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DEA for measuring the academic performance of a higher educational institute of Uttarakhand, India

Imran Ali[1], Millie Pant[2], U S Rana[3] and Sunil Kumar Jauhar[2]

[1]Department of Mathematics, Government PG College Gopeshwar, Chamoli, 246401, Uttarakhand, India
ali.imranmath@gmail.com

[2]Department of Applied Sciences and Engineering, Indian Institute of Technology Roorkee, 247667, Uttarakhand, India
millidma@gmail.com,suniljauhar.iitr@gmail.com

[3]Department of Mathematics, DAV PG College, Dehradun, 248001, Uttarakhand, India
drusrana@yahoo.co.in

***Abstract*: This paper estimates the performance assessment of 15 academic department of government PG College, Gopeshwar, Chamoli Uttarakhand (India) for the academic year 2011-2012. In Indian context efficiency of a government PG degree college of Uttarakhand state (India) is being measured for the first time to the best of authors knowledge. Using DEA models, we estimate the overall technical, pure technical and scale efficiency and identify the reference sets for inefficient departments for teaching and research separately. We also classify the academic departments in the high, middle and low robustness in terms of overall technical efficiency (OTE) for teaching and research efficiency.**

***Keywords*:** Data envelopment analysis, Higher educational institute, Teaching and research efficiency, Performance measurement

I. Introduction and background of the study area

In this study the target area is a government post graduate college (GPGC),Gopeshwar Chamoli Uttarakhand an A-grade, 50 years old, post graduate degree college(i.e. a higher educational institute). A grade is received by NAAC-Banglore in 2014. In general teaching is the main activity of the degree colleges, but in this college research is also given importance. The GPGC, Gopeshwar established in July 1966 and is affiliated to H.N.B. Garhwal University (a central university), Srinagar, Garhwal, Uttarakhand, India. The college has provision for twenty two academic departments out of which in seventeen departments UG and PG Courses are running and which are eligible for both teaching and research work. But from last 5 years (2009-2014) there is no faculty in two departments namely Music and Mathematics therefore we drop these two departments for this present study and we take only 15 academic departments for teaching, research and total efficiency measurements for the year 2011-2012 through DEA model.

The college encourages and motivates the faculty members to conduct quality research work. The college research committee actively supports the faculty members to promote the research work as per the norms and demands. Committee also extended support to organize International, national, state and local level seminars and workshops. The college faculty members has carried out good research and publication work last 6 or 7 years and organized various seminars and workshop of International, national and state level.

II. Literature review

Study of education system has been done by several researchers from time to time in context to different countries. A brief country wise relevant study conducted on education sector to measure the efficiency of various colleges, departments of college, HEI and university are given as follows:

Here we see that most of the studies are conducted in USA (Bessent et al. (1983), Nunamaker (1985), Ahn et al.(1989), Breu and Raab (1984) and Bougnol and Dula (2006) and UK (Tomkins and Green (1988), Beasley (1990, 1995), Johnes (1996), Izadi et al. (2002) and Jonhes (2006a)). Other countries include Australia (Avkiran (2001) and Abbott and Doucouliagos (2003)), China (Chu Ng and Li (2000) and Johnes and Li (2008)), Inida (Tyagi et al. (2009), Jauhar et al. (2016)), Germany (Fandel (2007)), Canada (Arcelus and Coleman (1997)), Taiwan (Kao and Hung (2008).

In the present study, the performance is measured through DEA, which depends a lot on the input and output parameters. Rayeni and Saljooghi (2010), used number of registered students , number of teaching staffs as input parameters (i/p) and number of graduates, number of passed students ,the

performed research work as output parameters (o/p). Aziz et al., (2012) considered academic and non-academic staff, operating expenses as input and no .of graduates, research grant, total no. of publication as output parameters. Aristovnik, A. (2013), considered expenditure per student, public expenditure per pupil as a % of GDP per capita, expenditure per student, total expenditure on education as i/p and school enrolment, teacher ratio, labor force, education, PISA 2006 average as o/p. Rosenmayer, T. (2014) considered expenses, no. of academic and non-academic Staffs as i/p and no. of graduates, no. of publications, applied research as o/p. Yousfat et al. (2015), took registered students, academic staff as i/p and net annual wages, successful students as o/p while Barra and Zotti (2016), took no. of academic staff, non-academic staff, operating cost on research activities, total amount of financial resources for teaching activities, total enrolled students as i/p and no. of publications, research funding, research productivity index, capacity resources index, no. of graduates, no. of undergraduates as o/p. researchers Jauhar et al. 2016 [24], took academic and non-academic staffs, no. of taught course students, average students qualifications, DOC, no. of research staffs, average research staff qualifications, no. of research students, research grants as i/p and no. of graduates from taught courses, average graduates results, graduate rates, graduate employment rate, GHG emission, no. of Ph.D. awards, no. of publications, no. of awards, no. of intellectual activities as o/p.

Besides background and literature review, given in sections 1 and 2 respectively, this paper has 5 more sections. DEA are briefed in section 3. In section 4 and 5 experimental setup and formulation of mathematical model which is used for performance assessment are discussed. In the section 6 results and discussion of this present study are given and finally in section 7, conclusions are given.

III. DEA model

A. *Ddata envelopment analysis*

DEA is a well known mathematical linear programming data analysis technique used by various researchers (Charnes et al.1978; Banker et al. 1984; Talluri 2000; Tyagi et al. 2009; Ramanathan 2003; Puri and Yadav 2015; Moga et al.2016; Jauhar et al.2016 respectively). It is used for measuring the relative performance of the Decision Making Units (DMU's) which includes departments of big organizations, such as universities, colleges, schools, hospitals, power plants, police stations, tax offices, a set of firms.DEA methodology is always successful to measure the performance efficiency of all these kinds of DMU's.

