumar (1999), Cheng and Lin (2002), Chen *et al.* (2006), Önüt and Soner (2008), Wang and Chang (2007), Lee *et al.* (2009).

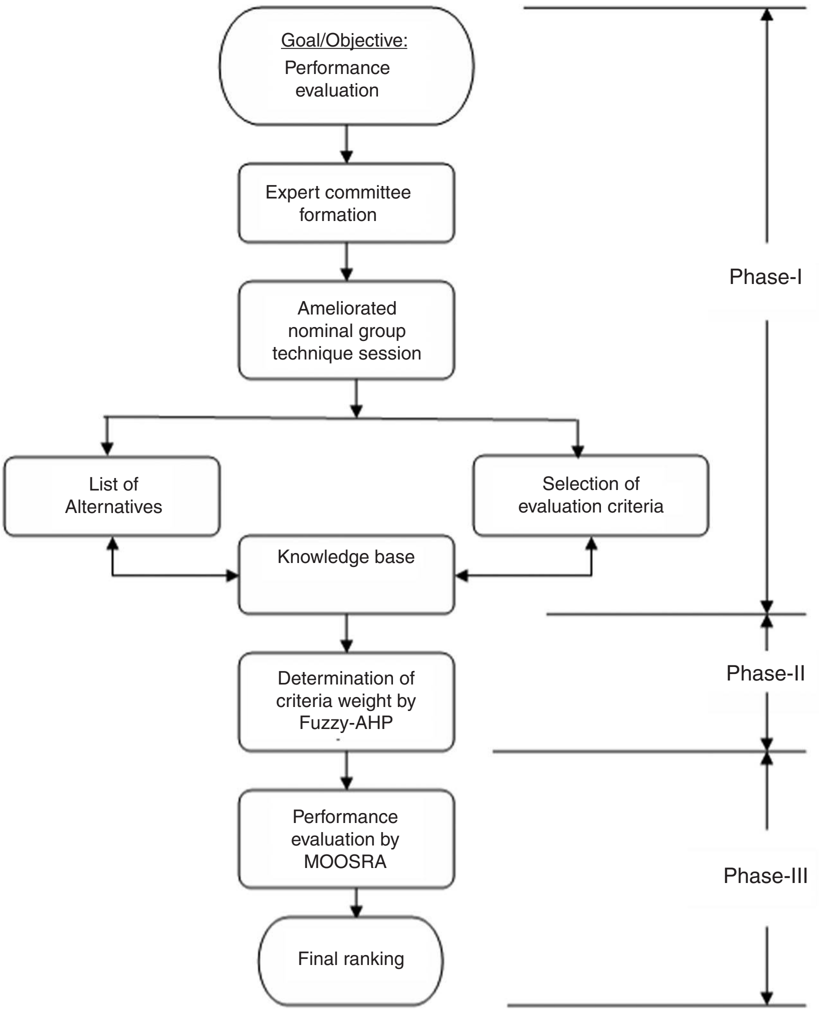

Figure 3.
Schematic view of the proposed model

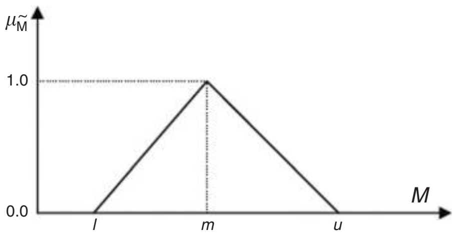

Figure 4.
Triangular fuzzy number *M*

The membership function $\mu_M(x)$ can be defined as:

$$\mu_M(x) = \begin{cases} 0, if \ \ x \prec l \\ \frac{x-l}{m-l}, l \leqslant x \leqslant m \\ \frac{x-u}{m-u}, m \leqslant x \leqslant u \\ 0, if \ x \succ u \end{cases} \quad (1)$$

Fuzzy scale (Chang, 1996) for pairwise comparisons of one criterion over another is shown in Table I. This scale is used to develop pairwise comparison matrix.

In this paper the extent fuzzy AHP is utilized, which was originally introduced by Chang (1996).

4.2.2 MOOSRA. Like other MCDM tool, MOOSRA method, as proposed by Das *et al.* (2012c), is used to prioritize the alternatives on the basis of several criteria or objective. The computational procedure of this method has been described in the following steps:

Step 1. Formation of the decision matrix.

