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PRODUCTIVITY AND EFFICIENCY OF AGRO-FOOD FIRMS IN INDIA: AN APPLICATION OF DATA ENVELOPMENT ANALYSIS AND MALMQUIST PRODUCTIVITY INDEX

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Abstract
Given the backward and forward linkages; and export potential of agro-food firms, in this paper an attempt has been made to analyse the firm level efficiency and total factor productivity of this sector. In this context, Data Envelopment Analysis and Malmquist Productivity Index were utilized panel data spanning over twenty two years from 1994-95 to 2015-16 75 Indian agro-food firms. Broadly, study concluded that the first and second generation reforms contributed considerably to efficiency and total factor productivity of agro-food firms. Specifically, Technological change during the second generation reforms was instrumental to aise the productivity. However, global meltdown and overall fall in demand for exports lead to fall in productivity after 2008.
Keywords: DEA, Malmquist Productivity Index, Efficiency, Productivity, Agro-food firms.

Introduction

The relevance of agro-based industry and food industry in particular in an agricultural economy is not debatable. It links the agriculture sector to the rest of the segments of the economy. By 2025, it may touch $470 billion segment of the manufacturing sector. As per the Annual Survey of Industries (2019-20), in the context of net value added, it has contributed approximately 8 percent of total manufacturing output, 11 percent of total workers engaged in of manufacturing sector and on capital intensity front it accounted for 6 percent of total fixed assets of manufacturing sector. Further, it constituted approximately 10.5 percent of total exports [Ministry of Commerce and Industry, 2023]. Given the backward and forward linkages; and export potential of this segment, it can generate growth and employment opportunities in other sectors also. However, Kumar and Basu (2008) concluded that despite of a strong base and third largest producer of food products in the world, India's food processing industry was operating far below its potential on account of low rate of technological progress and increasing inefficiencies. In addition, Gupta et al., (2014) was of the opinion that performance of food processing SMEs not only depended on technology, research and development but also on suppliers, competitors and government/research Institution. In this context, many serious efforts have been made to develop and modernize this segment of industry in India in order to have better rural development in terms of employment, value addition and exports. For instance, Twelfth five year plan proposed to setup National Mission on Food Processing to improve coordination and implementation of schemes and to enable greater involvement of state governments, this sector was announced as priority sector under Make in India initiative, PM Kisan SAMPADA Yojana to develop mega Food Park, cold chain infrastructure, food safety and quality assurance etc., Credit facility was provided upto 95 percent of protect cost by NABARD etc.

1. Review of Literature

Lachaal et al., (2004) for Tunisian agro-food Industry firms showed that overtime technical inefficiency has increased due to aging of capital stock, of large firms and also due to the government intervention in the form of subsidy. Jajri and Ismail (2006) for Malaysian manufacturing sector revealed that over the time, on an average basis, total factor productivity declined in mid 90s due to financial crises. However, some labour intensive industries like food and wood products were experiencing high efficiency and technological change. Yodafiatfinda et al., (2012) for the Malaysian food processing industry suggested

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that industry can further increase its output by 31 percent. Further, it was also found that productivity growth had positive relationship with public infrastructure, IT expenditure and foreign ownership while energy price was negatively associated with productivity growth. Afzal and Ayaz (2013) in case of food sector of Pakistan revealed that the year wise performance of food producing companies had improved over the past four years. Further the study also concluded that performance of food sector of Pakistan could improve significantly if attempts were made to bring modern technology in food production and food processing. Baran (2016) for Polish food industry the sales revenues, wages and salaries were more in highly globalized companies and the small and medium polish companies to face tough competition from the global companies. Rezitis and Kalantzi (2016) found that all the nine sectors of Geek food and beverages manufacturing industry were found to be technically inefficient due to the fact that industry consisted of mainly small traditional firms which lacked modern technology. Gardijan and Lukac (2018) analyzed the relative efficiency of the food and drink industry of the 19 EU countries and found that Cash liquidity ratio was the main area of inefficiency for more than 50 percent of countries, followed by earnings before interest and taxes (EBIT) per employee for more than 38 percent of countries. These were the areas which demanded more managerial attention. Machmud et al., (2019) utilized the DEA approach in order to analyse the food industry in Indonesia. CRS and VRS models confirmed that the food industry was operating at decreasing returns in Indonesia. This was due to conditions of raw material and labour which were needed to be optimized.

