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ESTIMATION OF TECHNICAL EFFICIENCY USING DEA APPROACH: A CASE OF AUTOMOBILE COMPANIES

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ABSTRACT

In this paper, Data Envelopment Analysis (DEA) is employed for measuring the technical efficiency of a sample of Automobile Companies. DEA is a non-parametric linear programming based technique used for measuring the relative performance of organizational units where multiple inputs and multiple outputs are present. Three automobile companies are randomly selected for this study, as three different DMUs. Three inputs and two outputs are identified. The input variables are raw-material, employees and other expenses; while two outputs are net income and net profit. Based on the results two companies were efficient in both the years in 2015-2016.The calculation provide an outlook about the performance of automobile company and deriving strategy to reduce their input resources to maximize output.

Keywords: *CCR Model, DEA, Technical Efficiency.*

I. DATA ENVELOPMENT ANALYSIS

Data envelopment analysis is a Linear Programming Problem that provides a means of calculating apparent efficiency levels within a group of organizations. The efficiency of an organization is calculated relative to the group's observed best practice.

The efficiency score in the presence of multiple input and output factors is defined as:

$$\text{Efficiency} = \frac{\text{Weighted sum of outputs}}{\text{Weighted sum of inputs}}$$

Technical Efficiency relates to how much output can be obtained from a given input such as a worker or a machine or a specific combination of inputs. Maximum technical efficiency occurs when output is maximized from a given quantity of inputs.

II. THE CCR MODEL

The CCR model was initially proposed by Charnes, Cooper and Rhodes in 1978. For each DMU, the virtual input and output by (yet unknown) weights $\{v_i\}$ and (u_r) are formed. Then determine the weight, using linear programming so as to maximize the ratio

$$\frac{Virtual\ Output}{Virtual\ Input}$$

The optimal weights may (and generally will) vary from one DMU to another DMU. Thus, the weights in DEA are derived from the data instead of being fixed in advance. Each DMU is assigned a best set of weights with values that may vary from one DMU to another.

III. AUTOMOBILE INDUSTRY

The automobile industry, along with the auto components industry, is one of the core industries in India. A well-developed transportation system plays a key role in the development of an economy, and India is no exception to it. Automobile is one of the largest industries in the global market.

Here we are taking three automobile companies to compute or analyse their efficiency. They are Hero Motocorp, Bajaj Auto and TVS Motor Company

IV. DATA COLLECTION

In this work a case study approach was followed to compute and analyse the efficiency of the automobile companies. The case study approach is used that which company is gives best result or performance in certain circumstances that are used to produce certain outputs such as sales, production, income etc. to relative number of inputs such as workers, machinery, land area, expenses etc.

Sample Selection: Three automobile industries were selected for this study. Three industries are Hero Motocorp Ltd., Bajaj Auto Ltd. And TVS Motor Company Ltd. as DMU1, DMU2 and DMU3 respectively.

- **Data Collection**: For the purpose of this study we take three inputs as Raw Material in Rs. Crores, Employee Expenses in Rs. Crores and Other Expenses in Rs. Crores. And take Two outputs as Net Income in Rs. Crores and Net Profit in Rs. Crores.
- **Model Selection**: The DEA CCR with constant return to scale model developed by Charnes and Cooper (1978) and used to measure the Technical Efficiency of the Automobile Companies.
- **Model Development**: Six models are developed to evaluate the relative efficiency score of each DMU involved in the study during 2015-16.

In this study we prefer to solve by Microsoft Excel Solver 2007 Linear programming tool**.**

Solving Envelopment DEA model for Table-I and Table–II as a linear program in spread sheet

Table (I) Year 2015

(Rs. In Crores)

	Input			output	
DMUs	Raw material	Employee	Other expenses	Net Income	Net Profit
DMU1	19,754	1,173	3,271	28,078	2,386
DMU2	13,752	896	1,808	21,817	2,814
DMU3	7,200	665	1,674	10,255	328

Table (II) Year 2016

(Rs. In Crores)

	Input			output	
DMUs	Raw material	Employee	Other expenses	Net Income	Net Profit
DMU1	19,315	1,320	3,518	28,990	3,132
DMU2	13,717	917	1,949	22,967	3,652
DMU3	7,743	743	1,942	11,516	369

Creating the Linear Programming model to represent the problem in Table–1 and Table–II for DMUs in Excel Worksheet first we define the following parameters.

Decision Variables are the amounts of money should be invested in each unit.

