

Study on Performance Analysis of Training and Development Departments or T&D UNITS of Indian Companies with Data Envelopment Analysis (DEA) based on Variable Returns to Scale (VRS)

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Abstract: Training and Development (T & D) department in any industry or corporate world is one of the most important unit (UNIT) to decide the success of any organization. The Training and development units (T&D UNITS) have multiple investments as inputs for extracting several tangible and or intangible revenue outputs. Each unit is considered as Decision Making Unit (DMU). This study has considered three sectors of T&D UNITS viz., Large, Medium and Small companies. The Data Envelopment Analysis (DEA) approach on Variable Returns to Scale (VRS) is used to get the Technical Efficiency (TE) of various T&D UNITS. The benchmarking UNITS and the follower UNITS were identified based on the data for a period from 2007 to 2012. The studied T & D UNITS were ranked basing on several criteria such as complete achievement of TE, frequencies of full TE, the coefficient of variations in TEs, etc. Finally this research paper paves the way to prove that TE alone cannot be the major decision factor to estimate the efficiency of DMUs. This also concludes that the DEA is a method to identify the efficient 'T & D Unit' and also to rank the T & D Units based on their efficiency.

Keywords: Co-efficient of Variance (CV), Data Envelopment Analysis (DEA), Decision Making Unit (DMU), Training and Development Units (T & D UNITS), Technical Efficiency (TE), Linear Programming Problem (LPP), Variable Returns to Scale (VRS).

I. INTRODUCTION

The relevance of statistics to study the economic variables has been more prominent in the recent past. Operations Research is a significant area of applying the mathematical concepts to understand the overall behavior of an organization. It provides the indicators on optimal decision making outputs. Linear programming problems (LPP) are the suitable tools for converting the business environment in to a mathematical notion. Usual optimization methods will be considered when there is availability of parameters on single dimensional way of seeking the optimal solutions. Whereas, when there are more than one decision making units (DMU) searching for more optimal solutions with a set of input and output variables, the conventional approaches of LPP have limitations. Understanding the performance of an organization is a combination of mathematical programming methods with suitable nonparametric tools. Applying the technique of DEA is an appropriate option to identify the best performing DMU. There is an absolute need of understanding the complex system of operational issues for studying the efficiency of a T & D UNIT. Making money by means many strategies and methods is main activity of any T & D UNIT. The

competitions in business among several T & D UNITS need to evaluate the performance of their own and to have the comparisons with their competitors. Every T & D UNIT has a special approach on the business performance within the frame work of common issues on strategies, methods, investments and earnings. The T & D UNITS may have different proportions of investments on different input variables as there is flexibility in certain operations from UNIT to UNIT. As far as T & D UNITS operations are concerned, the activities on input variables and output variables will have several dynamics on income and expenditures. Analyzing the performance of a T & D UNIT based on its input investments and output achievements is the need of the hour. Several studies have focused on statistical analysis in which single output variable influenced many output variables. When there is context of multiple inputs influenced on multiple outputs, the conventional or parametric based studies have limitations. In such cases, non-parametric study for overall understanding of the T & D UNIT's performance is the proper alternative. This study is designed on the basis of Data frontier/ envelopment analysis by involving seven input and seven output variables simultaneously. The study

is focused on seventy seven T & D UNITS operating in Indian business environment.

II. METHODOLOGY

A. About Method

The study has focused on implementation of DEA for analyzing the Indian T & D UNIT's performance. Center for Monitoring Indian Economy is one of the organizations to evaluate economy related functioning of Indian T & D UNITS. The data for around 118 T & D UNIT is available with them. Each T & D UNIT's performance is assessed on the information of 88 variables (input and output). Historical data for each quarter in a year was provided by them. The yearly average data was obtained with the four quarters. We have segregated the data in to year wise, variable wise and UNIT wise form 2007 to 2012. However, since the data has many gaps we have extracted the valid contents only. The final data set consists of 77 T & D UNITS and 14 variables, such that 7 are input variables and 7 are output variables. The extraction of valid data has been done with MS excel. We have prepared 77 sets of linear programming problems by involving the input and output variables, for all the T & D UNITS under study. Further, the programming problems obtained with two orientations, such as input orientation (investment minimization) and output orientation (Revenue maximization).