The performance assessment of DMU is given by Charnes et al.1978; as: The concept of efficiency or productivity, which is the ratio of total outputs to total inputs (or "ratio of weight sum of o/p to weight sum of i/p") i.e. It can be expressed in term of formula

$$Efficiency = \frac{\text{Weight sum of Outputs}}{\text{Weight sum of Inputs}} \quad (1)$$

The weights, which maximize the efficiency lies in the range 0 to 1, for a DMU are calculated using the mathematical programming. Such DMU is also known as by the term reference or base DMU or the DMU under the assessment (Ramanathan, R. 2003).

Fractional form of DEA

The mathematical program in fractional form is given by

$$Max\ e_o = \frac{\sum_{r=1}^{s} v_r \beta_{ro}}{\sum_{i=1}^{m} u_i \alpha_{io}} \quad (2)$$

Subject to

$$0 \le \frac{\sum_{r=1}^{s} v_r \beta_{rn}}{\sum_{i=1}^{m} u_i \alpha_{in}} \le 1; \quad n = 1,2,3 \ldots o, \ldots, N; r = 1,2,3, \ldots,$$

s and i = 1,2,3, …, m (3)

$$u_i, v_r \ge 0; \quad \text{for all i, r} \quad (4)$$

Where, e_o is the efficiency of the o^{th} DMU,
β_{ro} is the r^{th} output of the o^{th} DMU, and v_r is the weight for the output β_{ro} ,α_{io} is the i^{th} input of the o^{th} DMU, and u_i is the weight for the input α_{io}, β_{rn} and α_{in} are the r^{th} output and i^{th} input, respectively, of the n^{th} DMU, Where n = 1,2,3, …, $o^{\#}$, …,N;
Note that here n includes o (Ramanathan, R. 2003)

The fractional form obtained in the above equation can be easily reduced to a linear form from which we can easily obtain the CCR and BCC models of DEA given in the next sections:

General form of CCR DEA models: It can be defined as follows.

$$Max\ e_o = \sum_{r=1}^{s} v_r \beta_{ro} \quad (5)$$

$$Subject\ to = \sum_{r=1}^{m} u_i \alpha_{io} = 1, \quad (6)$$

$$\sum_{r=1}^{s} v_r \beta_{rn} - \sum_{i=1}^{m} u_i \alpha_{in} \le 0, \forall n \quad (7)$$

$$u_i, v_r \ge 0; \quad \text{for all i, r} \quad (8)$$

Similarly, we can define a general input minimization CCR DEA model.

Mathematically, the general form of BCC (Banker et al.1984) DEA model is given by

$$Max\ e_o = \sum_{r=1}^{s} v_r \beta_{ro} + u_{0o} \quad (9)$$

Subject to

$$\sum_{i=1}^{m} u_i \alpha_{io} = 1, \quad (10)$$

$$\sum_{r=1}^{s} v_r \beta_{rn} - \sum_{i=1}^{m} u_i \alpha_{in} + u_{0o} \le 0 \ \forall n \quad (11)$$

$u_i, v_r \geq 0$ and u_{0o} is unrestricted in sign (12)

The model executes n times to justify the efficiency scores of each DMU. The efficiency of all DMUs vary in the range between 0 and 1, if efficiency of a DMU is unity than it is efficient, otherwise it is called inefficient or less efficient.

IV. Experimental setup

A. ***Institution Selected:*** Government post graduates degree college (GPGC) Gopeshwar, Chamoli (Uttarakhand) India; it is an A-grade post graduate degree college (i.e. higher educational institute).

B. ***Decision making units (DMUs):*** Here fifteen academic departments of GPGC, Gopeshwar are taken. Academic departments are taken as DMUs by the following researchers Jauhar et al. (2016; Tyagi et al. 2009; Beasley 1995; Johnes and Johnes 1995) previously.

C. ***Inputs and outputs variables:*** Four inputs and three outputs have been chosen for the performance assessment of the teaching efficiency these are below given.

1) Inputs for teaching efficiency

a) *Number of academic staffs (α_1)* - Number of academic staff is must for all the departments for both research and teaching activity. It is also considered as inputs by the following researcher Jauhar et al. 2016; Tayagi et al. 2009; Kuah and Wong 2011; Johnes and Johnes 1995.

b) *Number of taught course students (α_2)* - Teaching is the initial work of all departments and is connected to the academic staff. In most of the department two types of students are enrolled (1) under graduates (UG) and (2) post graduates (PG) while in some departments only UG students are enrolled. So we take total enrolled students in UG & PG as an input variable. This input is also used as an input variable by the following researchers Kuah and Wong 2011; Jauhar et al. 2016; Tyagi et al. 2009.

c) *Average students qualification in percentage (α_3)* - To calculate the academic progress of the students at pass out level we take average students qualification as a input variable at entering level .This is also used as an input variable in Kuah and Wong 2011; Jauhar et al. 2016. It is the qualification of total enrolled students in UG and PG courses in a department.

d) *Departmental operating cost (DOC in rupees α_4)*- For development of all types of activities of the students and faculty in departments like as teaching and research departmental operating cost (DOC) is necessary. It has been also used previously by Basely 1995; Abbott and Doucouliagos2003; Tyagi et al. 2009; Jauhar et al. 2016.

2) Outputs for teaching efficiency

The outputs of teaching activities are focused on (1) Number of graduates from taught courses (β_1) (2) Average graduate's results in % (β_2) and (3) Graduate rate in % (β_3) of departments of the Gopeshwar degree college which are associated with the academic quality of graduates. Therefore we are taking these as output variables for teaching efficiency. The above outputs variables are taken by the following researchers, Kuah and Wong 2011; Jauhar et al. 2016. The above output variables are discussed as follows:

a) *Number of graduates from taught courses (β_1) - Consists* of UG and PG students who passed all the subjects of their concerned departments. Here, we form a new output variable "Number of graduates from taught courses".

b) *Average graduates results in percent (β_2)* - Outputs of teaching activities are focus on graduates. The average of the total passed students' results in percentage of UG and PG courses of a department of HEI is define as a new output variables namely "Average graduates results".

c) *Graduate rate in percent (β_3)* - Graduates rate of the students of a post graduates degree college (a HEI) are related to with the academic excellence of graduates. The pass out rate in percent of all the UG & PG enrolled students is defined as a output variable "Graduate rate".