In case of Indian agro-based firms" Gandhi et al (2001) opined that due to economic liberalization growth of agro-industry differ over agro-industrial groups. Whereas employment generation was substantial in agro food processing industry, it was negligible in case of firms like agriculture/fishery/cattle-raising. On the other hand, Kumar and Basu (2008) concluded that due to low technical progress and high inefficiencies, Indian food processing sector was not able to perform to its full potential. Manonmani and Geetha (2009) highlighted declining total factor productivity for Tamil Nadu agro-based industry. The study concluded that any fall in efficiency lowers the marginal productivity of labor and pulls down employment. Ali (2007) for Indian meat processing industry found that it is possible to reduce technical inefficiency in meat processing industry by 41 percent and by 7 percent for CRS and VRS model respectively. The study concluded that efficiency of this industry can be increased by improving market infrastructure, removal of intermediaries, technical know-how and managerial capabilities.

In the context of Indian Sugar industry, factors like strategic productivity management (i.e. unscientific harvesting of sugarcane, delays in crushing, variations in area under cultivation), low yielding varieties of seeds, lack of managerial skills at all were responsible for low efficiency (Pandey, 2007 & Javalagi and Bhushi 2014). Singh et al., (2007) for Uttar Pradesh sugar industry highlighted the role of organizational setup. The study concluded that private sector firms in Western region were most efficient with 84.29 percent efficiency, state owned firms were operating at efficiency above 75 percent and cooperative firms were least efficient with 60 percent efficiency. Furthermore, the difference in efficiency was on account of operational and managerial skills. It was also found that the capacity utilization of sugar industry was less across the entire region. Kumar and Arora, (2009) & Ray (2012) also bring out that there was diminishing capacity utilization growth rate in sugar industry during post reform period. In addition, Kumar and Arora (2009) also highlighted that acute shortage of sugarcane, which compels the several firms to cease their operations even in the mid of peak season and excessive government control regarding Statuary Minimum Price (SMP) has reduced the cost efficiency of sugar firms. Kaur and Kaur (2016) found that the market liberalization had not encouraged investment in capital goods which could have facilitated the capacity utilization. The study further suggested the additional investment in food processing industry with increasing and constant returns to scale to encourage the profitable output. The units with decreasing returns to scale should be facilitated with modern techniques of production. Malhotra (2018) found that the Food processing industry in Punjab experienced a considerable growth due to positive growth of Total Factor Productivity growth, and in the post reforms period growth of Total Factor Productivity was mostly affected by technical progress.

On the whole, the above literature stressed upon the problems like managerial inefficiency, obsolete technology, low capacity utilization, absence of marketing infrastructure, unskilled labour, high energy prices etc. But, the existing literature, in case of agro-based industry in India, stressed mainly on industry specific studies. Therefore, in this paper an attempt has been made to comprehensively analyze the firm level efficiency of agro-food industry in India.

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2. Database and Methodology

3.1 Database

The study utilized panel data spanning over twenty two years from 1994-95 to 2015-16 for 75 agro-food firms. While selecting the initial year of the study it has been kept in the mind that adequate number of firms could qualify for the sample for maximum number of years. In order to avoid the outlier in the sample, the firm which has merged during the study period, was not included in the sample. Attempt has also been made to analyse the impact of initial phase of economic reforms from 1994-95 to 2000-01, second generation reforms from 2001-02 to 2007-08 and later during the economic slowdown from 2008-09 to 2015-16 while measuring efficiency and total factor productivity. For empirical analysis three input ratios were worked out to measure efficiency of firms using Compensation to Employees, Raw Material and Power and Fuel. The ratios in this were defined as

1. Total Income to compensation to employees
2. Total Income to Raw Material
3. Total Income to Power and Fuel

Further, Total Income was used as output variable. Total income and Raw Material were deflated by using wholesale price index. Compensation to employee expense was deflated by consumer price index. Finally, Power and Fuel were deflated by price index of power and fuel. For this, the series for whole sale price index and consumer price index were collected from International Financial Statistics, IMF (2017) and the series on index of Power and Fuel, and GDP deflator was collected from Handbook of Statistics on Indian Economy, RBI (2017). As far as the data on agro-food firms is concerned, it was collected from Prowess Database compiled by Centre for Monitoring Indian Economy (CMIE).

