Cost Efficiency of Listed Food and Agro-Based Firms in India Using DEA Approach

Md. Monzur Hossain*

Assistant Professor, Department of Finance and Banking, Comilla University, Cumilla, Bangladesh;

Abstract: This paper uses Data Envelopment Analysis to examine the determinants of cost efficiency of selected firms from Food and Agro-based firms in India. The information has been obtained from the CMIE ProwessIQ database and compiled for this report. After that, the cost efficiency score is regressed on various criteria, such as the size of the company, return on assets, return on equity, and return on sales. According to the study's findings, the only metric needed to meet the criteria for statistical significance was the return on assets. Return on equity is adversely associated with the cost efficiency of a company. However, the firm's size and the return on sales contribute favourably to which firms are the most efficient. In contrast, return on sales has a positive relationship.

Keywords: Cost Efficiency, Data Envelopment Analysis, Panel Regression.

JEL Codes: C14, C23, D24.

1. INTRODUCTION

In economic literature, the efficiency of any firm is defined in various ways. Farrell (1957) presented the ideas of technical efficiency and allocative efficiency. Allocative efficiency means that a company uses its inputs most cost-effectively and efficiently possible in light of the market price of those inputs and the technology used in its production process. The combined efficiency is known as the overall economic efficiency. This combined economic efficiency can be studied from input (overall cost efficiency) and output (overall revenue efficiency). Aigner et al. (1977) introduced the Stochastic Frontier Approach (SFA), and Charnes et al.(1978) introduced Data Envelopment Analysis (DEA) for measuring the input and output efficiency. When compared to the optimal cost of producing the same quantity of product under the same conditions, the cost efficiency of a corporation may be determined through this comparison. Input-side cost efficiency estimation has been the primary focus of most investigations (Berger et al.,1993); Resti, 1997). Only some studies have looked at the output side, analyzing how efficiently income and profit are generated (Maudos et al., 2002); Bader et al. (2008)). Therefore, the DEA approach is the subject of this study, and its use in assessing cost efficiency is first described. Following that, an attempt is made to determine the possible determinants of this variable.

Indian agriculture and food production have been crucial to economic expansion. It has also been a significant source of revenue for federal and state governments. It is projected to increase by three times by 2020. The government has allowed 100% foreign direct investment in this sector. Presently, the market size of the Food and Agro-based industry in India stood at around $1.3 billion in 2017-18. According to the data provided by the Department of Industrial Policies and Promotions in India, the worth of Foreign Direct Investment (FDI) during the period 2000-2017 of the Food and Agro sector in India has received around $ 7.54 billion. While looking at Asia's increasing contribution to the worldwide Food & Agro-based industry, the Indian sector stands out. The Indian food & grocery market retail contribution is 70 percent of the sales and is the world’s sixth largest market. The share of the food & agro-based industry in India's food market is 32%, the share in India’s total export is 11.70% & share in total employment is 11.60%. Companies in the food and agriculture sector that want to succeed in the face of impending threats should measure their performance against an industry benchmark. Accordingly, this study has attempted to explore the cost efficiency of firms in this industry and to find the determinants of such efficiency scores.

The remainder of the work is structured as follows: excluding this introduction section, a literature review is presented in Section 2, and the related methodology and data sources are available in Section 3. Section 4 presents the results, and the discussion is carried out accordingly before the paper is concluded in Section 5.

2. REVIEW OF LITERATURE

Efficiency analysis produced a lot of financial institution literature in the 1990s (Berger & Humphrey, 1997), and their survey of 130 frontier-based studies found that most studies focused on cost-efficiency analysis. Din et al. (2007) examined the technical efficiency of Pakistan manufacturing companies using Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) of 101 industries for the years 1995-96 & 2000-2001. Moreover, the study applied variables as input (Capital, Labour & Industrial cost) and output (Con-

*Address correspondence to this author at the Assistant Professor, Department of Finance and Banking, Comilla University, Cumilla, Bangladesh; Tel: +8801810065345; E-mail: mmhrabbi@cou.ac.bd

