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EXAMINING ASSOCIATION BETWEEN FIRM EFFICIENCY AND STOCK RETURNS USING DEA EVIDENCE FROM INDIA

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Abstract: The study used data envelopment analysis for measuringefficiency of sample firms using financial data for the year ended March 31, 2012.Sample firms were ranked on efficiency, using scale efficiency scores based on BCC and CRR models. Firms were also ranked on the basis of stock returns, calculated for the period April 1, 2011 to March 31, 2012. Pearson rank correlation was calculated to measure the degree of association between firm efficiency and stock returns.

JEL: G110, G170

Keywords: Data envelopment analysis, Financial analysis, Stock return.

I. INTRODUCTION

The current study postulates that firm's operating efficiency impacts stock returns, thus investing in the stocks of firms with better efficiency should yield better returns. In a situation where multiple variables for input and output are taken for cross sectional units, it becomes difficult to comment on overall performance of each unit and also to draw comparison across units. This study examines the use of data envelopment analysis (DEA) in measuring firm efficiency, DEA takes into account multiple input and output variables for homogeneous units and calculates technical efficiency score for each unit, based on which we can comment on overall efficiency and peer comparison is possible. In the current study DEA is applied to financial data of constituent firms of index S&P BSE FMCG, S&P BSE Healthcare and S&P BSE Consumer Durables, takingfour input variables and two output variables. The remaining part of the paper is into three sections, following section briefs about theoretical foundation of DEA and presents some earlier work involving application of DEA on financial data. Next section presents methodology adopted for the study and analysis of the data.

II. THEORETICAL FRAMEWORK AND REVIEW OF LITERATURE

DEA is a non-parametric frontier analysis technique which makes no assumptions about the form of the production function and all the observations are treated as non-stochastic. The name of the technique is because it tries to build a frontier by enveloping all the observed input-output vectors. Efficiency of each firm is measured by the distance of its input-output vectors to the frontier. Charnes, Cooper and Rhodes (1978) coined the term DEA and proposed an input orientation with constant returns to scale (CRS) model popularly known

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as CCR model. Later, Banker, Charnes and Cooper (1984) proposed variable returns to scale (VRS) model popularly known as BCC model. The CRS assumption is only appropriate when all firms are operating at an optimal scale, the use of the CRS specification when all firms are not operating at the optimal scale results in measures of technical efficiency (TE) which are confounded by scale efficiencies (SE).The use of the VRS specification permits the calculation of TE devoid of these SE effects which can be calculated by estimating both the CRS and VRS models and looking at the difference in scores.

Technical efficiency h_0, of a decision-making unit (DMU_0) can be determined using CCR model (1) and BCC model (2) as follow,

$$\max h_0 = \frac{\sum_{r=1}^{S} u_r\, y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \tag{1}$$

$$\text{subject to } \frac{\sum_{r=1}^{S} u_r\, y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1$$

$$\max h_0 = \frac{\sum_{r=1}^{S} u_r\, y_{r0} - u_0}{\sum_{i=1}^{m} v_i x_{i0}} \tag{2}$$

$$\text{subject to } \frac{\sum_{r=1}^{S} u_r\, y_{rj} - u_0}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1$$

$j = 1, \ldots, n$, where $u_r, v_i > 0$, $i = 1, \ldots, m$, $r = 1, \ldots, s$.

where, $y_{rj}, x_{ij} > 0$

y_{rj} are outputs for DMUs, u_r is the weight given to output r and s is the number of outputs

x_{ij} are inputs for DMUs, v_i is the weight given to input i and m is the number of inputs

n is the number of DMUs

h_0 is the efficiency value of DMU_0.

The constraints in equation (1) ensure that an optimal $h_0^* = \max h_0$ will always satisfy $0 \leq h_0^* \leq 1$with the optimal solution values $u_r^*, v_i^* > 0$.