This methodology starts with the definition of decision matrix which has in general four components, namely: alternatives; criteria or attributes; subjective weights or significance coefficients of each criteria and; measure of performance of alternatives with respect to the criteria. The decision matrix can be expressed as follows:

$$\begin{matrix} C_1 & C_2 & .. & C_j & .. & C_n \\ W_1 & W_2 & .. & W_j & .. & W_n \end{matrix}$$

$$D = [x_{ij}] = \begin{matrix} A_1 \\ A_2 \\ .. \\ .. \\ A_i \\ .. \\ .. \\ A_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & .. & x_{1j} & .. & x_{1n} \\ x_{21} & x_{22} & .. & x_{2j} & .. & x_{2n} \\ .. & .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. & .. \\ x_{i1} & x_{i2} & .. & x_{ij} & .. & x_{in} \\ .. & .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. & .. \\ x_{m1} & x_{m2} & .. & x_{mj}. & .. & x_{mn} \end{bmatrix} \quad (2)$$

where A_i represents the alternatives, $i = 1, 2, \ldots, m$; C_j represents jth criterion or attribute, $j = 1, 2, \ldots, n$, related to ith alternative. The criteria or attributes are classified

Preference of pairwise comparisons	Fuzzy numbers
Equal	(1,1,1)
Moderate	(0.67,1,1.5)
Fairly strong	(1.5,2,2.5)
Very strong	(2.5,3,3.5)
Absolute	(3.5,4,4.5)

Table I. Fuzzy Scale

as either beneficial criteria or non-beneficial criteria. The subjective weight of the jth attribute is denoted by W_j; and x_{ij} indicates the performance of each alternative A_i with respect to each criterion C_j.

Step 2. Normalization of the decision matrix.

Like MOORA method, the normalized elements of the decision matrix in MOOSRA method are computed using the ratio form as shown in Equation (3). In this method each performance of an alternative on an objective is compared to a denominator which is a representative for all the alternatives concerning that objective. This denominator is basically the square root of the sum of squares of each alternative per objective. This ratio is expressed as:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \quad (\text{for } j = 1, 2, \ldots\ldots n) \tag{3}$$

The value x_{ij}^{*} represents the normalized performance of ith alternative on jth objective. This value belongs to the interval of [0, 1] and it is a dimensionless number.

Step 3. Determination of performance score of the alternatives.

The performance score (y_j) of alternative is computed as the simple ratio of weighted sum of beneficial criteria to the weighted sum of non-beneficial criteria. This is shown in the following equation:

$$y_i = \frac{\sum_{j=1}^{g} w_j x_{ij}^{*}}{\sum_{j=g+1}^{n} w_j x_{ij}^{*}} \tag{4}$$

with $j = 1,2, \ldots, g$ indicate the beneficial criteria, and $j = g+1, g+2, \ldots\ldots\ldots, n$ indicate the non-beneficial criteria. W_j is the Associated weight of the jth attribute.

If we consider that the attributes are equally important then the optimization formula becomes:

$$y_i = \frac{\sum_{j=1}^{g} x_{ij}^{*}}{\sum_{j=g+1}^{n} x_{ij}^{*}} \tag{5}$$

An ordinal ranking of y_i indicates the ranking of the alternatives.

5. Data and computation

The proposed integrated fuzzy AHP-MOOSRA model for performance evaluation of private colleges in West Bengal consists of two basic stages: determination of weights of importance of evaluation criteria and evaluation and ranking of alternatives using MOOSRA. After identification of evaluation criteria with the help of expert committee, fuzzy linguistic values are used to determine weights of criteria. Though the evaluation criteria are quantitative, their relative importance has been determined through fuzzification by different experts. So it is the opinion of experts who conceive and perceive these factors under the unstructured and ill-defined environment to assess their relative importance irrespective of the alternatives. Under many conditions, crisp data are inadequate or insufficient to model real life decision problems. Indeed, human judgments including preference information are vague or fuzzy in nature and as such it may not be appropriate to represent them by accurate numerical values. A more realistic approach could be to use linguistic variables to model human judgments. So, in this paper we use fuzzy AHP to determine weights of criteria.