D. ***Inputs and outputs for research efficiency mix*:** In this section we also taken four inputs and three outputs variable discussed as follows given below.

1) Inputs for research efficiency

a) *Departmental operating cost (DOC in rupees, α_5)* - As we know that DOC is a common source for both teaching and research activities therefore to measure the teaching and research efficiency of the academic departments of GP, Gopeshwar, Chamoli Uttarakhand. The proportion of the DOC for both functions is needs to be determined and hence the DOC for research is same as α_4.

b) *Number of research staffs (α_6)* - For research activities of UG, PG students in the department and for research of research scholars' in the department research staffs is

required. It is the important task in terms of human resource used by all academic departments of GPGC, Gopeshwar Chamoli for research purpose. Since in the department all the academic staff also involve in research and research activity accept the teaching activity so all the academic staff also we consider as a research staff. This input also used Kuah and Wang 2011, Jauhar et al. 2016.

c) *Average research staffs qualifications (α_7)* - The average research staffs qualifications of GPGC, Gopeswar Chamoli is calculated based on scoring system presented by Kuah and Wang 2011;(professor and above = 4, associate professor= 3, assistant professor = 2, lecturer and others =1).This input also used as a input variable Jauhar et al. (2016).

d) *Number of research students(α_8)* - The research scholar in the departments of post graduates degree colleges is minimum under any higher educational institute like universities campus, IITs, NITs etc., the reason is that there is no professor designation, lack of U grants and research lab but in post graduates degree college research activities is presents as in PG (M.Sc./ MA/ M.Com/MCA) degree courses like dissertation work/ Project in semester system is compulsory in the last semester and in year system it is compulsory in some PG courses and in some courses it is optional also some project work/field work/ industrial training are compulsory in some UG courses also some department doing the research project funded by UGC. Due to above reason and time required for the completion of the degree and credit (or percentage) completed for the degree we include these students also as a part of the total number of research students enrollment by this, we aim to measure whole contribution of the department for research that comes out as the input variables. Using these criteria we find "total enrolled research student's index" defind as:

Total enrolled research students index = 0.005 (number of UG students who is appear in first year) + 0.05 (number of PG students who is appear in first year) + 1.5 (number of faculties or students in the department of pg college doing the major (or minor) research projects funded by U/some other agency) + 2.0 (Number of research scholar guided by research staff of the department of college but not a research centre) +2.5 (Number of research scholars whose research guide and research centre is the research staff of the department of the PG degree college).

2) *Outputs for research efficiency*

The outputs of research activities are focused on number of graduates from research index (β_4) (or Research award index (β_4)), Number of publications (β_5) and Number of intellectual activities (β_6) of departments of government PG degree college Gopeshwar, Chamoli, Uttarakhand which are associated with the academic quality of the research graduates.

Therefore we are taking these as output variables for research efficiency. The above outputs variables are taken by the following researchers, Kuah and Wong 2011; Jauhar et al. 2016. The above output variables are discussed as follows:

a)Research award index (β_4) – According the total enrolled research scholar index we aim to find the total research award index which is defined as: Total research award index = 0.005 (number of UG students in the department who is done dissertation/ summer training/ project work/ industrial training in UG course work) + 0.05 (number of PG students in departments who is appear in final year and who is done dissertation/ summer training/ project work/ industrial training in PG course work) + 1.5 (Number of faculties or students completed the major(or minor) research projects funded by U/some other agency) + 2.0 (Number of research award students whose research guide and research centre is the research staff of the department and but PG college is not a research centre) +2.5 (Number of research award degree students whose research guide and research centre is the research staff of the department and PG degree college).

b)Number of publication (β_5) - Research publications is one of the main research activity performed by a department thus authors are considered as outputs for the research efficiency which includes A- book/chapter in books, /monograph, B- papers in journals, C- papers in conference/ symposia.

c)Number of intellectual activities (β_6) - Organization and participation of staff in conference, seminar, workshop, symposia, short term course, dissertation/ project in PG courses and UG courses in the departments of college done by the students under the guidance of academic staff.

E. ***Data collection:*** Input output data is collected from the national assessment and accreditation council (NAAC)-Bangalore in the year 2014. (i.e. NAAC report-2014 GPGC, Gopeshwar), staff statement register (SSR) of the academic year 2011-12 and from the examination section of the college. Some data is collected from the departments of the college and college annual book Madhuri of the academic year 2011-2012. Input and output data of 15 departments for teaching and research efficiency are given below in Table 1 and Table 2.

Characteristics	Inputs				Outputs		
	α_1	α_2	α_3	α_4	β_1	β_2 (%)	β_3 (%)
Max	5	384	68.41	15000	281	100	76.428
Min	1	20	47.41	150	13	41.88	42.50
Average	2.87	178.13	53.44	2270	108.6	86.52	57.95
S.D.	2.12	137.89	5.07	3323.40	125.15	11.83	12.83

Table 1. Inputs and Outputs data for teaching efficiency

Characteristics	Inputs				Outputs		
	α_5	α_6	α_7	α_8	β_4	β_5	β_6
Max	15000	5	10	7.45	3.75	7	35
Min	150	1	2	0.15	0	0	1
Average	2270	2.87	6.13	2.28	1.11	3.07	11.27
S.D.	3323.40	2.12	4.24	1.73	1.34	1.41	2.83

Table 2. Inputs and Outputs data for research efficiency

F. ***Choice of model:*** CCR and BCC output oriented DEA models are used for this study (i.e. constant return to scale (CRS) and variable return to scale (VRS) DEA approaches are used)

G. ***DEA variant used:*** DEAP version 2.1 (Coelli 1996) is used for all calculation related to DEA method.

V. Formulation of mathematical model

Let us assume n departments of a college DMU_1, DMU_2, DMU_3,…, DMU_n. Each department j, DMU_j (j=1,2,3,…, n) uses four inputs α_{ij} (i =1,2,3,4) to produce 3 outputs β_{rj} (r =1,2,3) from its teaching activities; and four inputs α_{ij} (i = 5,6,7,8) to produce 3 outputs β_{rj} (r = 4,5,6) from its research activities. Departmental operating cost (DOC) is common for the both teaching and research and thus apportioned in order to determine the teaching and research efficiency performance assessment.