Scale efficiency is calculated using (3),

$$SE = TE_{CRR} / TE_{BCC} \tag{3}$$

DEA in past has been used for analysing financial statement data [Yao, Luvai and Riaz (2004), Malhotra D and Rashmi (2008),Mohammed, Sudershan and Sunil (2011), Sten, George and Fred (1994)] in various study. Sten, George and Fred (1994) used DEA on financial data of U.S. computer industry with six input variables (costs of goods sold, capital expenditures, expenditures on R&D, selling, general and administrative expenditures, labor force, holdings of plant, property and equipment) and three output (gross sales revenue, income before tax and market capitalization of stock) variables to evaluate and compare three alternative sets of input-output variables. Mohammed, Sudershan and Sunil (2011) applied DEA on the financial data of selected Indian pharmaceutical firms taking three input (equity, operating expenses and tangible assets) variables and three output (operating profit, operating cash flows and sales) variables. Similarly Malhotra D and Rashmi (2008) applied DEA on financial data of sixteen pharmaceutical firms with three input variables and nine output variables. DEA has been applied to measure the performance of firms based on financial data or ratios [Yi-De Liu (2008), Jau-Shin and Song-Jwu (2011)]. Yi-De Liu (2008) used DEA to measure profitability of U.K. theme parks with five variables. Recent studies have proposed DEA as a tool for stock selection and portfolio construction [Tatyana (2011), Mohamed Dia (2009), Jennifer and Patrick (2000) and Hsin-Hung (2008)]. Studies have used DEA even to rate bonds Rashmi, Malhotra D and Philip (2010), for ranking corporations based on sustainable and socially responsible practices, Constantin (2009), also for measuring the effects of ownership on bank efficiency, Catarina, Joseph and David (2009).

III. METHODOLOGY AND ANALYSIS

For the study four input variables and two output variables have been identified. The selected variables for the study capture important dimensions of the technical efficiency of a revenue producing unit (DMU).

(A) Input Variables

(i) COGS: Cost of goods sold (raw material + power & fuel + other manu. Exp.)

(ii) SAME: Selling, administrative and miscellaneous Expenses

(iii) EC: Employee cost

(iv) GB: Gross block

(B) Output Variables:

(i) GS: Gross sales

(ii) EBT: Earnings before tax

A Static One-period Production Function. Let there be one single period of analysis *t*, and use the notation

y_t = vector of outputs in period t

x_t = vector of inputs in period t

K_{t-1} = stock of real capital at beginning of period t and consider the conventional one-period production function

$$y_t = f(x_t, K_{t-1}) \tag{4}$$

inputs: COGS, SAME, EC, GB

outputs: GS, EBT

(C) Data and Sample Selection

Data for the accounting year ended March 31, 2012 was taken from the software CAPITALINE. Constituent firms of S&P BSE FMCG index, S&P BSE Healthcare and S&P BSE Consumer Durableswere taken as sample firms. The S&P BSE FMCG index comprises of eleven firms. One firm was excluded as earnings before tax was negative for the year ended March 31, 2012, DEA can be applied only with positive values for input and output variables, with this filter we were left with ten firms. Table 1(A) provides descriptive statistics for the input and output variables for FMCG firms.

Table 1(A)
Descriptive Statistics– FMCG

	COGS	*SAME*	*EC*	*GB*	*GS*	*EBT*
Mean	4139.57	1637.97	453.70	3348.50	10169.47	1709.98
Std Error	1348.29	520.57	131.97	1295.88	3572.43	856.99
Median	2022.56	1000.90	224.40	2102.34	4823.42	587.71
Std Dev.	4263.67	1646.19	417.33	4097.93	11297.03	2710.06
Kurtosis	0.59	1.83	0.19	6.36	1.61	6.58
Skewness	1.39	1.64	1.28	2.37	1.52	2.52
Minimum	380.46	256.29	100.70	255.69	1017.36	154.66
Maximum	12353.05	5263.99	1248.47	14144.35	35247.25	8897.53
Sum	41395.66	16379.72	4536.96	33484.98	101694.70	17099.78

Source: Capitaline database

S&P BSE Healthcare index comprises of seventeen firms belonging to three different sectors viz. pharmaceutical, hospitals and firms dealing within medical devices. Only pharmaceutical firms were included in sample, as DEA can be performed on homogeneous decision making units (DMU) only, so with this filter we were left with fifteen firms. Further two firms were excluded as earnings before tax was negative for the year ended March 31, 2012, DEA can be applied only with positive values for input and output variables, with this filter we were left with thirteen firms. Two more firms were excluded from sample as data for March 31, 2012 was not available for them, finally sample comprised of eleven pharmaceutical firms. Table 1 (B) provides descriptive statistics for the input and output variables for pharmaceutical firms.