5.1 Priority of criteria

Considering the feedback of the experts from various fields, we form pairwise comparison matrix of five criteria to get their relative weight over other. Table II shows the fuzzy evaluation of the criteria. The value of fuzzy synthetic extent S_i with respect to the *i*th object is shown in the last column of Table II.

Using extent analysis method of defuzzification proposed by Chang (1996) the degree of possibility of $S_j = (l_j, m_j, u_j) \geqslant S_i = (l_i, m_i, u_i)$ can be computed by comparing the values of S_i as determined above. Table III shows the values of $V(S_j \geqslant S_i)$.

The weight vector which is basically the minimum degree of possibility of $V(S_j \geqslant S_i)$ for $i,j = 1,2,3, \ldots, k$ becomes:

$$W' = (1.000,\ 0.167,\ 0.235,\ 0.619,\ 0.176)^{T}$$

Normalizing the weight vector we get:

$$W = (0.455,\ 0.076,\ 0.107,\ 0.282,\ 0.080)^{T}$$

Therefore, the final weights of six criteria FS/SI, BOOKS/SI, DGPA, PLACEMENT and DO/SI become 0.455, 0.076, 0.107, 0.282 and 0.080, respectively. The relative weights which are non-fuzzy numbers are described in the following figure (Figure 5).

5.2 Performance evaluation of institutions using MOOSRA method

For the purpose of performance evaluation of the technical institutions, the quantitative data used are shown in Table IV. In the table the institutions are considered as the alternatives and these are placed in the rows. The criteria or attributes are placed in columns. The graphical representations of the same are also shown in the Figure 6.

The normalized performance scores of the alternatives with respect to the considered attributes are shown in Table V. Then, according to MOOSRA methodology, we determine the performance score (y_i) of all the alternatives by computing simple ratio of sum of weighted normalized beneficial criteria to the sum of weighted normalized non-beneficial criteria. The results are shown in Table V that

Criteria	FS/SI	BOOKS/SI	DGPA	PLACEMENT	DO/SI	S_i
FS/SI	(1.00,1.00,1.00)	(0.67,1.00,1.50)	(1.50,2.00,2.50)	(1.50,2.00,2.50)	(2.50,3.00,3.50)	(0.20,0.30,0.45)
BOOKS/SI	(0.67,1.00,1.50)	(1.00,1.00,1.00)	(1.00,1.00,1.00)	(0.40,0.50,0.67)	(0.67,1.00,1.50)	(0.10,0.15,0.23)
DGPA	(0.40,0.50,0.67)	(1.00,1.00,1.00)	(1.00,1.00,1.00)	(0.40,0.50,0.67)	(1.50,2.00,2.50)	(0.12,0.17,0.24)
PLACEMENT	(0.40,0.50,0.67)	(1.50,2.00,2.50)	(1.50,2.00,2.50)	(1.00,1.00,1.00)	(1.50,2.00,2.50)	(0.16,0.25,0.37)
DO/SI	(0.29,0.33,0.40)	(0.67,1.00,1.50)	(1.00,1.00,1.00)	(0.40,0.50,0.67)	(1.00,1.00,1.00)	(0.09,0.13,0.19)

Table II. Fuzzy evaluation of the criteria

$V(S_j \geqslant S_i)$	Value	$V(S_j \geqslant S_i)$	Value	$V(S_j \geqslant S_i)$	Value	$V(S_j \geqslant S_i)$	Value	$V(S_j \geqslant S_i)$	Value
$V(S_1 \geqslant S_2)$	1.000	$V(S_2 \geqslant S_1)$	0.167	$V(S_3 \geqslant S_1)$	0.235	$V(S_4 \geqslant S_1)$	0.619	$V(S_5 \geqslant S_1)$	0.176
$V(S_1 \geqslant S_3)$	1.000	$V(S_2 \geqslant S_3)$	0.846	$V(S_3 \geqslant S_2)$	1.000	$V(S_4 \geqslant S_2)$	1.000	$V(S_5 \geqslant S_2)$	1.000
$V(S_1 \geqslant S_4)$	1.000	$V(S_2 \geqslant S_4)$	0.562	$V(S_3 \geqslant S_4)$	0.667	$V(S_4 \geqslant S_3)$	1.000	$V(S_5 \geqslant S_3)$	0.917
$V(S_1 \geqslant S_5)$	1.000	$V(S_2 \geqslant S_5)$	0.917	$V(S_3 \geqslant S_5)$	1.000	$V(S_4 \geqslant S_5)$	1.000	$V(S_5 \geqslant S_4)$	0.600

Table III. Values of $V(S_j \geqslant S_i)$

exhibits the MOOSRA method based comparative ranking of alternatives as E>F>A>H>D>C>G>B when arranged according to descending order of their performance score. The graphical view of the scores is also presented in Figure 7.