In this study, BCC-DEA model based on VRS with output orientation is considered. DEAP software has been used to obtain the technical efficiencies for the formulated linear programming problems. These results also provided the names of peer T & D UNITS, peer count for each peer T & D UNIT, weightage of each peer T & D UNIT, names of non-peer T & D UNIT, slackness of non-peer T & D UNIT in several input and output variables. The performance of T & D UNIT is analyzed with the results of technical efficiencies. While ranking the T & D UNITS, we considered the criteria like frequency of attaining complete technical efficiency among the six years from 2007 to 2012; and the coefficient of variation of technical efficiency based on the six performing years.

B. Output Oriented LPP's in DEA:

Let Y_j be the number of UNITS in j^{th} output variable, for $j=1,2,3,\dots,n$, ($n=7$); Let X_i be the number of UNITS in i^{th} input variable for $i=1,2,\dots,m$ ($m=7$); Let k be the number of DMUs, for $k=1,2,\dots,N$ ($N=77$); Let O_{kj} be the value per UNIT of j^{th} Output belong to k^{th} DMU; I_{ki} be the value per UNIT of i^{th} Input variable belong to k^{th} DMU; The overall output on all the variables for k^{th} DMU is

$$z = \sum_{j=1}^n O_{kj} y_j; \text{ for } k=1,2,3,\dots,N \text{ since } Z \text{ is the output}$$

function, it is to be maximized. We have to formulate N number of objective functions as there are N number of DMU's. Therefore

$$\text{Max } z = \sum_{j=1}^n O_{kj} y_j; \text{ for } k=1,2,3,\dots,N.$$

in order to formulate the subjective constraints with the input variables, it is considered that the total input on all the variables for k^{th} DMU is having a UNIT value. The overall

input due to all 'm' input variables is $\sum_{i=1}^m I_{ki} X_i$, and hence

the constraints with k^{th} DMU are

$$\sum_{i=1}^m I_{ki} X_i = 1; \text{ for } k=1,2,3,\dots,N$$

Let E_k be the Efficiency of k^{th} DMU which can be obtained as the ratio between overall output to the overall input, and it has to be more than 0 and less than UNIT $y(1)$, Therefore the constraints with the efficiency of k^{th} DMU are

$$0 \leq \frac{\sum_{j=1}^n O_{kj} Y_j}{\sum_{i=1}^m I_{ki} X_i} \leq 1; \text{ for } k=1,2,\dots,N$$

By considering the above notion, we have developed N (=77) LPP's. Each LPP has one objective function for maximizing the overall output; one equation constraint with input variables as a convex combination of input variables; and N-1 (=76) in-equation constraints with ratio of overall output with overall input. As there are six years for study period, we have developed six sets of such linear programming problems for 2007, 2008, 2009, 2010, 2011 and 2012 separately.

All LPPs have been run on the software DEAP and extracted the TEs under VRS. The analysis is focused on the dimensions of Exploring the names of peer T & D UNITS and non-peer T & D UNITS; measuring the TEs of each T & D UNIT, Identifying the peer counts; obtaining the peer T & D UNIT for non-peer T & D UNITS with their weightages; Ranking the peer T & D UNITS based on the several criteria such as (i) based on Frequency of complete TE in six years and (ii) based on the CV of TE for six years data. Ranking of T & D UNITS of various companies (Used numbers to maintain the confidentiality as per the request by the T & D UNITS management or Companies participated in this study)

Table 1: Ranking of T & D UNITS based on Percentage of Complete Technical Efficiencies with VRS during 2007-12.