3.2 Methodology

3.2.1 Measurement of Technical Efficiency: Data Envelopment Analysis

In the earliest attempt, Farrell(1957) utilized linear programming model to measure technical efficiency with reference to benchmark technology characterized by constant returns to scale (Ray, 2004, pp.24-26). Later, Charnes et al., (1978) coined Data Envelopment Analysis (DEA hereafter), which is now very extensively used method of measuring efficiency in case of constant returns to scale. DEA, basically, is a non-parametric approach to measure efficiency and it does not require information on the functional form of production function. The DEA essentially constructs a frontier using input-output bundles utilized by Decision Making Units (DMUs). The DMUs, which lie on the frontier, are termed as technically efficient one and the rest are known as inefficient DMUs. The input-oriented measure of technical efficiency under constant returns to scale [i.e. CCR models] and variables returns to scale [i.e. BCC models] are shown in the Figure 3.1. As per constant returns to scale under CCR model technical efficiency at point P is equal to TP. That is in order to produce OA output a firm can reduce inputs to the amount of TP. On the other hand, under variable returns to scale, the inefficiency is to the extent of SP. The difference between TP and SP i.e. TS is termed as scale inefficiency. In terms of ratios, these efficiencies can be expressed as follows:

$TE_{CRS}=AT/AP$

$TE_{VRS}=AS/AP$

$SE=AT/AS$

It may be noted that the value of all efficiencies lies between 0 and 1. Further, $TE_{CRS}=TE_{VRS}*SE$. In addition to this, the figure also shows various stages of returns to scale. This is facilitated by including curve NIRS i.e. non-increasing returns to scale. It signifies that the stages where NIRS is equal to VRS there are increasing returns to scale. On the other hand, when NIRS is different from VRS there is decreasing returns to scale (Coelli, 1996, p.20). For instance, the firm operating at point P is experiencing decreasing returns to scale and the firm operating at point Q is experiencing increasing returns to scale.

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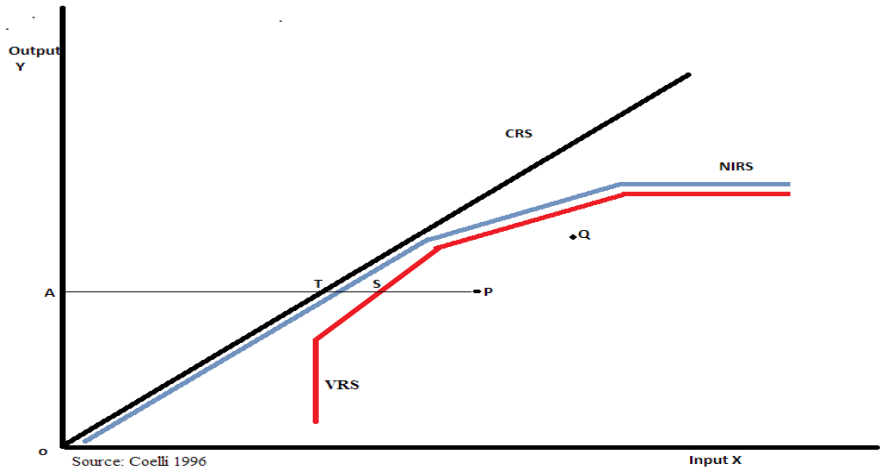

Source: Coelli 1996

In terms of mathematical constraints, the equations 3.1, 3.2 and 3.3 depicted CCR model. The concept of efficiency derived from these constraints is termed as Overall Technical Efficiency under constant returns to scale. On the other hand, inclusion of equation 3.20 in the overall setup of constraints transformed the model into BCC model. The efficiency scores recorded under this scheme are termed as Pure Technical Efficiency scores. Basically equation 3.3 is the convexity constraint, where a convex hull of intersecting planes envelops the data point more tightly than CRS hull. Thus, it provides efficiency score greater than equal to the score obtained in case of CRS (Coelli, 1996, p.14).