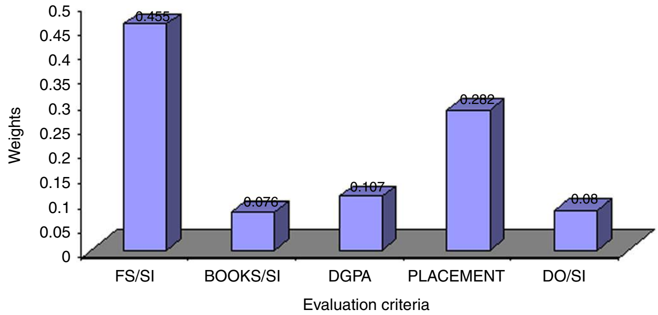

Figure 5.
Relative weights for evaluation criteria

Table IV.
Quantitative data for performance evaluation of alternatives

Criteria→Optimization direction→Alternatives↓	FS/SI max	BOOKS/SI max	DGPA max	PLACEMENT max	DO/SI min
A	0.222	55.833	0.850	0.600	0.014
B	0.234	55.447	0.917	0.830	0.039
C	0.275	78.703	0.940	0.650	0.031
D	0.219	48.788	0.690	0.550	0.021
E	0.156	50.000	0.800	0.600	0.010
F	0.227	69.233	0.340	0.510	0.012
G	0.222	97.037	0.700	0.750	0.030
H	0.235	64.706	0.500	0.750	0.020
$\sum_{i=1}^{8} x_{ij}^2$	0.409	35,662.443	4.418	3.519	0.005
$\sqrt{\sum_{i=1}^{8} x_{ij}^2}$	0.639	188.845	2.102	1.876	0.068

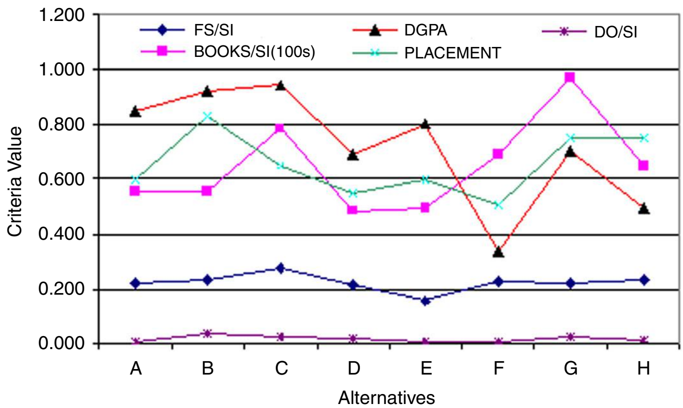

Figure 6.
Graphical display of criteria value of the alternatives

In Figure 7 we see that the composite performance scores of institutions A, E and F are above the mean performance score value. Therefore these three institutions can be considered as the peer group or benchmark for the remaining five institutions which lie below the mean line of the performance score value.

6. Sensitivity analysis

In earlier section relative performances of institutions have been determined using fuzzy AHP-MOOSRA method with respect to five evaluation criteria. The importance of evaluation criteria has been determined with the help of experts' opinion through fuzzy AHP method. As mentioned earlier that, it is the opinion of experts who conceive and perceive these factors under the unstructured and ill-defined environment to assess their relative importance irrespective of the alternatives, therefore in this section an effort has been exerted to see how the ranking of the institutions change if the value of criteria weights interchange among themselves. There being five criteria (C_1-C_5), the possible number of interchanges become ten (${}^5C_2$). Thus ten sets of priority rankings of institutions are available and the same have been shown in the sensitivity plot in Figure 8.