Let us consider p to be the proportion of expenditure on teaching activities and let (1-p) be the proportion of expenditure on research activities, let input and output weight u_i (i = 1,2,3, …, m) and v_r (r = 1,2,3, …, s) as variables .Let the j^{th} DMU, DMU_j to be calculated on any trial be designated as DMU_o (o = 1,2,3, …, n). The teaching efficiency of the DMU_O is denoted by T_O and research efficiency of the DMU_o denoted by R_0 and defined (Kuah and Wang 2011) as:

$$T_o = \frac{\sum_{r=1}^{3} v_r \beta_{ro}}{\sum_{i=1}^{3} u_i \alpha_{io} + p(u_4 \alpha_{4o})} \quad (13)$$

$$R_o = \frac{\sum_{r=4}^{6} v_r \beta_{ro}}{\sum_{i=5}^{8} u_i \alpha_{io} + (1-p)\, u_4 \alpha_{4o}} \quad (14)$$

The DEA model to evaluate and measure the overall efficiency (E_0) is modeled as follows:

$$\text{Max } E_o = \frac{\sum_{r=1}^{6} v_r \beta_{ro}}{\sum_{i=1}^{8} u_i \alpha_{io}} \quad (15)$$

for E_o; subject to

$$\sum_{r=1}^{6} v_r \beta_{rj} - \sum_{i=1}^{8} u_i \ \alpha_{ij} \le 0, \text{ for all j} \quad (16)$$

for T_o;

$$\sum_{r=1}^{3} v_r \beta_{rj} - \sum_{i=1}^{3} u_i \alpha_{ij} - p(u_4 \alpha_{4o}) \quad (17)$$

≤ 0, for all j

For R_0;

$$\sum_{r=4}^{6} v_r \beta_{rj} - \sum_{i=5}^{8} u_i \alpha_{ij} - (1-p)(u_4 \alpha_{4o}) \le 0 \quad (18)$$

for all j

$$0.3 \le p \le 0.7 \quad (19)$$

$$u_i, v_r \ge \in \quad (20)$$

Equation (15) is the objective function to find the optimum (i.e. maximum / minimum) set of weight (u_i and v_r) that gives the maximum relative overall efficiency for j^{th} DMU, DMU_j under measurement, while subject to the constraints condition (16) to (20). Constraints (16) to (18) are to limit the relative overall efficiency (E_o), teaching efficiency (T_o) and research efficiency (R_o).

The model is executed to identifying the relative efficiency scores of all DMUs. If the efficiency score of the DMUs is 1 mean that it is considerable more efficient decision making unit, while less than 1 efficiency score DMUs are consider as inefficient. With the optimum set of weights for J^{th} DMU are evaluated, the teaching efficiency (T_0) and research efficiency (R_0) for j^{th} DMU are obtained by using (13) and (14) equations respectively. Same as BCC, DEA modeled to determined and assess the overall efficiency (E_0).

VI. Results and discussions

Teaching efficiency (T_0), research efficiency (R_0) and total efficiency (E_0) for 15 departments of government PG College Gopeshwar, Chamoli (Uttarakhand) is estimated for the year 2011-2012 using CCR and BCC output- oriented model. The

teaching, research and total efficiency scores are described as follows.

A. Result and discussion for teaching efficiency (T_0)

1) Overall technical efficiency (OTE)

The teaching efficiency results of 15 departments are given in table 3, from the result it is clear that out of all the 15 departments 8 departments (53.3%) are technically efficient since the OTE scores of these departments is 1. These departments are Hindi, Geography, History, Political science, Sociology, Military Sciences, Education, and Commerce. The remaining 7 (46.7%) departments are comparatively less technical efficient since the OTE scores of these 7 departments is less than 1.The average OTE score is 0.920. Five departments English, Physics, Chemistry, Botany, and Zoology have score less than the average efficiency score. The 8 efficient departments with codes D1, D4, D5, D6, D8 and D9 D10, D12 form the 'reference set' for inefficient departments. Since 0.617(61.7%) is the least efficiency from all the above 7 inefficient departments it can be said that English department (D3) is the most inefficient department and having an overall poor performance.

From the above 7 inefficient departments 5 departments have scored less than average efficiency and 2 departments have scored above the average efficiency score. The average overall technical efficiency score 0.920 reveals that on an average departments have to increase their output by 8.0% by maintaining the existing level of inputs. We also see that History and Political Science departments having peer count (=5) represents as peer for maximum number of departments, and can therefore be considered as the most technical efficient departments.

On the basis of peer counts, the efficient departments are categorized as follows:

H**igh robustness:** History department (D5, number of peer count =5) and political science department (D6, number of peer count=5) are measured high robust departments as they have maximum number of peer counts. Therefore, these departments characterized in the high robust group and can be considered as global leaders in terms of OTE.

Middle robustness: (3 ≤ number of peercounts≤ 4) Sociology department (D8, number of peer count = 4) is measure in the middle robust group in terms of OTE.

Low robustness: (1≤ number of peercounts≤2) Education department (D10, number of peer counts = 2), Commerce department (D12, number of peer counts =2) and Geography department (D4, number of peer count =1) are measured low robust departments as they have min. number of peer counts. Therefore these departments characterized in the low robust group in terms of OTE.