$\mathbf{X_1}$=Cost of Raw Material $\mathbf{Y_1}$=Net Income

$\mathbf{X_2}$=Cost of Employee $\mathbf{Y_2}$=Net Profit

$\mathbf{X_3}$=Cost of Other Expenses

Objective Function: to maximize the total annual profit.

For DMU1 (Year 2015),

Maximize $DMU_1=19754x_1+1173x_2+3271x_3$

Subject to: $28078y_1+2386y_2=1$

$19754x_1+1173x_2+3271x_3<=28078y_1+2386y_2$

$13752\ x_1+896\ x_2+1808\ x_3<=21,817\ y_1+2814\ y_2$

$7200\ x_1+665\ x_2+1674\ x_3<=10255\ y_1+328\ y_2$ and $x_1, x_2, x_3, y_1, y_2 >=0$

Sensitivity Report

FOR DMU1 YEAR 2015

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
D5	x1	0.000050623	0	19754	1E+30	0
E5	x2	0	0	1173	0	1E+30
F5	x3	0	0	3271	0	1E+30
H5	y1	0.000035615	0	0	1E+30	0
I5	y2	0	0	0	0	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
E13	DMU1 LHS	1	1	0	0.002056127	1
E14	DMU2 LHS	0.696162802	0	0	1E+30	0.08085123
E15	DMU3 LHS	0.364483143	0	0	1E+30	0.000749424
J6	efficiency	1	1	1	1E+30	1

For DMU1 (Year 2016),

Maximize DMU2 = $19315x_1+1320x_2+3518x_3$

Subject to: 28990y1+3132y2=1

19315x1+1320x2+3518x3<=28990y1+3132y2

13717 x1+917 x2+1949 x3<=22967 y1+3652 y2

7743 x1+743 x2+1942 x3<=11516 y1+369 y2

and x1, x2, x3, y1, y2 >=0

Sensitivity Report

FOR DMU1 YEAR 2016

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
D5	x1	0.000051303	0	19315	1E+30	5288.288363
E5	x2	0	-533.421800336	1320	533.4218003	1E+30
F5	x3	0	-1326.340695	3518	1326.340695	1E+30
H5	y1	0.000034495	0	0	1E+30	20206.81642
I5	y2	0	-2183.088962	0	2183.088962	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
E13	DMU1 LHS	0.990920685	0	0	1E+30	0.009079315
E14	DMU2 LHS	0.703725552	0	0	1E+30	0.088513151
E15	DMU3 LHS	0.397240428	2.494511171	0	0.003639717	0.397240428
J6	efficiency	1	0.990920685	1	1E+30	1

Similarly, we can frame the linear programming problems for DMU2 and DMU3 for the years 2015 and 2016.

V. RESULT AND CONCLUSION

The table-3 lists the DMU_s according to their efficiency calculate in excel solver by the DEA models. It appears that in year 2015 there were two efficient automobile companies, i.e. DMU_1 and DMU_2 both are efficient in the year 2015 and DMU_2 was not efficient in year 2015. And in year 2016 also DMU_1 and DMU_3 were efficient but DMU_2 was not efficient. Because it could not reach the efficiency target, it shows that the company who were efficient in year 2015 are consistent in their performance and this cause that they are efficient in year 2016. Also it has sufficient income and profit amount with respect to their expenses, the other inefficient company do not control their expenses and this cause that their income and profit were not maximum in both the years 2015 and 2016.

The Hero motocorp Ltd Company is the efficient firm in both the years 2015-2016. The company scoring technical efficiency 100%. It has sufficient profit amount with respect to their expenses. This clearly indicates that this firm is capable of converting their inputs into outputs with 100% managerial efficiency.

As same as Hero Motocorp Ltd company, the TVS motor company is also efficient in both the years 2015-2016.This company scoring technical efficiency 100%. It also has sufficient income and profit amount with respect to their expenses and this indicates that this firm is capable of converting their inputs into outputs with 100% managerial efficiency.

Out of these 3 automobile companies the Bajaj auto Ltd company is the most inefficient firm, scoring technical efficiency 89% in year 2015 and 88% in year 2016.This firm can increase output by 11% in year 2015 and 12% in year 2016 with the existing level of inputs to be on the efficiency frontier and should reduce inputs such as salaries, expenses, machinery and material used.

Listing the Efficiency scores of three Automobile Companies in year 2015 and 2016

Table (3)

DMUs	2015	2016
DMU1	1	0.99
DMU2	0.89	0.88
DMU3	1	1

Based on the results two companies (Hero motocorp& TVS motors) were efficient in both the years in 2015-2016.The calculation provide an outlook about the performance of automobile company and deriving strategy to reduce their input resources to maximize output.

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