Table VI prioritizes a candidate-institution when comparing the same with the associated candidate-alternatives by interchanging the weights of a pair of criteria. It may be noted that the candidate-institution E outperforms over other institutions in almost all the cases. It is clear from the sensitivity plot that, in general, the rankings

Weights ALT	0.455 FS/SI	0.076 BOOKS/SI	0.107 DGPA	0.282 PLACEMENT	0.08 DO/SI	y_i	Rank
A	0.348	0.296	0.404	0.320	0.204	19.269	3
B	0.366	0.294	0.436	0.442	0.576	7.819	8
C	0.430	0.417	0.447	0.347	0.448	10.400	6
D	0.343	0.258	0.328	0.293	0.314	11.664	5
E	0.244	0.265	0.381	0.320	0.153	21.451	1
F	0.356	0.367	0.162	0.272	0.178	19.935	2
G	0.348	0.514	0.333	0.400	0.435	9.938	7
H	0.368	0.343	0.238	0.400	0.288	14.414	4

Table V. Normalized decision matrix and results of MOOSRA method

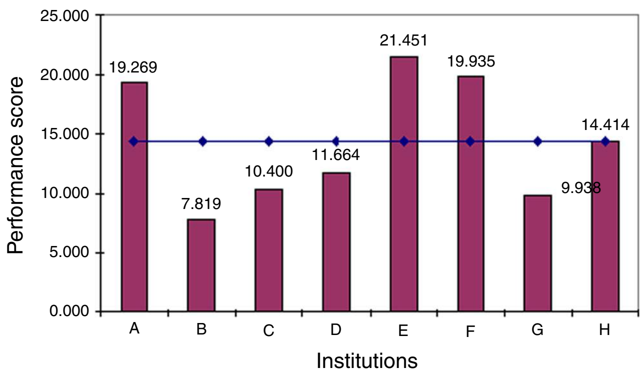

Figure 7. Graphical view of the performance scores of the alternatives

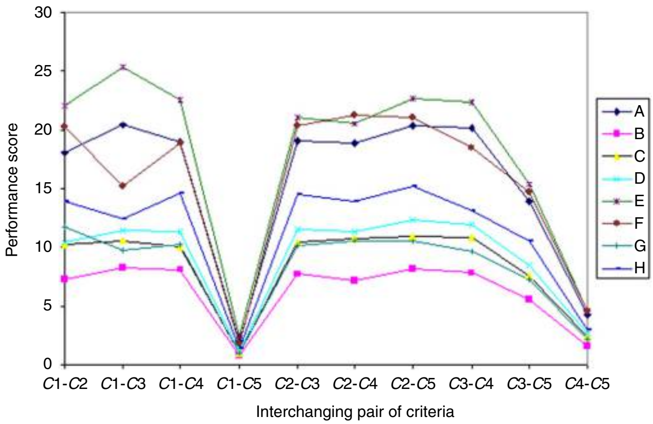

Figure 8.
Sensitivity analysis

Table VI.
Priority rankings of the candidate-institutions for interchanging criteria weights

Interchanging pair of criteria	Order of preference
C_1-C_2	E>F>A>H>G>D>C>B
C_1-C_3	E>A>F>H>D>C>G>B
C_1-C_4	E>A>F>H>D>G>C>B
C_1-C_5	E>A>F>H>D>G>C>B
C_2-C_3	E>A>F>H>D>C>G>B
C_2-C_4	F>E>A>H>D>C>G>B
C_2-C_5	E>F>A>H>D>C>G>B
C_3-C_4	E>A>F>H>D>C>G>B
C_3-C_5	F>E>A>H>D>C>G>B
C_4-C_5	F>E>A>H>D>C>G>B

of the institutions do not vary greatly even often interchanging the criteria weights. This clearly indicates ranking of the institutions obtained by the methodology is highly justified.

7. Discussion and conclusion

It is clear from Figure 7 that the relative performance score for the institutions B, C, D and G are well below the mean performance score. According to MOOSRA methodology as explained in Section 4.2.2, the relative performance score is determined by computing a simple ratio of weighted sum of beneficial criteria to weighted sum of non-beneficial criteria (Equation (4)). If there is only one criterion which is either beneficial criteria or non-beneficial criteria, the same plays a crucial role in the evaluation of performance score. In this research problem there is only one non-beneficial criterion which is annual drop out per student intake (DO/SI) and it has been observed in Table V that the performance score (y_i) has become very much sensitive to this criterion.