Sr. No.	Code	Name of Department	OTE (CRS Score)	Peer department (R.SET)	Peer weight	Peer count
1	D1	Hindi	1	D1	1	0
2	D3	English	0.617	D10,D12,D6	0.076,0.023, 0.916	0
3	D4	Geography	1	D4	1	1
4	D5	History	1	D5	1	5
5	D6	Political Science	1	D6	1	5
6	D7	Economics	0.954	D6,D8,D5	0.328,0.302, 0.437	0
7	D8	Sociology	1	D8	1	4
8	D9	Military Science	1	D9	1	0
9	D10	Education	1	D10	1	2
10	D12	Commerce	1	D12	1	2
11	D16	Physics	0.869	D5, D8	0.992,0.214	0
12	D17	Chemistry	0.716	D6, D4,,D9	0.415,0.209,0 . 583	0
13	D18	Geology	0.952	D5,D8	0.922,0.178	0
14	D19	Botany	0.851	D10, D6, D5	0.582,0.428,0 . 108	0
15	D20	Zoology	0.845	D5,D8,D6	0.784, 0.179, 0.274	0
		Average	0.920			

Table 3. Teaching efficiency scores of 15 academic departments using CCR model

2) *Pure Technical Efficiency (PTE)*

As we know that CCR model works on constant return to scale assumption Table 3 shows DEA results by using CCR model while BCC model work based on VRS assumption,(Banker at el.1984)[17]. Table 4 represents Data envelopment analysis results obtained by using CCR and BCC model. It is clear from the table 4 that out of above 15 departments, 8 department are overall technical Efficient (TE=1), and 12 departments are Pure technical efficient they form the VRS efficient frontier, since the VRS efficiency of these departments is equal to one i.e. in the above efficient departments there is no scope of improvements in the outputs (maintaining the same input label). The remaining 3 departments namely English, Chemistry and Botany are inefficient since their VRS efficiency score is less than one.

From Table 4, we also see that two or more than two departments having CRS score less than 1have VRS score is equal to 1. These are Economics, Physics, Geology and Zoology departments. Economics department have the CRS score 0.954(<1) but has VRS score =1. Similarly, Physics department have the CRS score 0.869(<1) but it is equal to one in case of VRS, Geology department have the CRS score 0.952(<1) but it is equal to one in case of VRS and also Zoology department have the CRS score 0.952(<1) but in case of VRS efficiency it is equal to one. This means that these four Economics, Physics, Geology and Zoology departments are capable to reduce these inputs in to outputs efficiently, but its technical efficiency is low due to its scale size.

Sr .No.	Dept. Code	OTE	PTE(VRS Score)	Peer Department	Peer Count	Teaching(SE)	RTS
1	D1	1	1	D1	0	1	_
2	D3	0.617	0. 623	D6,D12, D10	0	0.99	DRS
3	D4	1	1	D4	0	1	-
4	D5	1	1	D5	0	1	-
5	D6	1	1	D6	**3**	1	_
6	D7	0. 954	1	D7	0	0.954	DRS
7	D8	1	1	D8	1	1	-
8	D9	1	1	D9	0	1	_
9	**D10**	1	1	D10	**3**	1	-
10	D12	1	1	D12	2	1	-
11	D16	0.869	1	D16	0	0.869	DRS
12	D17	0.716	0.765	D12,D6, D10	0	0.936	DRS
13	D18	0.952	1	D18	0	0.952	DRS
14	D19	0.851	0.94	D6,D10, D8	0	0.906	DRS
15	D20	0.845	1	D20	0	**0.845**	DRS
	Average	**0. 920**	**0. 955**			**0.963**	

Table 4. For teaching efficiency (T_0): OTE (CRS Score), PTE (VRS score), Teaching (SE=CRS/VRS).

Increasing and decreasing return to scale (IRS and DRS): If we observe RTS, no department operates at IRS but seven departments D3, D7, D16, D17, D18, D19 and D20 operate at DRS. In the BCC model Political Science and education department have a maximum number of peer counts so these are most pure technical efficient departments.

3) *Scale Efficiency (SE):*

Only 8 departments, namely Hindi, Geography, History, and Political Science, sociology, Military Science, Education and commerce departments are scale efficient. Other 7 departments are scale inefficient, due to less than one scale efficiency score. Zoology department has the least (0.845) scale efficiency score.

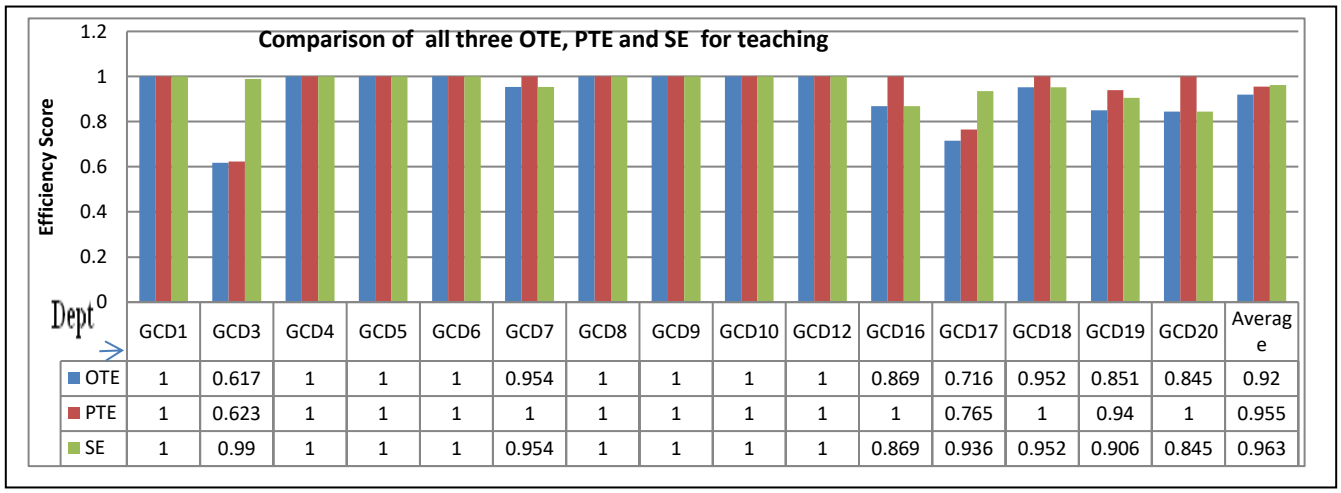


Figure 1. Comparison of all three TE, PTE and SE efficiency

B. Result and discussion for research efficiency (R_0)

1) Overall technical efficiency (OTE)