Code of T & D UNIT	TE value for 2007	TE value for 2008	TE value for 2009	TE value for 2010	TE value for 2011	TE value for 2012	Number of times/ freq. of TE=1	% of full TE for 6 years	Overall rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UNIT 1	1	1	1	1	1	1	6	100	1
UNIT 2	1	1	1	1	1	1	6	100	1
UNIT 3.	1	1	1	1	1	1	6	100	1
UNIT 4.	1	1	1	1	1	1	6	100	1
UNIT 5	1	1	1	1	1	1	6	100	1
UNIT 6	1	1	1	1	1	0.98	5	83.33	6
UNIT 7	0.976	1	1	1	1	1	5	83.33	6
UNIT 8	1	1	1	1	1	0.95	5	83.33	6
UNIT 9	1	1	0.938	1	1	1	5	83.33	6
UNIT 10	1	1	1	0.89	1	1	5	83.33	6
UNIT 11	1	1	1	0.89	1	1	5	83.33	6
UNIT 12	1	1	1	0.82	1	1	5	83.33	6
UNIT 13	1	1	1	0.78	1	1	5	83.33	6
UNIT 14	1	1	1	1	0.99	0.98	4	66.67	14
UNIT 15	1	1	0.97	1	0.996	1	4	66.67	14
UNIT 16	0.98	1	0.973	1	1	1	4	66.67	14
UNIT 17	1	1	1	0.95	0.975	1	4	66.67	14
UNIT 18	1	1	1	0.95	0.994	1	4	66.67	14
UNIT 19	0.955	1	0.963	1	1	1	4	66.67	14
UNIT 20	1	0.946	1	1	0.97	1	4	66.67	14
UNIT 21	1	0.962	0.949	1	1	1	4	66.67	14
UNIT 22	0.937	1	0.96	1	1	1	4	66.67	14
UNIT 23	1	0.933	1	0.96	1	1	4	66.67	14
UNIT 24	1	0.932	1	1	0.924	1	4	66.67	14
UNIT 25	0.934	0.912	1	1	1	1	4	66.67	14
UNIT 26	1	1	1	0.91	0.94	1	4	66.67	14
UNIT 27	0.894	1	1	0.99	1	1	4	66.67	14
UNIT 28	1	1	1	0.9	1	0.92	4	66.67	14
UNIT 29	0.965	0.874	1	1	1	1	4	66.67	14
UNIT 30	0.871	1	0.945	1	1	1	4	66.67	14
UNIT 31	1	1	1	0.86	1	1	4	66.67	14
UNIT 32	1	1	0.978	1	0.854	1	4	66.67	14
UNIT 33	1	1	1	0.85	1	0.98	4	66.67	14
UNIT 34	0.821	1	1	1	1	0.95	4	66.67	14
UNIT 35	1	0.984	1	0.81	1	1	4	66.67	14
UNIT 36	1	1	1	0.79	1	0.95	4	66.67	14
UNIT 37	1	1	1	0.77	0.92	1	4	66.67	14
UNIT 38	1	0.85	1	0.78	1	1	4	66.67	14
UNIT 39	0.635	1	1	1	0.994	1	4	66.67	14
UNIT 40	0.995	0.971	1	1	0.989	1	3	50	40
UNIT 41	0.978	1	0.994	0.97	1	1	3	50	40
UNIT 42	0.974	1	1	1	0.951	0.97	3	50	40
UNIT 43	1	1	0.948	1	0.968	0.99	3	50	40
UNIT 44	1	0.985	1	1	0.94	0.98	3	50	40
UNIT 45	0.971	0.96	1	1	1	0.93	3	50	40
UNIT 46	1	1	0.95	1	0.92	0.93	3	50	40
UNIT 47	1	0.895	1	1	0.982	0.99	3	50	40
UNIT 48	1	1	0.949	0.93	0.905	1	3	50	40
UNIT 49	0.913	1	0.916	1	1	0.98	3	50	40
UNIT 50	0.917	1	0.917	1	0.933	1	3	50	40
UNIT 51	0.967	1	0.886	1	1	0.98	3	50	40
UNIT 52	0.907	0.978	1	1	0.911	1	3	50	40