Input-oriented BCC Model under Variable Returns to Scale (VRS)

Minimize θ

Subject to $\quad -y^t + \sum_{j=1}^{N} \lambda_j y^j \geq 0 \qquad 3.1$

$$\theta x^t - \sum_{j=1}^{N} \lambda_j x^j \geq 0 \qquad 3.2$$

$$\sum_{j=1}^{N} \lambda_j = 1 \qquad 3.3$$

$$\lambda_j \geq 0 (j=1,2,3\ldots N) \qquad 3.4$$

Where, x^j and y^j are the vectors of inputs and outputs of DMUs. Further, x^t and y^t are the inputs and outputs of the DMU t. Let $\theta^*, \lambda_1^*, \lambda_2^*, \lambda_3^* \ldots \lambda_N^*$ be the optimal solution. Define $x_t^* = \theta^* x^t$, then (x_t^*, y^t) is the efficient input oriented radial projection of (x^t, y^t) on to the frontier and $TE^V(x^t, y^t) = \theta^*$

3.2.2 Measurement of Total Factor Productivity: Malmquist Productivity Index

Total factor productivity takes into account all the inputs and also helps to measure change in productivity over a period of time. It is descriptive measure of performance and unlike technical efficiency; it does not utilize any benchmark for making comparison of performance. Malmquist Productivity Index in this context measures productivity change and decomposes it into the broad concepts technological change and technical efficiency change (Coelli, 1996, p.27). Technical efficiency change, in turn, can be on account of pure technical efficiency change or scale efficiency change. Technological changes refer to the adoption of innovations and better techniques of production. Technical efficiency change, on the other hand, refers to the better utilization of inputs and economies of scale by the firms. Fare et al (1994) defined an Output-Oriented Malmquist Productivity index. However, an Input-Oriented Malmquist Productivity Index can also be specified as follows (Emrouznejad and Thanassoulis, 2010)

$$m_i(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d_i^{t+1}(x_{t+1}, y_{t+1})}{d_i^t(x_t, y_t)} \left[\frac{d_i^t(x_{t+1}, y_{t+1})}{d_i^{t+1}(x_{t+1}, y_{t+1})} * \frac{d_i^t(x_t, y_t)}{d_i^{t+1}(x_t, y_t)} \right]^{1/2} \qquad 3.5$$

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Where $\frac{d_i^{t+1}(x_{t+1},y_{t+1})}{d_i^t(x_t,y_t)}$ represents the change in efficiency; and $\left[\frac{d_i^t(x_{t+1},y_{t+1})}{d_i^{t+1}(x_{t+1},y_{t+1})} * \frac{d_i^t(x_t,y_t)}{d_i^{t+1}(x_t,y_t)}\right]^{1/2}$ represents the change in technology. This implies that TFP change= efficiency change* technology change

The equation 3.5 on the whole represents the productivity of production point (X_{t+1}, Y_{t+1}) relative to (X_t, Y_t). This implies that the above expression compares the technology at point t and at point t+1. The value of the score greater than unity indicates improvement in the total factor productivity growth. In order to measure the Total Factor Productivity change, the study assumed constant returns to scale. "Grifell-Tatje and Lovell (1995) illustrated that a Malmquist TFP index may not correctly measure TFP changes when VRS is assumed for the technology.