From normalized decision matrix the table of the weighted sum of beneficial criteria and non-beneficial criteria have been computed and shown in Table VII. It is clear from the Table VII that almost all the cases, the rankings of the institutions are inversely proportional to weighted sum of non-beneficial criteria (DO/SI).

It is evident both from Table VII and scatter plot of institutions presented in Figure 9 that the institution E ranks first primarily because of its lowest weighted non-beneficial criterion. Though the institution C, G and B have got higher values of weighted sum of beneficial criteria, these institutions get sixth, seventh and last position in the comparative ranking due to their lower values of weighted non-beneficial criterion which is annual drop out of students per student intake.

There are many factors which play a vital role for higher value of drop out rate. If a particular institution fails to attract good students, the probability of success rate of students in degree examination decreases. Geographical location of the institutions may become another factor. Students generally prefer to get admitted in the institutions at major cities. As the probability of getting good students in these institutions is more than the institutions in district villages, therefore, in general, the students studying in institutions located in major cities do well in the examinations and it results a lower drop out rate. The quality of faculty and infrastructural facilities may affect the drop out rate also.

This paper applies fuzzy AHP-MOOSRA methodology to evaluate the performance of the private engineering colleges in the state of West Bengal of the country. The study reveals that the institution E is the best. According to the method the ranking we get is in the order of E>F>A>H>D>C>G>B. Due to generic nature, the proposed model can be used for performance evaluation of any kind of organization. Apart from private engineering colleges the performance of other academic institutions in national and state level can be evaluated using the proposed model and it becomes the future scope of the present work.

Table VII. Weighted sum of beneficial and non-beneficial criteria

Institutions	A	B	C	D	E	F	G	H
Weighted sum of beneficial criteria	0.314	0.360	0.373	0.293	0.262	0.284	0.346	0.332
Weighted sum of non-beneficial criteria (DO/SI)	0.016	0.046	0.036	0.025	0.012	0.014	0.035	0.023
Rank	3	8	6	5	1	2	7	4

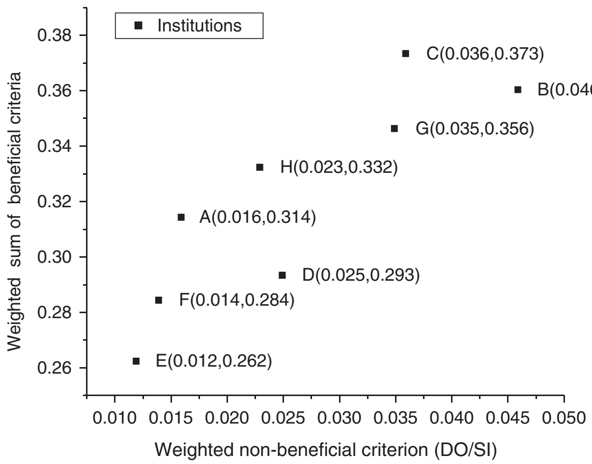

Figure 9. Scatter plot of institutions

References

Abbott, M. and Doucouliagos, C. (2003), "The efficiency of Australian universities: a data envelopment analysis", *Economics of Education Review*, Vol. 22 No. 1, pp. 89-97.

Athanassopoulos, A. and Shale, E. (1997), "Assessing the comparative efficiency of higher education institutions in the UK by means of data envelopment analysis", *Education Economics*, Vol. 5 No. 2, pp. 117-134.

Avkiran, N.K. (2001), "Investigating technical and scale efficiency of Australian Universities through data envelopment analysis", *Socio Economic Planning Sciences*, Vol. 35 No. 1, pp. 57-80.

Biswas, G., Chopra, K.L., Jha, C.S. and Singh, D.V. (2010), *Profile of Engineering Education in India: Status, Concerns and Recommendations*, Narosa Publishing House Pvt. Ltd, New Delhi.

Brauers, W.K.M. and Zavadskas, E.K. (2006), "The MOORA method and its application to privatization in a transition economy", *Control and Cybernetics*, Vol. 35 No. 2, pp. 445-469.

Casu, B. and Thanassoulis, E. (2006), "Evaluating cost efficiency in central administrative services in UK universities", *Omega*, Vol. 34 No. 5, pp. 417-426.