UNIT 53	0.941	1	0.888	1	1	0.97	3	50	40
UNIT 54	0.951	0.894	0.929	1	1	1	3	50	40
UNIT 55	1	1	0.877	1	0.976	0.95	3	50	40
UNIT 56	0.904	1	0.897	0.99	1	1	3	50	40
UNIT 57	1	0.89	0.989	0.9	1	1	3	50	40
UNIT 58	1	0.987	0.861	1	0.96	1	3	50	40
UNIT 59	1	0.856	1	1	0.968	0.96	3	50	40
UNIT 60	1	0.842	1	0.98	1	0.95	3	50	40
UNIT 61	1	0.844	1	0.93	0.959	1	3	50	40
UNIT 62	1	0.855	0.993	0.9	1	1	3	50	40
UNIT 63	0.954	0.825	0.913	1	1	1	3	50	40
UNIT 64	1	0.87	0.914	0.85	1	1	3	50	40
UNIT 65	1	0.957	1	0.81	1	0.97	3	50	40
UNIT 66	0.825	1	0.865	1	1	0.96	3	50	40
UNIT 67	0.891	1	0.835	1	0.848	1	3	50	40
UNIT 68	0.687	1	1	1	0.942	0.97	3	50	40
UNIT 69	1	0.964	0.973	0.96	0.986	1	2	33.33	69
UNIT 70	0.978	0.991	1	1	0.986	0.94	2	33.33	69
UNIT 71	1	0.994	1	0.9	0.964	0.95	2	33.33	69
UNIT 72	1	0.991	0.959	0.91	0.895	1	2	33.33	69
UNIT 73.	0.95	0.874	1	0.88	1	0.96	2	33.33	69
UNIT 74	0.925	0.938	1	0.79	0.954	1	2	33.33	69
UNIT 75	0.866	0.737	1	0.87	1	0.98	2	33.33	69
UNIT 76	1	0.946	0.962	0.95	0.94	0.94	1	16.67	76
UNIT 77	0.995	0.884	1	0.87	0.951	0.99	1	16.67	76

The ranking of UNITS has done based on the percentages of their achievement of complete TEs calculated with VRS during 2007-12. It is observed that, Five UNITS have achieved 100% TE on VRS. They are UNIT 1, UNIT 2, UNIT 3, UNIT 4 and UNIT 5 for all the six years of study. Further, UNIT 6, UNIT 7, UNIT 8, UNIT 9, UNIT 10, UNIT 11, UNIT 12, UNIT 13 have achieved next position, i.e. 6th rank, as per complete TE.

Table 2: Ranking of T & D UNITS based on CV of Technical Efficiency based on VRS

Name of UNIT	2007	2008	2009	2010	2011	2012	Mean	SD	CV	Rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
UNIT 1	1	1	1	1	1	1	1.00	0.00	0.00	1
UNIT 2	1	1	1	1	1	1	1.00	0.00	0.00	1
UNIT 3	1	1	1	1	1	1	1.00	0.00	0.00	1
UNIT 4	1	1	1	1	1	1	1.00	0.00	0.00	1
UNIT 5	1	1	1	1	1	1	1.00	0.00	0.00	1
UNIT 14	1	1	1	1	0.99	0.98	1.00	0.01	0.73	6
UNIT 6	1	1	1	1	1	0.97	1.00	0.01	0.94	7
UNIT 7	0.97	1	1	1	1	1	1.00	0.01	0.98	8
UNIT 40	0.99	0.97	1	1	0.98	1	0.99	0.01	1.15	9
UNIT 15	1	1	0.97	1	0.99	1	0.99	0.01	1.21	10
UNIT 16	0.98	1	0.97	1	1	1	0.99	0.01	1.24	11
UNIT 41	0.97	1	0.99	0.97	1	1	0.99	0.01	1.36	12
UNIT 69	1	0.96	0.97	0.96	0.98	1	0.98	0.02	1.74	13
UNIT 17	1	1	1	0.95	0.97	1	0.99	0.02	1.97	14
UNIT 42	0.97	1	1	1	0.95	0.97	0.98	0.02	2.08	15
UNIT 18	1	1	1	0.95	0.99	1	0.99	0.02	2.11	16