tribution to GDP), and this study is based on a comparative study of two cross-sections. The result of the study is that a large section of manufacturing firms improves their technical efficiency. However, some improvement is still needed to strengthen the legal, physical, and financial infrastructure. Zhang and Bartels et al. (1998) evaluated the effort of sample size on the mean efficiency in DEA for electricity distribution. The author selected three Countries for their study: Australia, Sweden, and New Zealand. The area for the study was electricity distribution. The author chose DEA as their statistical tool. The variable used as inputs are No. of employees, a kilometer of distribution line, and total transfer capacity used as output. The study shows an increase in sample size and a decrease in technical efficiency. The decrease rate depends upon the sample size. The study also shows that it is most useful for a researcher who uses DEA to make inter-industry comparisons of industry structure. Yin (2000) investigated the application of alternative methods for measuring productive efficiency. He used two primary techniques, stochastic frontier analysis (SFA) and data envelopment analysis (DEA), to determine the allocative and technical efficiency levels for 102 mills worldwide. In this study, the variables taken as input (fiber, energy, labor, material, Food & Agro based and electrical power) and output (production). The results show that the SFA cost efficiencies levels are higher than their DEA counterparts, and cost efficiencies levels vary in different regions. Baten et al. (2010) use the stochastic frontier approach (SFA) to study the status of technical efficiency of the Tea-producing industry by including the technical inefficiency effect model. In this study, the variables taken as input (area, labor time) and output (value added) and the technical efficiency were 59%. Therefore, by increasing input and technology and reducing cost, there is a great potential to increase the value by 51%. The study shows that value-added varies among regions and year-wise. Mean efficiency is unsteady during the period. Varmaghani et al. (2015) evaluated the performance of pharmaceutical companies for 13 years, from 2000 to 2013. The study uses Data Envelopment Analysis (DEA) and the variable taken as input (Total Asset, Capital Stock) and as output (Net sale, Net profit). In this study, the productivity of pharmaceutical companies fluctuated. Seven companies improved their management efficiency, and nine improved; less than 50% improved their technical efficiency. This can be because of less attention from managers toward productivity improvement, planning, and long-term strategy. Akgöbek and Yakut (2014) empirically examined the efficiency measurement of 14 manufacturing companies' sub-sectors for 12 years from 1996 to 2008. In this study, firms are based on the efficiency of financial performance in the manufacturing company. It showed an effective score of 78.5 out of 100, which increased in the last period in 2008 by 84.7. Fapohunda et al. (2017) evaluated the performance of 20 manufacturing companies for one year from 2015-2016. The study uses Data Envelopment Analysis (DEA) and the variable taken as input (Total Asset, Fixed Asset, Operating Expenses, and Equity) and as output (Revenue, Gross profit, Profit before tax, and profit after tax). This study concludes that only those firms can survive in the market that efficiently uses the resources and capture the production curve. It evaluated that 35% were scale efficient and 65% were scale inefficient. Based on constant return to scale (CSR), 30% of manufacturing companies were technically efficient, while 70% were technically inefficient. Based on variable return to scale (VRS), 40% were technically efficient, and 60% were technically inefficient. Moreover, to satisfy the maximization, the manufacturing companies need to lower costs to get maximum output profits. Constantin et al. (2009) examined the productivity in Brazilian Agri-business for six years from 2001-2006. The study uses Data Envelopment Analysis (DEA) & Cobb-Douglas, Translog, Stochastic production function (SFN), the variable taken as input (Harvested area increase, agriculture credit) and as output (obtained production). In this study, the aggregate productivity did not increase throughout the analyzed period. It is observed that the total factor of productivity changes in decreasing order. The most important input was land factor & agriculture credit, which contributed to Brazilian Agriculture credit. Zhang et al. (2017) examined the productivity of Alabama's Agricultural sector for 20 years, which was collected from the USDA's census of agriculture. This census was carried out for five years, which were acquired four times across the five years internals, i.e., in 1997, 2002, 2007 & 2012. Technical efficiency of 67 countries was taken. This study takes the variables as inputs (Land, Capital, Livestock, Labour, Fertilizer, and Food & Agro base) and output (Agriculture and products, including Livestock, Poultry, and crops). This study used Stochastic Frontier Analysis (SFA) to test the differences in productivity and efficiency between a less economically developed region (Black belt) and the rest of the country, from which 12 are less economically developed, and 55 are the rest of the country. In the Alabama sector, because of the lack of rainfall, uncertainties related to natural disasters & farm-specific variables also affect technical efficiency in agricultural production. In addition, the important determinants of technical efficiency for farmers are federal government payments. Battese and Coelli (1992) examined the technical efficiency of 38 paddy farmers in India through Stochastic Frontier Analysis (SFA), for which individual farmers' technical efficiency was taken. Limaei (2013) empirically examined the efficiency of the Iranian forest Industry. There are 82 Forest companies, of which 14 Iranian Forest companies were taken. This study estimated efficiency using a traditional DEA and two stages DEA models. In Iran, the Caspian forest is the only one used for industrial harvesting, whereas other locations are not for producing industrial wood. All sub-sectors improved their technical efficiency during the study period, while the sawmills and Wafer board sub-sectors had the highest technical efficiency. Smriti and Khan (2018) examined the efficiency of 1007 manufacturing firms in Bangladesh. The data was taken from an Enterprise survey (Funded by the World Bank). The Data Envelopment Analysis (DEA) was assigned to calculate the input and output's maximum efficiency and weight. Under the variable return to scale assumption, only 29 firms are found efficient. First and foremost, a manager is concerned with the effectiveness of manufacturing companies in Bangladesh.

In terms of methodology, while many studies have analyzed cost efficiency using parametric and non-parametric methods, only one study (Färe, & Grosskopf, 1997) has calculated standard profit efficiency using non-parametric methods without comparing it to cost efficiency, and no study has done so for alternative profit efficiency. This research examines the performance of government-owned fertilizer firms throughout ten years marked by unprecedented flux levels. To broaden the analysis, the study will use a non-parametric method to compare cost, revenue, and profit efficiency. This work employs cutting-edge methodology by employing a non-parametric strategy for evaluating alternative profit efficiency, which permits the presence of a monopoly in the market. As far as we know, no research has been conducted into the factors that influence the cost-effectiveness of businesses from a targeted sector perspective (at least in India). Hopefully, this research will help close that gap in the current literature. This study will therefore consider the cost efficiency of businesses in India's Food and Agro-based industry and investigate the factors that contribute to such efficiency.