Table 1(B)
Descriptive Statistics – Pharmaceuticals

	COGS	*SAME*	*EC*	*GB*	*GS*	*EBT*
Mean	1525.77	675.59	460.68	1714.91	3146.47	669.05
Std Error	298.90	152.23	81.06	376.87	676.43	128.35
Median	1143.53	553.44	393.57	1280.76	2348.63	670.40
Std Dev.	991.33	504.88	268.85	1249.94	2243.46	425.68
Kurtosis	0.41	2.62	-1.82	0.58	-0.56	-0.82
Skewness	1.24	1.38	0.18	1.07	0.98	0.56
Minimum	521.61	101.79	145.16	272.04	810.80	121.22
Maximum	3603.21	1887.90	825.80	4298.18	7074.73	1421.46
Sum	16783.52	7431.50	5067.52	18863.98	34611.14	7359.56

Source: Capitaline database

The S&P BSE Consumer Durables index comprises of ten firms. Two firms were excluded as data for March 31, 2012 was not available for them, with this we were left with eight firms. Table 1(C) provides descriptive statistics for the input and output variables for Consumer Durable firms.

Table 1(C)
Descriptive Statistics–Consumer Durables

	COGS	*SAME*	*EC*	*GB*	*GS*	*EBT*
Mean	5642.49	337.28	120.10	323.18	6373.31	276.91
Std Error	2959.03	119.36	45.70	114.23	2976.40	89.40
Median	2015.37	220.91	77.30	237.47	3179.53	178.63
Std Dev.	8369.41	337.60	129.27	323.10	8418.54	252.86
Kurtosis	5.11	-0.26	2.32	-0.36	4.76	3.76
Skewness	2.19	1.11	1.57	1.12	2.10	1.92
Minimum	82.62	20.59	14.98	37.14	250.13	69.78
Maximum	25007.52	919.48	392.34	857.68	25653.85	838.45
Sum	45139.88	2698.26	960.78	2585.42	50986.46	2215.31

Source: Capitaline database

Using DEA frontier analysis software, technical efficiency scores were calculated for input oriented DEA, for both BCC and CRR models. Based on the technical efficiency scores, using (3) scale efficiency scores were calculated, as a measure for firm efficiency. Firms were ranked on the basis of their scale efficiency score. Firms with a score of one are considered to be the most efficient, as DEA is a frontier analysis technique, the efficiency score tells the distance of firm from the frontier, lower score means more distance from the frontier and hence low on efficiency compared to peer firms with a higher efficiency score. Table 2(A), 2(B) and 2(C) presents the scale efficiency scores and ranks of the FMCG, Pharmaceutical and Consumer durable firms respectively.

Table 2(A)
Ranking of FMCG Firms based on DEA

Sample Firms	TE_{CRR}	TE_{BCC}	*SE*	*Rank*
Colgate-Palm.	1.00	1.00	1.00	1
ITC	1.00	1.00	1.00	1
Dabur India	0.54	0.76	0.71	6
Godrej Consumer	0.69	1.00	0.69	7
Hind. Unilever	0.94	1.00	0.94	2
Jubilant Food.	0.82	1.00	0.82	5
Nestle India	0.61	0.68	0.90	4
Tata Global	1.00	1.00	1.00	1
United Breweries	0.93	1.00	0.93	3
United Spirits	1.00	1.00	1.00	1

Source: DEA Analysis of data taken from Capitaline database

Table 2 (B)
Ranking of Pharmaceuticals Firms based on DEA

Sample Firms	TE_{CRR}	TE_{BCC}	*SE*	*Rank*
Biocon	0.82	0.95	0.86	5
Cadila Health	0.91	0.93	0.98	2
Cipla	0.89	1.00	0.89	4
Divis Lab	1.00	1.00	1.00	1
Dr Reddys Lab	1.00	1.00	1.00	1
GlaxosmitPharma	1.00	1.00	1.00	1
GlenmarkPharma.	1.00	1.00	1.00	1
IPCA Lab	0.86	0.86	1.00	1
Lupin	0.95	1.00	0.95	3
PiramalEnterp.	0.74	1.00	0.74	7
Wockhardt	0.43	0.58	0.75	6