3. Empirical Analysis

4.1 Distribution of Technical Efficiency and Its Components

Table 4.1 presents the results of the distribution of different measures of efficiencies for various groups of agro-based firms for the year 1994-95, 2000-01, 2007-08 and 2015-16. The first panel of the table reported the results for "Agro Firms", where the Overall Technical Efficiencies (OTE hereafter), Pure Technical Efficiency (PTE hereafter) and Scale Efficiency (SE hereafter), have been discussed under three categories, namely, Least Efficient, Medium Efficient and Relative Efficient firms. As discussed before, OTE, under BCC model, is the combination of PTE and SE. PTE measures the efficiency due to managerial performance whereas the SE is due to the size of the firms (Kumar and Gulati, 2008). The results showed that under the category of Least Efficient group of firms remained more or less stagnant except for the year 2015-16. In this year the percentage was recorded at 76. As far as the other categories of efficiencies were concerned, the percentage for Medium Efficient category was dipped in 2015-16, however, for Relative Efficient firms the percentage has increased following economic recession after 2008.

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Table 4.1 Distribution of Firms in Least, Medium and Relative Efficiency Categories					
Categories of Efficiency	**Efficiency Range**	**1994-95**	**2000-01**	**2007-08**	**2015-16**
Percentage & Total Number of Firms under OTE	**Least Efficient (0.00-0.39)**	50 (66.67)	38 (50.67)	49 (65.33)	57 (76.00)
	Medium Efficient (0.40-0.69)	13 (17.11)	13 (17.11)	17 (22.37)	7 (9.21)
	Relative Efficient (0.70-1.00)	12 (15.79)	24 (31.58)	9 (11.84)	11 (14.47)
	Total Firms	75 (100)	75 (100)	75 (100)	75 (100)
Percentage & Total Number of Firms under PTE	**Least Efficient (0.00-0.39)**	35 (46.67)	26 (34.67)	41 (54.67)	44 (58.67)
	Medium Efficient (0.40-0.69)	18 (23.68)	17 (22.67)	17 (22.37)	13 (17.11)
	Relative Efficient (0.70-1.00)	22 (28.95)	32 (42.67)	17 (22.37)	18 (23.68)
	Total Firms	75 (100)	75 (100)	75 (100)	75 (100)
Percentage & Total Number of Firms under SE	**Least Efficient (0.00-0.39)**	10 (13.16)	5 (6.58)	4 (5.26)	8 (10.53)
	Medium Efficient (0.40-0.69)	11 (14.47)	21 (27.63)	7 (9.21)	8 (10.53)
	Relative Efficient (0.70-1.00)	54 (72.00)	49 (65.33)	64 (85.33)	59 (78.67)
	Total Firms	75 (100)	75 (100)	75 (100)	75 (100)
Source: Authors' Calculations					

The same trend was also observed in case of PTE, where the highest percentage of least efficient and relative efficient firms have increased in 2015-16, whereas a dip was observed in case of Medium Efficient group in 2025-16. Further, under the category of Relative Efficient firms, highest percentage was observed in 2000-01. The percentage of firms under SE was very low in the first category. The number of firms under Relative Efficient firms has increased considerably and the highest percentage was observed in 2007-08 and it was again dipped in the year 2015-16.

On the whole, it can be concluded that under the category of OTE and PTE most of the firms were concentrated in first category i.e. Least Efficient firms. However, the percentage of concentration of inefficient firms was less for PTE firms. This implies that the percentage of globally inefficient firms was more than the locally inefficient firms. Further, in case of SE, the majority of firms were concentrated around relatively efficient firms. In another important conclusion, it was found that there was increase in efficiency between 2001 and 2008 for all groups of efficiencies. Specifically, the first and second generation reforms were underway and the manufacturing sector was performing exceptionally well during this period. Particularly, the performance of manufacturing sector was at the peak in 2007-08. Furthermore, number of efficient firms again dipped after 2008 as shown by the percentage of firms in 2015-16. This may be due to the global meltdown and overall fall in demand for exports.

