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FIRM EFFICIENCY AND STOCK RETURNS: EVIDENCE FROM INDIAN PHARMACEUTICAL INDUSTRY A DATA ENVELOPMENT ANALYSIS APPROACH

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ABSTRACT

The study used data envelopment analysis for measuring efficiency 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.

KEYWORDS: Data Envelopment Analysis, Stock Return, Financial Analysis, Indian Pharmaceutical Firms

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 Healthcare, taking four 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.

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 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,

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r \ y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \quad (1)$$

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

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r \ y_{r0} - u_0}{\sum_{i=1}^{m} v_i x_{i0}} \quad (2)$$

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

j = 1,. . . , n, where u_r, $v_i > 0$, i = 1, . . . ,m, r = 1, . . . , 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),

$$SE = TE_{CRR} / TE_{BCC} \quad (3)$$

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).

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).

Input Variables

- **COGS:** Cost of goods sold (raw material + power & fuel + other manu. Exp.)
- **SAME:** Selling, administrative and miscellaneous Expenses
- **EC:** Employee cost
- **GB:** Gross block

Output Variables

- **GS:** Gross sales
- **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

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

inputs: COGS, SAME, EC, GB

outputs: GS, EBT

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 Healthcare index were taken as sample firms. The 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 3, 2012 was not available for them, finally sample comprised of eleven pharmaceutical firms. Table 1 provides descriptive statistics for the input and output variables.

Table 1: Descriptive Statistics

	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

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 presents the scale efficiency scores and ranks of the sample firms.

Table 2: Ranking of 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

Table 3: Ranking of Firms 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

Table 3, presents the data for stock opening price (as on April 1, 2011) and closing price (as on March 30, 2012). Based on opening and closing price stock returns were calculated and sample firms were ranked.

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 -0.3, which is a weak negative association. Thus study failed to prove the postulate that firm efficiency has strong positive association with stock returns.

$$r = 1 - \frac{6 \sum d^2}{n^3 - n} \quad (5)$$

where,

r is Pearson rank correlation coefficient

d is difference of two rankings for each sample firms

n is number of sample firms

CONCLUSIONS

The study identified a weak association between firm efficiency and stock return. The study was conducted on sample pharmaceutical 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. Hence, the study failed to prove the postulate that firm efficiency has strong positive association with stock returns

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