Source: DEA Analysis of data taken from Capitaline database

Table 2 (C)
Ranking of Consumer Durable Firms based on DEA

Sample Firms	TE_{CRR}	TE_{BCC}	*SE*	*Rank*
Bajaj Electrical	0.90	1.00	0.90	2
Gitanjali Gems	1.00	1.00	1.00	1
Rajesh Exports	1.00	1.00	1.00	1
Symphony	1.00	1.00	1.00	1
Titan Inds.	0.87	1.00	0.87	3
TTK Prestige	0.84	1.00	0.84	5
V I P Inds.	0.78	0.91	0.86	4
Whirlpool India	0.82	1.00	0.82	6

Source: DEA Analysis of data taken from Capitaline database

Table 3(A), 3(B), 3(C) presents the data for stock opening price (as on April 1, 2011) and closing price (as on March 30, 2012) for FMCG, Pharmaceuticals and Consumer durable firms respectively. Based on opening and closing price stock returns were calculated and sample firms were ranked.

Table 3(A)
Ranking of FMCG Firms based on Stock Returns

Sample Firms	*Opening Price*	*Closing Price*	*Absolute Return*	*Percentage Return*	*Rank*
Colgate-Palm.	824.50	1116.00	291.50	35.35	3
Dabur India	97.10	106.40	9.30	9.58	9
Godrej Consumer	364.25	479.65	115.40	31.68	4
Hind. Unilever	284.05	409.90	125.85	44.31	2
ITC	182.70	226.85	44.15	24.17	6
Jubilant Food.	556.20	1168.15	611.95	110.02	1
Nestle India	3664.35	4602.85	938.50	25.61	5
Tata Global	100.65	112.05	11.40	11.33	8
United Breweries	484.40	541.15	56.75	11.72	7
United Spirits	1049.40	606.05	-443.35	-42.25	10

Source: Capitaline database

Table 3 (B)
Ranking of Pharmaceuticalfirms based on Stock Returns

Sample Firms	*Opening Price**	*Closing Price***	*Absolute Return*	*Percentage Return*	*Rank*
Biocon	356.2	238.05	-118.15	-33.17	11
Cadila Health	798.55	760.1	-38.45	-4.81	9
Cipla	320.8	304.55	-16.25	-5.07	10
Divis Lab	625.4	766.65	141.25	22.59	3
Dr Reddys Lab	1617.6	1758.65	141.05	8.72	7
GlaxosmitPharma	2092.6	2290.8	198.2	9.47	6
GlenmarkPharma.	292.4	307.65	15.25	5.22	8
IPCA Lab	300.1	335	34.9	11.63	5
Lupin	416.3	529.65	113.35	27.23	2
PiramalEnterp.	418.5	469	50.5	12.07	4
Wockhardt	326.3	599	272.7	83.57	1

Source: Capitaline database

Table 3 (C)
Ranking of Consumer Durable Firms based on Stock Returns

Sample Firms	*Opening Price**	*Closing Price***	*Absolute Return*	*Percentage Return*	*Rank*
Bajaj Electrical	242.50	194.75	-47.75	-19.69	5
Gitanjali Gems	249.80	325.00	75.20	30.10	2
Rajesh Exports	104.85	130.90	26.05	24.85	3
Symphony	297.21	196.65	-100.56	-33.83	8
Titan Inds.	192.83	228.60	35.77	18.55	4
TTK Prestige	2254.50	2941.60	687.10	30.48	1
V I P Inds.	136.21	99.90	-36.31	-26.66	7
Whirlpool India	266.20	198.85	-67.35	-25.30	6
Bajaj Electrical	242.50	194.75	-47.75	-19.69	5
Gitanjali Gems	249.80	325.00	75.20	30.10	2
Rajesh Exports	104.85	130.90	26.05	24.85	3