The proposed research area is an attempt to examine what factors influence the cost-effectiveness of the selected businesses. The objectives of this study are twofold. Firstly, this paper explores the nature and trend of efficiency in terms of cost among businesses; and then investigates the causes of cost efficiency among the chosen companies.

3. DATA & METHODOLOGY:

3.1. Data Source

The research compared the success rates of several companies in India's food and agriculture sectors. The research conducted over 12 years, from Fiscal Years (FY) 2006 to (FY) 2017. Firms were analysed using data gleaned from the CMIE ProwessIQ database, which included annual reports, websites, research reports, and presentations given by company representatives. A fair panel was assembled after data on all relevant companies in the Food and Agro-Based Products sector were collected and processed. At last, comprehensive information was accessible for 142 businesses. The DEA was then used to calculate the cost-effectiveness of some sample businesses in this research. Our research then focused on companies with a cost efficiency of 0.25 or higher. Twelve firms are chosen in this manner. These are: A V Thomas & Co. Ltd., Cotton Corporation of India Ltd., Divya Jyoti Inds Ltd., Gokul Refolls & Solvent Ltd., J V L Agro Inds Ltd., Jayant Agro-Organics Ltd., Kwality Ltd., Natraj Proteins Ltd., Poona Dal & Oil Inds Ltd, Ruchi Soya Inds Ltd., Vijay Solvex Ltd., and Vimal Oil & Foods Ltd.

3.1.1. Financial Ratios of the Selected Firms

This study has considered ROA, ROE, and ROS for financial analysis of the selected companies from 2006 to 2017.

3.1.2. Return on Asset (ROA) Ratio

Return on Asset (ROA) is the ratio for determining how much the company's management uses its asset to generate earnings or profits. It is always shown as a percentage. The higher the number, the more efficiently the company management manages its balance to generate profit where ROA= Operating profit/ Total assets. Operating profit is the profit earned from a company's operating business. Operating profit reflects the residual income. Operating profit does not include any investments.

Moreover, the sale of assets and production equipment are not included because these are not the business's core operations. Total assets are the total assets an entity or a person owns. If the operating cost of the firm or company is high, then the operating profit will be moving low. This result will decline Earnings before Interest & Tax Depreciation and Amortization.

Return on Equity (ROE) Ratio

Return on Equity (ROE) is a ratio that is used for the measurement of the financial performance of a company. Return on equity measures how effectively management uses a company's assets to create profits. It is the average shareholder's equity. ROE= Operating Profit/ Average shareholder's equity. An increase in the ROE can generate a profit internally. However, it does hide the risk associated with the return of that ROE. A company depends more on debt to generate and cost the ROE.

Return on Sales (ROS) Ratio

Return on sales, often known as ROS, is a ratio used to assess a company's operational effectiveness. It determines how much of a profit is being generated for each dollar that is being sold. An increase in return on sales indicates the company is functioning or performing very well, while a decrease in return on sales indicates the company is facing financial trouble. Thus, ROS= Operating profit/ Net sales.

3.2. Methodology

All financial information has been gathered or converted to Indian Rupees (in Crore INR). In order to create a representative sample for analysis, we exclude companies having gaps in their accounting data that were discovered during the data cleaning process. No approximation or rounding-off was performed to improve the precision of the data. The data must first be prepared for statistical analysis by checking for assumptions like normality, multicollinearity, heteroskedasticity, and the presence of outliers before panel data analysis can be used. Specification tests are also performed to ensure the model fits the data well.

3.2.1. Cost Efficiency DEA Model

Assume there are N different firms (i = 1,…, N) that produce a vector of q outputs yi = (yi1,…, you) and that they sell at prices ri=(ri1,…, riq) using a vector of p inputs xi=(xi1,…, zip) for which they pay prices wi=(wi1,…,wip). The following linear programming problem can be used to determine the cost-effectiveness for company j:

$$Min \sum_{p} w_{jp} x_{jp}$$

$$s.t. \sum_{i} \lambda_i y_{iq} \geq y_{jq}$$

$$\sum_{i} \lambda_i x_{ip} \leq x_{jp}$$

$$\sum_{i} \lambda_i = 1; \text{ for all i=1,2,.....N}$$

Table 1. Descriptive Statistics of Financial Ratios.

Symbol	Definition	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
SIZE	Size of the Firm	8.72	8.92	9.11	9.11	9.28	9.44	9.33	9.65	9.54	9.36	8.99	8.81
ROA	Return on Assets	0.07	0.09	0.05	0.33	0.04	0.33	0.15	0.39	-0.03	0.28	0.09	0.09
ROE	Return on Equity	0.24	0.28	-1.90	1.98	0.03	0.89	-0.04	1.55	-4.85	3.99	0.61	-0.18
ROS	Return on Sales	0.02	0.03	-0.13	0.09	0.00	0.08	-0.02	0.09	-0.25	0.10	0.10	-0.02

Source: Author's calculation.