Name of UNIT	2007	2008	2009	2010	2011	2012	Mean	SD	CV	Rank
UNIT 70	0.97	0.99	1	1	0.98	0.94	0.98	0.02	2.13	17
UNIT 8	1	1	1	1	1	0.94	0.99	0.02	2.14	18
UNIT 19	0.95	1	0.96	1	1	1	0.99	0.02	2.16	19
UNIT 43	1	1	0.94	1	0.96	0.98	0.98	0.02	2.19	20
UNIT 20	1	0.94	1	1	0.97	1	0.99	0.02	2.33	21
UNIT 21	1	0.96	0.94	1	1	1	0.99	0.02	2.37	22
UNIT 44	1	0.98	1	1	0.94	0.98	0.98	0.02	2.37	23
UNIT 76	1	0.94	0.96	0.95	0.94	0.94	0.96	0.02	2.38	24
UNIT 9	1	1	0.93	1	1	1	0.99	0.03	2.56	25
UNIT 45	0.97	0.96	1	1	1	0.93	0.98	0.03	2.72	26
UNIT 22	0.93	1	0.96	1	1	1	0.98	0.03	2.81	27
UNIT 23	1	0.93	1	0.96	1	1	0.98	0.03	3.03	28
UNIT 46	1	1	0.95	1	0.92	0.93	0.97	0.03	3.61	29
UNIT 24	1	0.93	1	1	0.92	1	0.98	0.04	3.82	30
UNIT 71	1	0.99	1	0.9	0.96	0.95	0.97	0.04	4.05	31
UNIT 25	0.93	0.91	1	1	1	1	0.97	0.04	4.14	32
UNIT 47	1	0.89	1	1	0.98	0.99	0.98	0.04	4.22	33
UNIT 26	1	1	1	0.91	0.94	1	0.97	0.04	4.23	34
UNIT 48	1	1	0.94	0.93	0.90	1	0.96	0.04	4.31	35
UNIT 49	0.91	1	0.91	1	1	0.97	0.97	0.04	4.36	36
UNIT 27	0.89	1	1	0.99	1	1	0.98	0.04	4.36	37
UNIT 50	0.91	1	0.91	1	0.93	1	0.96	0.04	4.47	38
UNIT 51	0.96	1	0.88	1	1	0.98	0.97	0.04	4.57	39
UNIT 10	1	1	1	0.89	1	1	0.98	0.04	4.57	40
UNIT 28	1	1	1	0.9	1	0.92	0.97	0.05	4.64	41
UNIT 52	0.90	0.97	1	1	0.911	1	0.97	0.04	4.66	42
UNIT 53	0.94	1	0.88	1	1	0.97	0.97	0.05	4.68	43
UNIT 54	0.95	0.89	0.92	1	1	1	0.96	0.05	4.69	44
UNIT 11	1	1	1	0.89	1	1	0.98	0.05	4.74	45
UNIT 72	1	0.99	0.95	0.91	0.895	1	0.96	0.05	4.84	46
UNIT 55	1	1	0.87	1	0.976	0.95	0.97	0.05	4.99	47
UNIT 29	0.96	0.87	1	1	1	1	0.97	0.05	5.20	48
UNIT 56	0.90	1	0.89	0.99	1	1	0.97	0.05	5.21	49
UNIT 30	0.87	1	0.94	1	1	1	0.97	0.05	5.46	50
UNIT 57	1	0.89	0.98	0.9	1	1	0.96	0.05	5.56	51
UNIT 58	1	0.98	0.86	1	0.96	1	0.97	0.05	5.65	52
UNIT 59	1	0.85	1	1	0.96	0.96	0.96	0.06	5.79	53
UNIT 31	1	1	1	0.86	1	0.99	0.98	0.06	5.82	54
UNIT 73	0.95	0.87	1	0.88	1	0.96	0.94	0.06	5.98	55
UNIT 32	1	1	0.97	1	0.85	1	0.97	0.06	6.02	56