The research efficiency results of 15 departments are given in Table 5, from the result it is clear that out of 15, 4 departments (26.7%) are technically efficient since the OTE scores of these departments is 1. These are History, Military Sciences, Education and Physics. The remaining 11 (73.7%) departments are comparatively less technical efficient since the OTE scores of these 11 departments is less than 1. The average OTE score is 0.748. Seven departments Hindi, English, Geography, Sociology, Chemistry, Geology and Botany have score less than the average efficiency score. The 4 efficient departments whose department code in this present study are D5, D9, D10 and D16.

Form the 'reference set' for inefficient departments. Since 0.188(18.8%) is the least efficiency from all the above 11 inefficient departments therefore Zoology department (D20) is found to be the most inefficient department and we can say that its overall performance is very poor. From the above 11 inefficient departments 7 departments have scored less than average efficiency and 4 departments have scored above the average efficiency score. The average overall technical efficiency score 0.748 reveals that on an average departments have to increase their output by 25.20% by maintaining the existing level of inputs.

Maximum peer count indicates the extent of robustness of the departments compared to other efficient departments. In other words, a department with maximum number of peer count is likely to be a department which is efficient under a large number of factors and is probably a good example of a

'global leader' or a department with high robustness (Aggarwal et al., 2010).On the basis of Peer counts, the efficient departments are distinguished as follows:

High robustness (9 ≤ number of peer counts≤ 10) Education department (D10, peer count =10) is measured as a highly robust department as it has max. Number of peer count.

Middle robustness: (6 ≤ number of peer counts≤ 8) History department **(**D5, peer count = 8) is measure in the middle robust group in terms of OTE.

Low robustness: (1 ≤ number of peer counts≤ 5) Physics department (D16, peer counts = 5) and Military Science department (D9, peer counts = 1) are measured low robust departments as they have min. number of peer counts. Therefore these departments characterized in the low robust group in terms of OTE.

Sl.No.	Code	OTE(CRS Score)	Peer department (R.SET)	Peer weight	Peer count
1	D1	0.552	D10,D5	0.754,1.246	0
2	D3	0.628	D10,D5	.038,1.962	0
3	D4	0.624	D10	1.608	0
4	D5	1	D5	1	8
5	D6	0.928	D10,D16, D5	0.063, 0.259, 0.771	0
6	D7	0.855	D5,D10,D16	1.116, 0.028, 0.032	0
7	D8	0.455	D10, D16,D5	0.201, 0.362, 1.171	0
8	D9	1	D9	1	1
9	**D10**	**1**	**D10**	**1**	**10**
10	D12	0.939	D5,D10,D16	0.093 , 0.056, 0.131	0
11	**D16**	**1**	**D16**	**1**	**5**
12	D17	0.475	D5, D10	0.093, 0.056, 0.131	0
13	D18	0.602	D10	0.911	0
14	D19	0.987	D16	0.941	0
15	D20	0.188	D5,D10,D9	0.084 2.680 1.118	0
Average		0.748			

Table 5. Research efficiency scores of 15 departments using CCR model for the year 2011-2012.

2) Pure Technical Efficiency (PTE)

Table 6 represents DEA results obtained by using CCR and BCC model. It is clear from the table 6 that out of 15 departments, 4 are overall technical Efficient (TE=1), and 9 departments are Pure technical efficient, since the VRS efficiency of these departments is equal to one i.e. in these departments there is no scope of improvements in the outputs (maintaining the same input label). The remaining 6 departments namely Hindi, Economics, Sociology, Geology, Botany and Zoology are inefficient since their VRS efficiency score is less than one.

S No.	**Dept. Code**	**OTE(CRS score)**	**PTE(VRS Score)**	**Peer Department**	**Peer Count**	**Research(SE)**	**RTS**	**Total Effic.(E_0)**
1	D1	0.552	0.999	D10,D3,D17,D5	0	0.552	DRS	0.776
2	D3	0.628	1	D3	3	0.628	DRS	0.809
3	D4	0.624	1	D4	0	0.624	DRS	0.812
4	D5	1	1	D5	2	1	-	1
5	D6	0.928	1	D6	1	0.928	DRS	0.964
6	D7	0.855	0.990	D5,D17,D16,D3	0	0.864	DRS	0.909
7	D8	0.455	0.707	D10,D17, D16,D3,D6	0	0.630	DRS	0.815
8	D9	1	1	D9	0	1	_	1
9	D10	1	1	D10	4	1	-	1
10	D12	0.939	1	D12	2	0.939	IRS	0.9695
11	D16	1	1	D16	3	1	-	0.9345
12	D17	0.475	1	D17	4	0.475	DRS	0.7055
13	D18	0.602	0.604	D12	0	0.997	IRS	0.9745
14	D19	0.987	0.993	D12,D16	0	0.994	IRS	0.95
15	D20	0.188	0.540	D10,D17	0	0.349	DRS	0.597
	Average	0.748	0.922			0.799		0.88107