The solution to which x*j = (x*j1,…, x*jp) corresponds to the input demand vector that is derived from a linear combination of businesses that produce at least as much of each of the outputs with the same number of inputs or fewer inputs, hence reducing costs given the pricing of those inputs. If this hypothetical company used the same input price vector as Firm j, its costs would be:

$$C_j^* = \sum w_{pj} . x_{pj}^*$$

Moreover, it cannot be more significant than that of firm j. Hence, the cost efficiency for firm j (CEj) is

$$CE_j = \frac{\sum_p w_{jp} x^*_{jp}}{\sum_p w_{jp} x_{jp}}$$

$CE_j \leq 1$ since it represents the ratio between the minimum costs (C^*_j) and the observed costs (C_j) for firm j.

3.2.2. Panel Regression

Panel data analysis, which incorporates cross-sectional and time series dimensions, has been used in this study to investigate the factors determining the cost efficiency of various companies operating within India's Food and Agro-based industry between 2006 and 2017. Following the lead of Baltagi et al. (2005), the current work considers the panel regression model presented below.

$$EFF_{it} = \beta_0 + \beta_1 . SIZE_{it} + \beta_2 . ROA_{it} +$$

$$\beta_3 . ROE_{it} + \beta_4 . ROS_{it} + +\alpha_i + U_{it} . . (1)$$

In addition, we consider a model with a unidirectional error component for the disruptions.

$$u_{it} = \mu_{it} + v_{it} \ (2)$$

For all i=1,2,…..12; and t=2006, 2007, …..2017

Subsequent subsections present and discuss the results obtained using this model. The ProwessIQ database is mined for the companies chosen. A fair panel was assembled after data on all relevant companies in the Food and Agro-Based Products sector were collected and processed. At last, comprehensive information was accessible for 142 businesses. The DEA was then used to calculate the cost-effectiveness of some sample businesses in this research. Our research then focused on companies with a cost efficiency of 0.25 or higher. Twelve businesses are chosen in this manner.

4. RESULTS AND DISCUSSIONS

4.1. Descriptive Analysis

The following table presents the summary statistics of the Input-output variables used in this study.

During the study period, the trend of the parameter 'SIZE' of the form is more or less uniform. Further, ROA and ROS ratios follow the same pattern, but the ROE ratio shows sharp fluctuations during 2008-10 and 2013-20.

4.2. Correlation Analysis

The correlation coefficient is a helpful measure for sketching out the nature of the connection between two variables. The variables were perfectly connected in one direction if the coefficient was either +1 or -1. When the coefficient is zero, there is no correlation between the two variables. The correlation coefficient can calculate the degree of association between the two variables. The coefficient of either +1 or -1 indicates a perfect positive or negative correlation between the variables. If the coefficient is zero, the chosen variable does not correlate. A linear link between two variables is the only relationship the correlation coefficient can measure. The significant correlations between the dependent and independent variables are shown in Table **2**.

Table 2. Correlation Matrix of Selected Variables.

	EFF	SIZE	ROA	ROE	ROS
EFF	1				
SIZE	0.0531	1			
ROA	0.1682	0.1079	1		
ROE	-0.0012	0.0263	0.6605*	1	
ROS	-0.0609	-0.0616	0.6020*	0.8988*	1

Source: Authors' calculation based on the sample data

Two variables (SIZE and ROA) are positively correlated, while two others (ROE and ROS) are negatively correlated. Moreover, ROA, ROE, and ROS are all statistically highly correlated. The results above show a strong and statistically significant link between the dependent variable and the chosen independent factors. However, the issue of multicollinearity may arise if some of the independent variables are highly correlated, which could lead to an inaccurately estimated

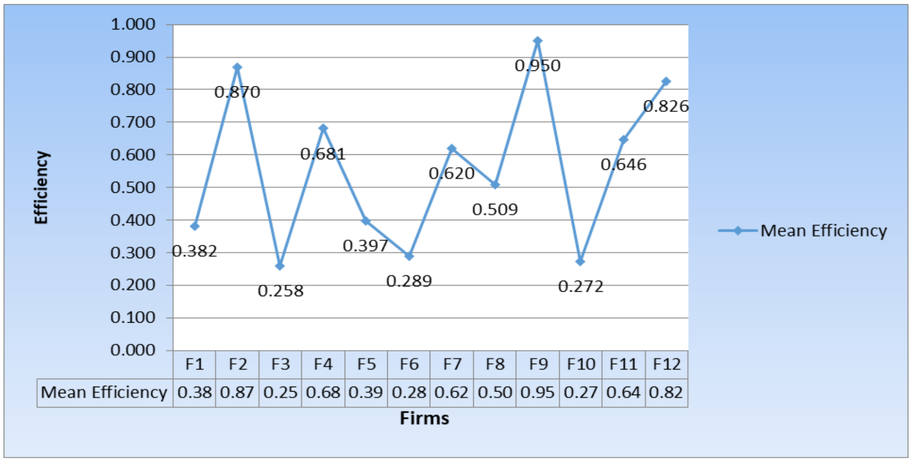

Fig. (1). Mean Cost Efficiency of the Selected Firms during 2006-17.
Source: Author's calculation.