Chang, D.Y. (1996), "Applications of the extent analysis method on fuzzy AHP", *European Journal of Operational Research*, Vol. 95 No. 3, pp. 649-655.

Charnes, A., Cooper, W.W. and Rhodes, E.L. (1978), "Measuring the efficiency of decision making units", *European Journal of Operational Research*, Vol. 2 No. 6, pp. 429-444.

Chen, C.T., Lin, C.T. and Huang, S.F. (2006), "A fuzzy approach for supplier evaluation and selection in supply chain management", *International Journal of Production Economics*, Vol. 102 No. 2, pp. 289-301.

Cheng, C.H. and Lin, Y. (2002), "Evaluating the best main battle tank using fuzzy decision theory with linguistic criteria evaluation", *European Journal of Operational Research*, Vol. 142 No. 1, pp. 174-186.

Das, M.C., Sarkar, B. and Ray, S. (2012a), "A framework to measure relative performance of Indian technical institutions using integrated fuzzy AHP and COPRAS methodology", *Socio Economic Planning Sciences*, Vol. 46 No. 3, pp. 230-241.

Das, M.C., Sarkar, B. and Ray, S. (2012b), "Comparative evaluation of Indian technical institutions using fuzzy AHP and MOORA", *International Journal of Multicriteria Decision Making*, Vol. 2 No. 1, pp. 74-93.

Das, M.C., Sarkar, B. and Ray, S. (2012c), "Decision making under conflicting environment: a new MCDM method", *International Journal of Applied Decision Sciences*, Vol. 5 No. 2, pp. 142-162.

Diamantis, G.V. and Benos, V.K. (2007), "Measuring student satisfaction with their studies in an International and European Studies Department", *Operational Research: An International Journal*, Vol. 7 No. 1, pp. 47-59.

Ding, J.F. and Liang, G.S. (2005), "Using fuzzy MCDM to select partners of strategic alliances for liner shipping", *Information Sciences*, Vol. 173 Nos 1/3, pp. 197-225.

Fandel, G. (2007), "On the performance of universities in North Rhine-Westphalia, Germany: government's redistribution of funds judged using DEA efficiency measures", *European Journal of Operational Research*, Vol. 176 No. 1, pp. 521-533.

Flegg, A.T., Allen, D.O., Field, K. and Thurlow, T.W. (2004), "Measuring the efficiency and productivity of British universities: an application of DEA and the Malmquist approach", *Education Economics*, Vol. 12 No. 3, pp. 231-249.

Glass, J.C., McKillop, D.G. and Hyndman, N. (1995). "Efficiency in the provision of university teaching and research: an empirical analysis of UK universities", *Journal of Applied Econometrics*, Vol. 10 No. 1, pp. 61-72.

Hashimoto, K. and Cohn, E. (1997), "Economies of scale and scope in Japanese private universities", *Education Economics*, Vol. 5 No. 2, pp. 107-115.

Healey, N.M. (2008), "Is higher education in really 'internationalising'?", *Higher Education*, Vol. 55 No. 3, pp. 333-355.

Herbert, D.T. and Thomas, C.J. (1998), "School performance, league tables and social geography", *Applied Geography*, Vol. 18 No. 3, pp. 199-223.

Hwang, C.L. and Yoon, K. (1981), *Multiple Attribute Decision Making Methods and Applications*, Springer, Berlin Heidelberg.

James, E. (1991), "Private higher education: the Philippines as a prototype", *Higher Education*, Vol. 21 No. 2, pp. 189-206.

Johnes, J. (1996), "Performance assessment in higher education in Britain", *European Journal of Operational Research*, Vol. 89 No. 1, pp. 18-33.

Johnes, J. (2006), "Measuring teaching efficiency in higher education: an application of data envelopment analysis to economics graduates from UK Universities 1993", *European Journal of Operational Research*, Vol. 174 No. 1, pp. 443-456.

Johnstone, D.B. (1988), "The financing and management of higher education: a status report on worldwide reforms", *UNESCO World Conference on Higher Education*, October 5-9, Paris.

Kao, C. and Hung, H.T. (2008), "Efficiency analysis of university departments: an empirical study", *Omega*, Vol. 36 No. 4, pp. 653-664.