Source: Capitaline database

Using (5), for Pearson's rank correlation, the degree of association between firm efficiency and stock returns was calculated. The value of correlation coefficient was –0.67 for FMCG firms, –0.3 for Pharmaceutical firms and –0.05 for Consumer durables which are weak negative association. Thus study failed to prove the postulate that firm efficiency has strong positive association with stock returns.

$$r = 1 - \frac{6\Sigma d^2}{n^3 - n} \tag{5}$$

where,

r is Pearson rank correlation coefficient

d is difference of two rankings for each sample firms

n is number of sample firms

CONCLUSION

The study identified a weak association between firm efficiency and stock return. The study was conducted on sample of FMCG, Pharmaceutical and Consumer durable firms, each firm's efficiency score was calculated using data envelopment analysis. Based on efficiency scores firms were ranked, firms were also ranked based on their annual stock return. Using Pearson rank correlation, degree of association was calculated, according to which there is a very weak association between firm efficiency and stock returns across all the three sectors. Hence, the study failed to prove the postulate that firm efficiency has strong positive association with stock returns

References

Banker R. D., Charnes A. and Cooper W. W. (1984), "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis," *Management Science*, Vol. 30, pp. 1078–1092.

CatarinaFigueira, Joseph Nellis and David Parker (2009), "The Effects of Ownership on Bank Efficiency in Latin America," *Applied Economics*, Vol. 41, pp. 2353–2368.

Charnes A., Cooper W. W. and Rhodes E. (1978), "Measuring Efficiency of Decision Making Units," *European Journal of Operational Research*, Vol. 2, pp. 429–444.

Constantin Belu (2009), "Ranking Corporations based on Sustainableand Socially Responsible Practices A Data Envelopment Analysis (DEA) Approach," *Sustainable Development*, Vol. 17 Issue 4, pp. 257-268.

D. K. Malhotra and Rashmi Malhotra (2008), "Financial Statement Analysis using Data Envelopment Analysis," Northeast Decision Sciences Institute Proceedings, pp. 330-335.

Hsin-Hung Chen (2008), "Stock Selection using Data Envelopment Analysis," *Industrial Management & Data Systems*, Vol. 108, Issue 9, pp. 1255-1268.

Jau-Shin Hon and Song-Jwu Chu (2011), "Performance Assessment between Taiwan and Korea TFT-LCD Panel Industry from a Risk and Return Perspective Before and After Global Financial Crisis," *International Journal of Electronic Business Management*, Vol. 9, No. 2, pp. 81-94.

Jennifer Powers and Patrick R. McMullen (2000), "Using Data Envelopment Analysis to Select Efficient Large Market Cap Securities," *Journal of Business and Management*, Vol. 7, No. 2, pp. 31-42.

Mohamed Dia (2009), "A Portfolio Selection Methodology Based on Data Envelopment Analysis," *INFOR*, Vol. 47, Issue 1, pp. 71-79.

Mohammed Akbar Ali Khan, Sudershan Kuntluru and Sunil Parupati (2011), "Analysis of Financial Statements using Data Envelopment Analysis (DEA): A Case of Select Indian Pharmaceutical Companies," The Business Review, Cambridge, Vol. 17, No. 1, pp. 178-1184.

Rashmi Malhotra, D. K. Malhotra and Philip S. Russel (2010), "Using Data Envelopment Analysis to Rate Bonds," *Journal of Business & Economic Studies*, Vol. 16, No. 1, pp. 58-76.

Tatyana Arshinova (2011), "Construction of Equity Portfolio on the Basis of Data Envelopment Analysis Approach," *Scientific Journal of Riga Technical University*, Vol. 49, pp. 104-108.

ThoreSten, Kozmetsky George and Phillips Fred (1994), "DEA of Financial Statements Data: The U. S. Computer Industry," *Journal of Productivity Analysis*, Vol. 5, Issue 3, pp. 229-248.

Yao Chen, LuvaiMotiwalla and M. Riaz Khan (2004), "Using Super-efficiency DEA to Evaluate Financial Performance of E-business Initiative in The Retail Industry," *International Journal of Information Technology & Decision Making*, Vol. 3, issue 2, pp. 337-351.

Yi-De Liu (2008), "Profitability Measurement of UK Theme Parks: An Aggregate Approach," *International Journal of Tourism Research*, Vol. 10, pp. 283–288.