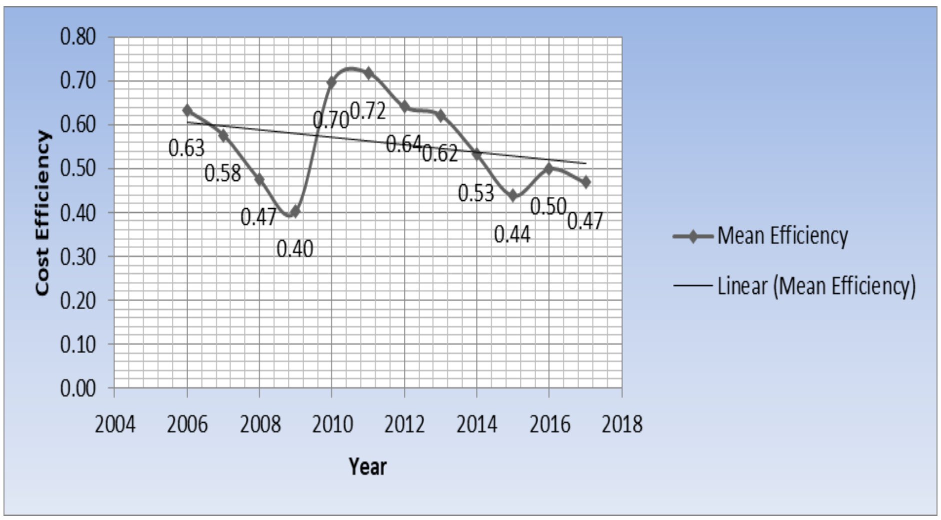

Fig. (2). Year Wise Mean Efficiency of Firms during 2006-17.
Source: Authors' calculation based on the sample data.

regression equation (Gujarati, 2003). The Variance Inflation Factor (VIF) method has been employed to detect the potential multicollinearity problem, and the estimated findings are shown below in order to prevent such skewed regression results:

Table 3. Test of Multicollinearity.

Variable	VIF	1/VIF
ROE	6	0.16667
ROS	5.42	0.184408
ROA	1.8	0.554121
SIZE	1.06	0.945702
Mean VIF	3.57	

Source: Authors' calculation based on the sample data.

Theoretically, multicollinearity could arise from using a variable with a VIF more significant than 10. Nonetheless, as shown in the table above, none of the VIFs are exceptionally high, suggesting that multicollinearity among the explanatory variables is mild.

4.3. DEA Results

The researchers in this study started by looking into India's food and agro-based industries between 2006 and 2017. After that, twelve companies are selected with a mean cost efficiency of at least 0.25, based on their performance, as measured by data envelopment analysis (DEA). The trend of cost efficiency scores of the selected firms is presented below:

The ninth company displayed maximum mean cost efficiency, followed by the second and twelfth companies. In contrast, the third company has the lowest mean cost efficiency, followed by the tenth. Below, we give the median efficacy of select businesses by year:

The average cost-effectiveness throughout the period ranges from 0.40 to 0.72. In 2011, cost-effectiveness was at its highest, and in 2009, it was at its lowest. Average cost-effectiveness varied considerably during the research period. The selected companies' mean cost efficiency steadily declined from 2006 to 2009, reaching a record low that year.

Table 4. Descriptive Statistics of Cost Efficiency Scores of Selected Firms During 2006-2017.

	Year-wise Cost Efficiencies of Selected Firms during 2006-17												Firm wise efficiency			
Firm	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Maximum**	**Minimum**	**Mean**	**sd**
F1	0.861	0.762	0.254	0.140	0.455	0.538	0.421	0.287	0.241	0.083	0.335	0.207	0.861	0.083	0.382	0.239
F2	0.863	0.661	1.000	1.000	1.000	0.899	0.629	1.000	1.000	1.000	1.000	0.383	1.000	0.383	0.870	0.204
F3	0.600	0.355	0.344	0.154	0.297	0.338	0.355	0.292	0.108	0.043	0.114	0.097	0.600	0.043	0.258	0.159
F4	0.391	0.293	0.494	0.510	1.000	1.000	1.000	1.000	1.000	0.424	0.054	1.000	1.000	0.054	0.681	0.353
F5	0.458	0.480	0.237	0.165	0.400	0.546	0.285	0.342	0.282	0.572	0.401	0.600	0.600	0.165	0.397	0.139
F6	0.410	0.434	0.437	0.368	0.804	0.403	0.160	0.085	0.068	0.080	0.079	0.138	0.804	0.068	0.289	0.226
F7	0.581	0.879	0.546	0.331	0.773	0.900	0.904	0.668	0.854	0.344	0.228	0.434	0.904	0.228	0.620	0.245
F8	0.639	0.478	0.285	0.208	0.577	0.612	0.668	0.637	0.495	0.201	0.929	0.373	0.929	0.201	0.509	0.214
F9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.938	0.502	0.956	1.000	1.000	1.000	0.502	0.950	0.143
F10	0.218	0.203	0.213	0.181	0.276	0.378	0.265	0.285	0.282	0.352	0.294	0.314	0.378	0.181	0.272	0.060
F11	0.646	0.587	0.413	0.298	0.777	1.000	1.000	0.924	0.545	0.266	0.678	0.620	1.000	0.266	0.646	0.249
F12	0.933	0.782	0.475	0.473	1.000	1.000	1.000	1.000	1.000	0.928	0.878	0.448	1.000	0.448	0.826	0.227
Maximum	1	1	1	1	1	1	1	1	1	1	1	1				
Minimum	0.218	0.203	0.213	0.140	0.276	0.338	0.160	0.085	0.068	0.043	0.054	0.097				
Mean	0.633	0.576	0.475	0.402	0.697	0.718	0.641	0.621	0.531	0.437	0.499	0.468				
sd	0.232	0.235	0.257	0.292	0.272	0.261	0.318	0.332	0.338	0.336	0.358	0.283				