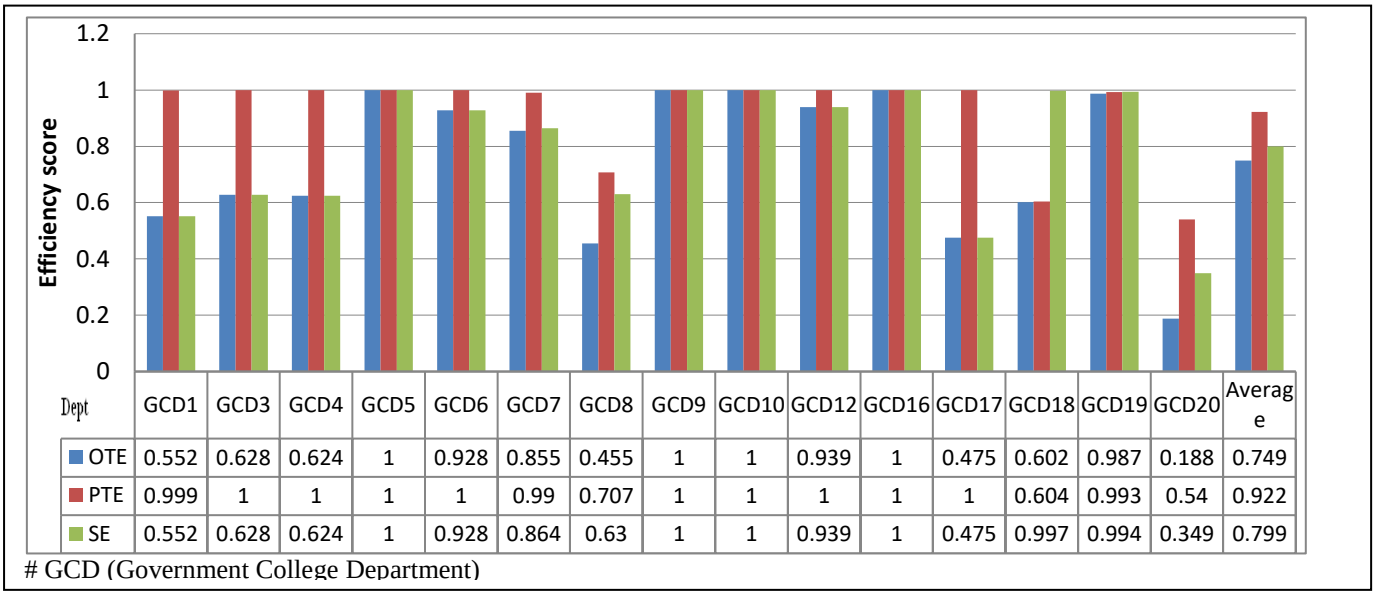
Table 6. For research efficiency (R_0): OTE (CRS Score), PTE (VRS score) and research (SE=CRS/VRS), peer depts., peer counts and RTS of 15 departments for the year 2011-12.

From Table 6, we also see that some departments which have CRS score less than 1have VRS score equal to 1. These departments are English, Geography, Political science, Commerce and Chemistry. This indicates that these five departments are capable to reducing their inputs into outputs efficiently, but their technical efficiency is low due to their scale size.

Increasing and decreasing return to scale (IRS and DRS)
If we observe RTS , only 3 departments D12, D18 and D19 operate at IRS but 8 departments D1, D3, D4,D6,D7 , D8,D17 and D20 at DRS. In the BCC model education and Chemistry department have same maximum number of peer counts(=4). So it is the most pure technical efficient departments.

3) Scale efficiency (SE)

Out of the 15, only 4 departments, namely History, Military Science, Education and Physics departments are scale efficient since their scale efficiency score is 1.So all these departments are acting at the maximum scale. Other 11 departments are scale inefficient, due to less than one scale efficiency score. Zoology department has the least **(0.349)** scale efficiency score.



Dept	GCD1	GCD3	GCD4	GCD5	GCD6	GCD7	GCD8	GCD9	GCD10	GCD12	GCD16	GCD17	GCD18	GCD19	GCD20	Average
OTE	0.552	0.628	0.624	1	0.928	0.855	0.455	1	1	0.939	1	0.475	0.602	0.987	0.188	0.749
PTE	0.999	1	1	1	1	0.99	0.707	1	1	1	1	1	0.604	0.993	0.54	0.922
SE	0.552	0.628	0.624	1	0.928	0.864	0.63	1	1	0.939	1	0.475	0.997	0.994	0.349	0.799

GCD (Government College Department)

Figure 2. Comparison of all three TE, PTE and SE efficiency for research (R_0)