Name of UNIT	2007	2008	2009	2010	2011	2012	Mean	SD	CV	Rank
UNIT 33	1	1	1	0.85	1	0.97	0.97	0.06	6.14	57
UNI 77	0.99	0.88	1	0.87	0.95	0.98	0.95	0.06	6.25	58
UNIT 60	1	0.84	1	0.98	1	0.95	0.96	0.06	6.42	59
UNIT 61	1	0.84	1	0.93	0.95	1	0.95	0.06	6.50	60
UNIT 62	1	0.85	0.99	0.9	1	1	0.96	0.06	6.64	61
UNIT 63	0.95	0.82	0.91	1	1	1	0.95	0.07	7.38	62
UNIT 34	0.82	1	1	1	1	0.954	0.96	0.07	7.45	63
UNIT 64	1	0.87	0.91	0.85	1	1	0.94	0.07	7.59	64
UNIT 12	1	1	1	0.82	1	1	0.97	0.07	7.62	65
UNIT 65	1	0.95	1	0.81	1	0.973	0.96	0.07	7.74	66
UNIT 35	1	0.98	1	0.81	1	1	0.97	0.08	7.92	67
UNIT 74	0.92	0.93	1	0.79	0.954	1	0.93	0.08	8.24	68
UNIT 66	0.82	1	0.86	1	1	0.963	0.94	0.08	8.24	69
UNIT 67	0.89	1	0.83	1	0.848	1	0.93	0.08	8.61	70
UNIT 36	1	1	1	0.79	1	0.945	0.96	0.08	8.89	71
UNIT 13	1	1	1	0.78	1	1	0.96	0.09	9.15	72
UNIT 37	1	1	1	0.77	0.92	1	0.95	0.09	9.64	73
UNIT 38	1	0.85	1	0.78	1	1	0.94	0.10	10.49	74
UNIT 75	0.86	0.73	1	0.87	1	0.97	0.91	0.10	11.40	75
UNIT 68	0.68	1	1	1	0.94	0.96	0.93	0.12	13.15	76
UNIT 39	0.63	1	1	1	0.99	1	0.94	0.15	15.83	77

The select UNITS are ranked on the basis of CV of complete TE with VRS for the period 2007-12 as shown in five UNITS which were ranked first in the previous analysis (refer to table 4) and have again shared rank one due to the fact their CV based on TE under VRS is zero. UNIT 14, UNIT 6, UNIT 7, and UNIT 40 have ranked 6th, 7th, 8th, and 9th place respectively. No other UNIT in the left out 72 has a tie on any rank. However, it is also observed that the least ranked UNITS are UNIT 38, UNIT 75, UNIT 68 and UNIT 39. Their ranks are 74, 75, 76 and 77 respectively. Each group consists of certain number of UNITS with TE value as one. The ratio between fully efficient UNITS to total gives efficiency of group as percentage to designated best group.

The entire study considered at least 3 digits after the decimal point to study the rankings and differentiate the DMUs with equal two digit number after the decimal. But to accommodate table in the given format or template, only two digits are considered.

III. CONCLUSION

In the phase one of the research the ranking of T & D UNITS based on percentage of complete Technical Efficiencies (TE) with Variable Returns to Scale (VRS) have been listed out. The data considered for the same is between the years 2007-12. Whereas, in phase two the TE has been used to estimate the CV to rank the DMUs. Many UNITS which have occupied the ranks from 6th position to 77th position have lost their rank or order in the Phase 2 and proved as, “not as efficient as” they have been believed. Based on the ranks attained from the Phase 2 of research, it is easy for the observers to decide the ‘peers’, ‘followers’, and ‘leaders’. This is easy for T & D UNITS to decide with whom to compete, who are role models and whom they have to consider as UNITS with best practices. This is a process to develop a road map to improve the efficiency of T & D UNITS in the corporate world.

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