Source: Compiled by the author from the CMIE ProwessIQ database source: Authors' calculation based on the sample data.
Note: F1: A V Thomas & Co. Ltd. F2:Cotton Corporation Of India Ltd. F3: Divya Jyoti Inds. Ltd. F4: Gokul Refoils & Solvent Ltd. F5: J V L Agro Inds. Ltd. F6: Jayant Agro-Organics Ltd. F7: Kwality Ltd. F8: Natraj Proteins Ltd. F9: Poona Dal & Oil Inds. Ltd. 10: Ruchi Soya Industries Ltd. F11: Vijay Solvex Ltd. 12: Vimal Oil & Foods Ltd.

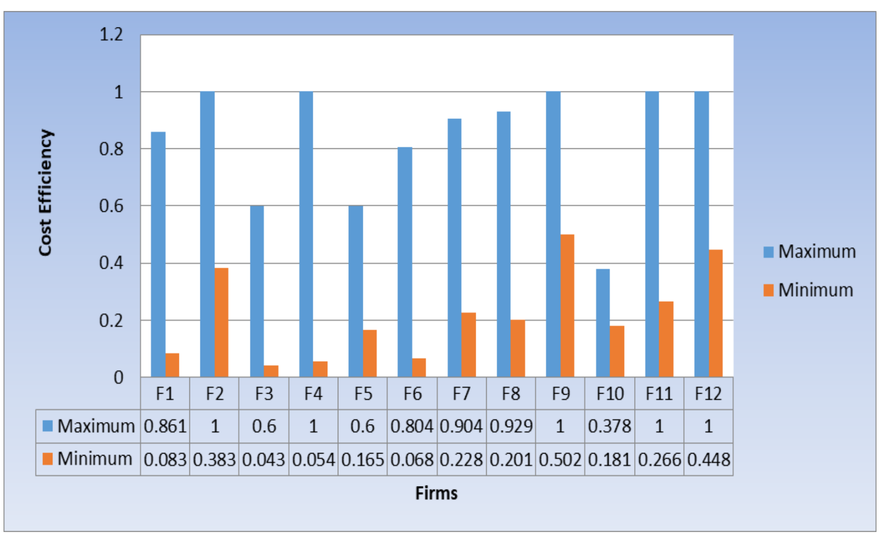

Fig. (3). Firm Wise Maximum and Minimum Efficiency Scores during 2006-17.
Source: Authors’ calculation based on the sample data.

After that, it began rising, and by 2011 it had reached its highest point ever recorded. Again, the trend was down until it nearly bottomed out in 2015. After that, it resumed its earlier upward trend. Therefore, a high-low chart of the cost efficiency score of the sampled firms during the study period is necessary for investigating the development of the mean cost efficiency.

The following is a High-Low chart based on Table **4** that compares the cost efficiency scores of various companies:

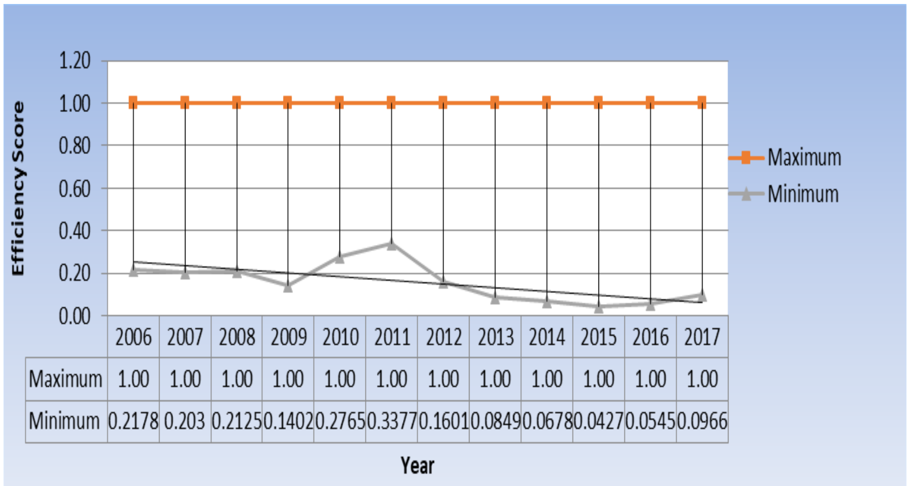

Fig. (4). Year Wise High-Low Chart of Cost Efficiency Scores.
Source: Author's calculation.