Korhonen, P., Tainio, R. and Wallenius, J. (2001), "Value efficiency analysis of academic research", *European Journal of Operational Research*, Vol. 130 No. 1, pp. 121-132.

Lee, S.K., Mogi, G. and Kim, J.W. (2009), "Decision support for prioritizing energy technologies against high oil prices: a fuzzy analytic hierarchy process approach", *Journal of Loss Prevention in the Process Industries*, Vol. 22 No. 6, pp. 915-920.

McMillan, M.L. and Datta, D. (1998), "The relative efficiency of Canadian universities: a DEA perspective", *Canadian Public Policy*, Vol. 24 No. 4, pp. 485-511.

Nicholls, M.G. and Cargill, B.J. (2011), "Establishing best practice university research funding strategies using mixed-mode modelling", *Omega*, Vol. 39 No. 2, pp. 214-225.

Önüt, S. and Soner, S. (2008), "Transshipment site selection using the AHP and TOPSIS approaches under fuzzy environment", *Waste Management*, Vol. 28 No. 9, pp. 1552-1559.

Portela, M.C.A.S. and Thanassoulis, E. (2001), "Decomposing school and school-type efficiency", *European Journal of Operational Research*, Vol. 132 No. 2, pp. 357-373.

Raj, P.A. and Kumar, D.N. (1999), "Ranking alternatives with fuzzy weights using maximizing set and minimizing set", *Fuzzy Sets and Systems*, Vol. 105 No. 3, pp. 365-375.

Saaty, T.L. (1980), *The Analytic Hierarchy Process*, 1st ed., McGraw-Hill, New York, NY.

Sanyal, B. (1998), "Diversification of sources and the role of privatization in financing higher education in the Arab region", *Arab Regional Conference on Higher Education: Beirut, UNESCO Regional Office for Education in the Arab States, International Institute for Educational Planning*, *Paris*, *March 2-5*.

Simon, J., Simon, C. and Arias, A. (2011), "Changes in productivity of Spanish university libraries", *Omega*, Vol. 39 No. 5, pp. 578-588.

Tilak, J.B.G. (1991), "The privatization of higher education", *Prospects*, Vol. 21 No. 2, pp. 227-239.

Tyagi, P., Yadav, S.P. and Singh, S.P. (2009), "Relative performance of academic departments using DEA with sensitivity analysis", *Evaluation and Program Planning*, Vol. 32 No. 2, pp. 168-177.

Varma, R. and Kapur, D. (2010), "Access, satisfaction, and future: undergraduate education at the Indian Institutes of Technology", *Higher Education*, Vol. 59 No. 6, pp. 703-717.

Wang, T.C. and Chang, T.H. (2007), "Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment", *Expert Systems with Applications*, Vol. 33 No. 4, pp. 870-880.

Wilkinson, R. and Yussof, I. (2005), "Public and private provision of higher education in Malaysia: a comparative analysis", *Higher Education*, Vol. 50 No. 3, pp. 361-386.

World Bank (1994), *Higher Education: The Lessons of Experience*, The World Bank, Washington, DC.

World Bank (1995), *Priorities and Strategies in Education: A World Bank Review*, The World Bank, Washington, DC.

Worthington, A.C. and Lee, B.I. (2008), "Efficiency, technology and productivity change in Australian Universities, 1998–2003", *Economics of Education Review*, Vol. 27 No. 3, pp. 285-298.

Xu, Z.S. and Chen, J. (2007), "An interactive method for fuzzy multiple attribute group decision making", *Information Sciences*, Vol. 177 No. 1, pp. 248-263.

Yorke, M. (1997), "A good league table guide?", *Quality Assurance in Education*, Vol. 5 No. 2, pp. 61-72.

Yorke, M. (1998), "The Times' 'league table' of universities, 1997: a statistical appraisal", *Quality Assurance in Education*, Vol. 6 No. 1, pp. 58-60.

Zadeh, L.A. (1965), "Fuzzy sets", *Information Control*, Vol. 8 No. 3, pp. 338-353.

Zimmerman, H. J. (1996), *Fuzzy Sets Theory and its Applications*, Kluwer Academic Publishers, Boston, MA.

Further reading

Johnstone, D.B. (1988), "The financing and management of higher education: A status report on worldwide reforms", *UNESCO World Conference on Higher Education, Paris, October 5-9*.

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