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4.2 Estimates of Technical Efficiency in "Agro Food Firms" Group in India

Table 4.2 presents the results of OTE, PTE and SE at four points of time namely, 1994-95, 2000-01, 2007-08 and 2015-16. The firms attaining Overall Technical Efficiency Score (OTE) equal to one are called 'Globally Efficient' firms and the firms who have attained Pure Technical Efficiency Score (PTE) equal to one are called 'Locally Efficient' firms (Kumar and Gulati, 2008). It was found that the average OTE scores in 1994-95, 2000-01, 2007-08 and 2015-16 were at 0.38, 0.45, 0.40 and 0.35 respectively. This persistence in decline in efficiency may be because of inability of the firms to efficiently utilize its resources due to several constraints at local and state level. Further, in case of PTE, the efficiency scores were found at 0.51, 0.61, 0.48 and 0.46. This implies that managerial inefficiency in agro food industry was at 49 percent, 39 percent, 52 percent and 54 percent in 1994-95, 2000-01, 2007-08 and 2015-16 respectively. On the other hand, scale inefficiencies for these years were found at 25 percent, 26 percent, 17 percent and 24 percent. Clearly, managerial inefficiency was found dominant in agro food firms.

Table 4.2 Estimates of Technical Efficiency in "Agro Food Firms" in India

	Efficiency Range	1994-95	2000-01	2007-08	2015-16
Average Score of efficiency	**OTE**	**0.38**	**0.45**	**0.40**	**0.35**
	PTE	**0.51**	**0.61**	**0.48**	**0.46**
	SE	**0.75**	**0.74**	**0.83**	**0.76**
Globally efficient		4	4	6	6
	OTE	(5.26)	(5.26)	(7.89)	(7.89)
		15	18	14	14
	PTE	(32.89)	(36.84)	(31.58)	(31.58)
		22	8	34	31
	SE	(28.95)	(10.53)	(44.74)	(40.79)
Locally efficient		71	71	69	69
	OTE	(94.67)	(94.67)	(92.00)	(92.00)
		50	47	51	51
	PTE	(66.67)	(62.67)	(68.00)	(68.00)
		53	67	41	44
	SE	(70.67)	(89.33)	(54.67)	(58.67)
Returns to Scale	**IRTS**	47	49	34	40
		(62.67)	(65.33)	(45.33)	(53.33)
	DRTS	19	23	20	24
		(25.00)	(30.26)	(26.32)	(31.58)
	CRTS	9	3	21	11
		(11.84)	(3.95)	(27.63)	(14.47)

Source: Authors' Calculations

The analysis of OTE also showed that 4 firms each in 1994-95 and 2000-01, 6 firms each in 2007-08 and 2015-16 were found with efficiency score equal to 1. All these firms are considered to be globally efficient. On the other hand, for the PTE scores, 15 firms in 1994-95, 18 firms in 2000-01, and 14 firms each in 2007-08 and 2015-16 were found with efficiency equal to 1. These firms were considered to be locally efficient.

The table also depicted returns to scale for "Agro Food Firms" in India. It showed that most of the agro-food firms in India were operating under increasing returns to scale. There was increase in firms operating DRTS in 2015-16 and there were 12 such firms, which continued to operate under diminishing returns to scale during the entire period of study. These firms were Jagatjit Industries Ltd., Khoday India Ltd., Glaxo Smith kline Consumer Healthcare Ltd., Nestle India Ltd., Jeypore Sugar Co. Ltd., Modi Industries Ltd., Ugar Sugar Works Ltd., Andrew Yule & Co. Ltd., Agro Tech Foods Ltd., Marico Ltd., Britannia Industries

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Ltd., Mondelez India Foods Pvt. Ltd. The Overall Technical Efficiency can be improved in these firms through better managerial skills and better use of inputs.