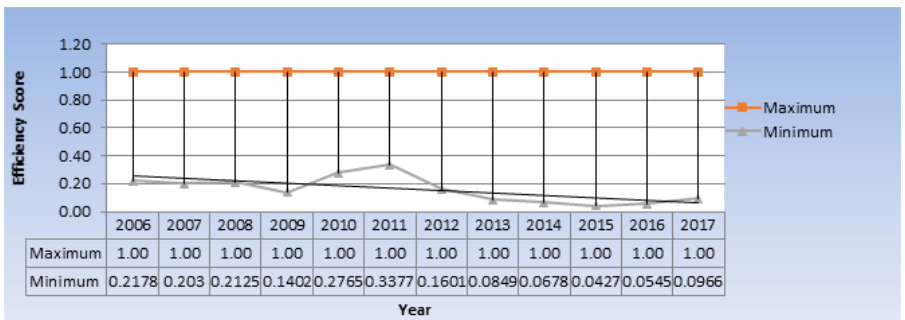

Fig. (5). Year Wise High-Low Chart of Cost Efficiency Scores.
Source: Author's calculation.

Table 5. Descriptive Statistics of Determinants of Cost Efficiency.

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
EFF	132	0.552609	0.318761	0.042709	1
SIZE	132	9.210238	1.404839	6.819689	12.54178
ROA	132	0.147472	0.508092	-0.91159	3.410986
ROE	132	0.107186	6.982307	-54.621	41.87601
ROS	132	-0.00165	0.387929	-3.01708	0.82195

Source: Authors' calculation based on the sample data.

The following graph shows that out of twelve companies, five have the most efficient one (scoring a perfect 1.00), and the third has the least efficient one (scoring a perfect 0.00).

In addition, the companies ranked 2nd, 9th, and 12th are the most reliable overall.

Of the top-scoring businesses, the fourth has the widest cost-effectiveness variation, followed by the eleventh.

Again, based on Table **4**, the High-Low chart of the cost efficiency scores over the years of selected firms is prepared. The maximum deviation occurred in 2015, followed by 2016, 2014, and 2017. The most minor deviations occurred during 2011, followed by 2010. This is presented in Fig. (**5**).

4.4. Regression Results

Below, we show you the outcomes of applying the strategies discussed earlier. To begin, we offer a brief overview of the descriptive statistics of the dependent and independent variables chosen for this study so that we may investigate their features. The sample data in this study have been summarized using 5-point measures. Then, the linear relationship between the two variables is determined by correlation analysis. Finally, the following chapters present and analyze the panel regression findings.

In this study, the Efficiency score (EFF) is regressed on the size of the firm (SIZE), Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS).

Table 6. Fixed-Effects (within) Regression vce (Robust).

Independent variables	Dependent Variables: EFF					
	Coef.	**Std. Err.**	**t**	**p>|t|**	**[95% Conf. Interval]**	
SIZE	0.154	0.034	4.09	0.002***	0.070	0.238
ROA	0.008	0.019	0.44	0.671	-0.034	0.051
ROE	-0.009	0.003	-3.58	0.005***	-0.015	-0.003
ROS	0.164	0.054	3.06	0.012**	0.045	0.283
Intercept	-0.865	0.345	-2.51	0.031**	-1.631	-0.098
Number of observations = 132; Number of firms = 12; Time Periods=11, F (4,112) = 13.95; probability> F = 0.0000						

Source: Authors' calculation based on sample data
Note: '*','**' and '***' signifies significant at 10%, 5% and 1% level, respectively

4.4.1. Panel Data Regression Analysis

This research begins by employing a Generalized Least Square (GLS) random Effects model; fitting this model to the random-effects data yields a probability greater than or equal to chi2 = 0.0016 < 0.05. Therefore, the GLS regression model cannot be dismissed. This study additionally employed the Breusch and Pagan Lagrangian multiplier test for the presence of random effects to evaluate random effects and pooled regression. It was discovered that the random-effect GLS regression could not be rejected. Hence, the panel structure is present in the dataset. So, the fixed effect regression model was used in this investigation. The findings indicate that this model cannot be dismissed because the model fits with the fixed-effects model with a probability greater than F = 0.0002<0.05. However, the Hausman test was also used to differentiate between random-effect and fixed-effect regression. The results showed that the model was consistent with the fixed-effect regression model (Prob>Chi2=0.0000<0.05). In addition, a regression diagnostic test was used in this research. However, before reporting the findings of the fixed-effect (inside) regression model, the researchers check for bias by looking for signs of heteroskedasticity and serial autocorrelation. Since the p-values corresponding to the modified Wald test for group-wise heteroskedasticity in the fixed-effect (within) regression model and the Wooldridge test for the presence of autocorrelation in panel data were both found to be less than 0.05, it can be concluded that the fixed-effect (within) regression model is biased. In addition, the robust estimation method is used in this work to provide objective findings. The estimated final results are shown below:

Hence, the estimated equation becomes

$EFF_{ij} = -0.865+0.154(SIZE_{ij})^{*}+0.008(ROA_{ij})-0.009\ (ROE_{ij})^{*} + 0.164(ROS_{ij})^{*}$

There is considerable statistical support for all of the parameters. The efficiency of the chosen businesses is positively correlated with company size and return on sales but adversely correlated with return on equity.