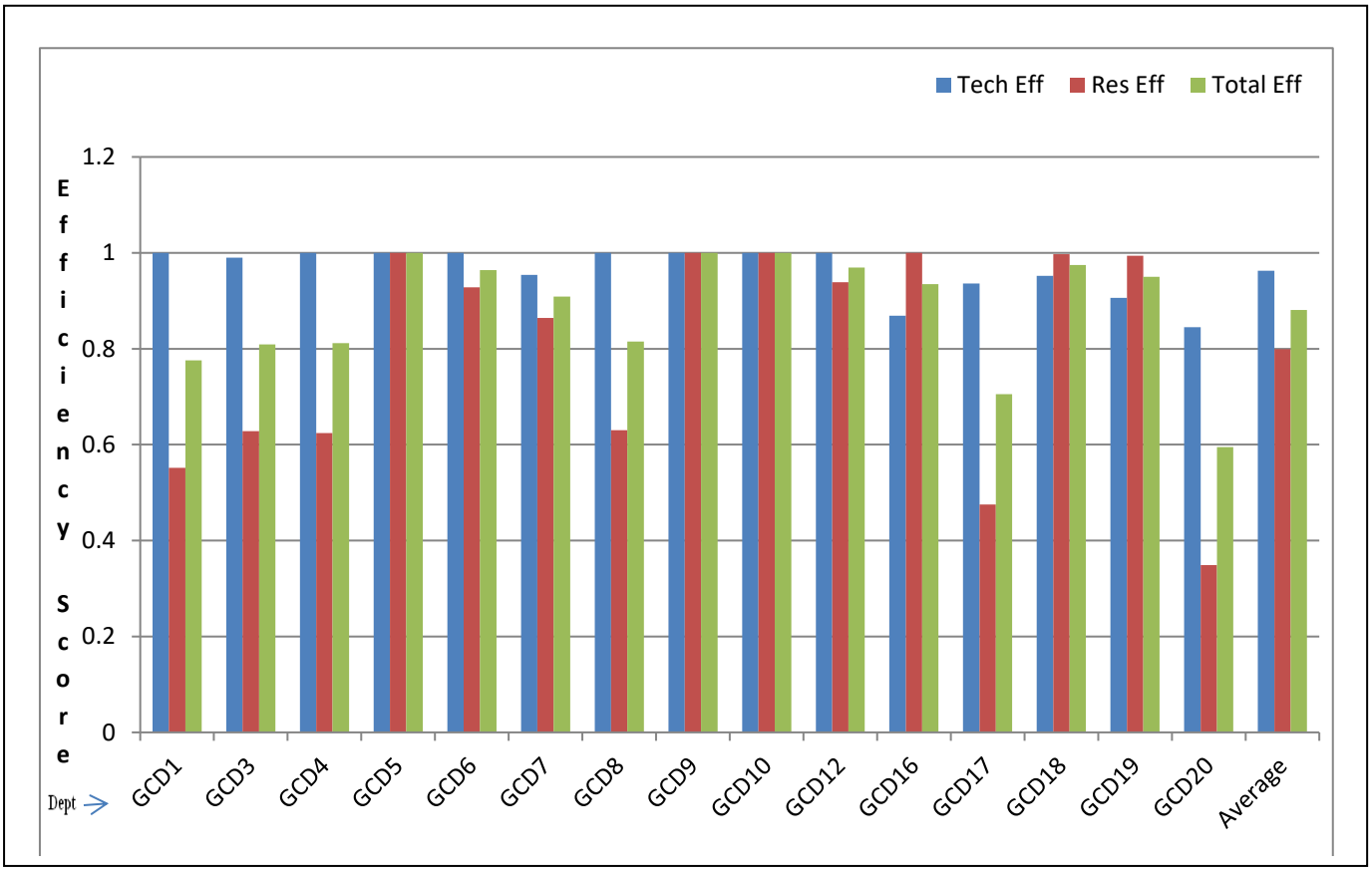


Figure 3. Comparison of all three teaching (T_0), research (R_0) and total (E_0) efficiency

The result table of the above figure 3 of all three teaching, research and total efficiency score are given below in Table 7.

S No.	Dept. Code	Teaching Efficiency (T0)	Research Efficiency (R0)	Total Efficiency (E0)	Ranking(r)
1	D1	1	0.552	0.776	11
2	D3	0.99	0.628	0.809	10
3	D4	1	0.624	0.812	9
4	D5	1	1	1	1
5	D6	1	0.928	0.964	4
6	D7	0.954	0.864	0.909	7
7	D8	1	0.630	0.815	8
8	D9	1	1	1	1
9	D10	1	1	1	1
10	D12	1	0.939	0.9695	3
11	D16	0.869	1	0.9345	6
12	D17	0.936	0.475	0.7055	12
13	D18	0.952	0.997	0.9745	2
14	D19	0.906	0.994	0.95	5
15	D20	0.845	0.349	0.597	13
	Average	0.963	0.799	0.88107	

*Table 7***.** Overall performance assessment of the academic departments

VII.Conclusion

In this study the idea is to examine the performance measurement of academic departments of Govt. PG College Gopeshwar Chamoli Uttarakhand (India) on the basis of department's activity. Some concluding remarks of the study are: Hindi, Geography, Political science, Sociology, and Commerce departments are high in teaching activity since their teaching efficiency is one but low in research activity since their research efficiency is less than one; Out of the above 15 departments only Physics has high research efficiency but low teaching efficiency; History, Military sciences and Education departments are strongly active (with high total efficiency=1) in both teaching and research activity but Zoology department gives poor performance for both activities (with low total efficiency=0.597) with rank 13; Zoology department can improve its teaching outputs by 0.155% (calculated by $1/T_0 = 1/0.845 = 1.18343$) and research outputs by 0.651% (calculated by $1/R_0 = 1/0.349 = 2.86533$); Three departments namely History, Military Science and Education are efficient in all the three field teaching, research and total activity. For remaining twelve departments there is scope of improvement.

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Author Biographies:

Imran Ali First author of this research paper belongs to district Haridwar, state Uttarakhand (India), date of birth is 20th March 1977. He did M.Sc. in Industrial Mathematics and Informatics from IIT Roorkee, Uttarakhand (India) in 2001, MA in Mathematics from HNBGU, Srinagar, Garhwal, Uttarakhand (India) in 2003 and cleared CSIR-UGC NET (Mathematical Sciences) in June-2010 and doing Ph.D. in Mathematics from HNBGU (A Central University), Srinagar, Uttarakhand (India) his research title "Efficiency study of the departments of the post graduate degree colleges of Uttarakhand using DEA". Presently working as a Assistant Professor in Department of Mathematics of Government PG College Gopeshwar, Chamoli, Uttarakhand (India).

Millie Pant did Ph.D. in Mathematics from IIT Roorkee, (India). She is Associate Professor in the department of applied sciences and engineering Saharanpur campus, IIT Roorkee. Her research areas include Optimization technique, Data envelopment analysis (DEA), Differential evolution (DE), Soft computing, Supply chain, Management.

U S Rana did M. Phil in Mathematics from University of Roorkee (India) and Ph.D. in Mathematics from HBTI Kanpur (India). He is Associate Professor in the department of Mathematics DAV PG College Dehradun Uttarakhand (India). His research area includes Computational fluid dynamics, Finance mathematics, Data Envelopment Analysis (DEA) and Biomathematics.

S K Jauhar did his PhD from Indian Institute of Technology Roorkee. He received his M. Tech in Industrial Engineering from VNIT, Nagpur (MH) India and BE from SGSITS, Indore, India in Industrial and Production Engineering. He has over 1.5 years of teaching experience at his parent institute SGSITS, Indore and CDGI Indore. His research interests include Supply chain management, Soft computing, Operations management, Artificial intelligence, Industrial engineering.