5. CONCLUSIONS

This study aims to evaluate the cost-effectiveness of firms operating in India's food and agro-based industries between 2006 and 2017. For estimating Cost efficiency of any firm, the actual cost incurred by any firm is compared with the minimum cost generating firm; and the ratio of minimum cost achieved by the best practiced firm to actual cost incurred by any specific firm is taken as the cost efficiency score of that particular firm. For this, the analysis has been presented in two stages. Firstly, this study employed the Data Envelopment Analysis and after which such efficiency scores are regressed on size of the firm, return on assets, return on equity and return on sales. Thus, all the issues which are raised as research question in the beginning of this study have been covered. This study analyses the determinants of cost efficiency. After that, the cost efficiency score is regressed on various criteria, such as the size of the company, return on assets, return on equity, and return on sales. According to the study's findings, the only metric needed to meet the criteria for statistical significance was the return on assets. Return on equity is adversely associated with the cost efficiency of a company. However, the firm's size and the return on sales contribute favourably to which firms are the most efficient. In contrast, return on sales has a positive relationship. The size of the firm and return on equity are statistically significant at 1% level whereas the return on sales along with the intercept term are statistically significant at 5% level. Moreover, the absolute value of slope coefficients of size of the firm and return on sales are much higher than return on equity and return on assets.

ACKNOWLEDGMENT

The author is grateful to the anonymous referee during the review for the insightful comment and suggestions.

FUNDING

The author didn't receive any funding for this study.

CONFLICT OF INTEREST

The authors declare that none of the authors have a conflict of interest to disclose.

REFERENCES

Aigner, D. J., Lovell, C. A., & Schmidt, P. (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics*, 1, 21-37.

Akgöbek, Ö., & Yakut, E. (2014). Efficiency measurement in Turkish manufacturing sector using data envelopment analysis (DEA) and artificial neural networks (ANN). *Journal of Economic & Financial Studies*, *2*(03), 35-45.

Bader, M. K., Mohamad, S., Ariff, M., & Hassan, T. (2008). Cost, Revenue, and Profit Efficiency of Islamic Versus Conventional Companys: International Evidence Using Data Envelopment Analysis. *Islamic Economic Studies, 15* (2).23-76.

Baten, A., Kamil, A. A., & Haque, M. A. (2010). Productive efficiency of tea industry: A stochastic frontier approach. *African Journal of Biotechnology*, 9(25), 3808-3816.

Battese, G. E., & Coelli, T. J. (1992). Frontier production functions, Technical efficiency, and panel data: With application to paddy farmers in India. (Vol. 3). *India: Journal of productivity analysis.*

Berger, A. N., & Humphrey, D. B. (1997). The efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research*, 98 (2), 198–212.

Berger, A. N., Hunter, W. C., & Timme, S. G. (1993). The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present, and Future. *Journal of Companying and Finance*, 17 (1), 221-249.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European journal of operational research*, *2*(6), 429-444.

Constantin, P. D., Martin, D. L., Rivera, R. Y., & De, E. B. B. (2009). Cobb-Douglas, translog stochastic production function and data envelopment analysis in total factor productivity in Brazilian agribusiness. *Journal of Operations and Supply Chain Management (JOSCM)*, 2(2), 20–33.

Din, M. U., Ghani, E., & Mahmood, T. (2007). Technical efficiency of Pakistan's manufacturing sector: A stochastic frontier and data envelopment analysis. *The Pakistan Development Review*, 1-18.

Fapohunda, F. M., Ogbeide, S. O., & Lgbinigie, O. O. (2017). An empirical assessment of manufacturing companies efficiency in Nigeria: Data envelopment analysis (DEA) approach. (Vol. 8). *Nigeria: Research journal of finance and accounting.*

Fare, R., & Grosskopf, S. (1997). Profit Efficiency. *Farrell Decomposition And the Mahler Inequality*, 283-287.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society*, 3(1), 60-71.

Limaei, S. M. (2013). The efficiency of the Iranian forest industry based on data envelopment analysis model. (Vol. 24). *Iran: Journal of forestry research*.

Maudos, J., Pastor, J., Pe'rez, F., & Quesaba, J. (2002). Cost and Profit Efficiency in European Companys. *J. Int. Finance. Mark. Inst. Money*, *12*, 33-58.

Resti, A. (1997). Evaluating the Cost-efficiency of the Italian Companying System: What Can be Learned from the Joint Application of Parametric and Non-parametric Techniques? *Journal of Companying and Finance*, 21 (1), 221–250.

Smriti, T. N., & Khan, M. H. (2018). Efficiency analysis of manufacturing firms using the DEA technique. (Vol. 8). *Bangladesh: Journal of data science.*

Varmaghani, M., Meshkini, A. H., Farzadfar, F., Yousefi, M., Yaghoubifard, S., Varahrami, V., & Zekri, H. S. (2015). Evaluation of productivity in Iranian pharmaceutical companies: A DEA-based Malmquist approach and panel data analysis. *Journal of Research in Pharmacy Practice*, *4*(2), 51.

Yin, R. (2000). Alternative measurement of productive efficiency in the global bleached softwood pulp sector. (Vol. 46). *America: Forest science.*

Zhang, Y., & Bartels, R. (1998). The effect of sample size on the mean efficiency in DEA with an application to electricity distribution in Australia, Sweden, and New Zealand. *Journal of productivity analysis*, *pp. 9*, 187–204.

Zhang, D., Xiw, J., & Affuso, E., (2017). An efficiency and productivity analysis of the agriculture sector in alabama. *International journal of Applies Economics*, 14(2). 19-36.

Received: April 13, 2023 Revised: April 17, 2023 Accepted: July 12, 2023