4.3 Productivity Growth and Agro-based Firms in India

In this section an attempt has been made to study the Total Factor Productivity Growth (TFPG) and its various components using Malmquist Productivity Index. Malmquist Productivity Index is based on the performance assumption that if the index is found to be less than unity, then it indicates deterioration and the value greater than unity indicates improvement/progress in relevant index (Fare et al., 1994). Interpreted thus, Total Factor Productivity Growth (TFPG) has been analyzed for the time periods 1995-01, 2002-08 and 2009-16. Average TFPG change in "Agro Food Firms" under the time period 1995-2001 was 1.00 and average score of its components-Technological Change and Technical Efficiency change, was 0.96 and 1.05 respectively [see table 4.3]. It means that the contribution of Technical Efficiency change was more in Total Factor productivity Growth. Further, Technical Efficiency change was higher during 1995-2001 due to higher contribution of Pure Technical Efficiency change (i.e.1.05) than the Scale Efficiency change (i.e.1.00). This implies that Pure Technical Efficiency change was contributing directly to Technical Efficiency change and indirectly to TFPG. Further, out of 75 "Agro Food Firms", 41 firms had shown rise in productivity. It depicted that there was positive change of around 54.7 percent during 1995-01.

Further, during 2002-08, TFPG score had risen to 1.02 which implied that there was positive change in TFPG. This positive change was contributed by positive change in Technological Changes as its score has risen to 1.05 during 2002-08 as compared to 0.96 during 1995-2001. On the other hand, there was negative change in Technical Efficiency as its score declined to 0.97 during the time period 2002-08 from 1.05 during the time period 1995-2001. Average Malmquist Index score of two components of Technical Efficiency i.e., Pure Technical Efficiency change and Scale Efficiency change was 0.96 and 1.02 respectively. It is clear that score of Pure Technical Efficiency change had declined and Scale Efficiency change had increased during 2002-08 in comparison to the previous time period i.e. 1995-2001. Thus, it can be concluded that although there was positive change in Scale Efficiency, but there was a negative change in Technical Efficiency due to Pure Technical Efficiency change.

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Table 4.3 TFPG in Agro-Food Firms in India

S. No.	Name of the Firm	TFPG			TC			TEC			PTEC			SEC		
		1995-01	2002-08	2009-16	1995-01	2002-08	2009-16	1995-01	2002-08	2009-16	1995-01	2002-08	2009-16	1995-01	2002-08	2009-16
1	Associated Alcohols & Breweries Ltd.	0.93	1.14	0.95	0.95	1.14	1.05	0.99	1.00	0.91	0.99	1.00	0.91	1.00	1.00	1.00
2	G M Breweries Ltd.	0.91	1.07	1.02	0.91	1.07	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	Jagatjit Industries Ltd.	0.82	0.97	1.08	0.93	1.01	1.06	0.88	0.96	1.01	0.95	0.98	0.97	0.92	0.98	1.05
4	Khoday India Ltd.	0.92	1.11	1.06	0.95	0.98	1.06	0.97	1.14	1.00	0.85	1.15	0.99	1.15	0.99	1.02
5	Mohan Meakin Ltd.	1.06	1.02	1.06	0.93	1.01	1.05	1.14	1.01	1.01	1.13	1.00	1.00	1.01	1.01	1.01
6	PiccadilSugar&AlliedInds. Ltd.	1.21	0.95	0.86	0.96	1.02	1.07	1.26	0.93	0.81	1.35	0.89	0.90	0.93	1.05	0.90
7	SomDistilleries&Breweries Ltd.	1.04	1.05	1.00	0.97	1.09	1.04	1.08	0.97	0.96	1.08	0.96	0.96	1.00	1.01	1.00
8	C C L Products (India) Ltd.	0.85	1.00	0.98	0.95	1.04	1.03	0.90	0.97	0.96	0.90	0.96	0.96	1.00	1.01	1.00
9	GlaxosmithklineConsumer Healthcare Ltd.	1.04	0.98	1.04	0.97	0.99	1.03	1.07	1.00	1.01	1.02	1.00	1.00	1.05	1.00	1.01
10	Hatsun Agro Products Ltd.	1.21	1.07	1.02	1.10	1.13	1.01	1.10	0.95	1.01	1.13	1.09	0.98	0.97	0.86	1.04
11	Heritage Foods Ltd.	0.97	1.08	1.00	0.93	1.13	1.07	1.04	0.95	0.94	1.05	1.02	1.01	0.99	0.93	0.93
12	Kwality Ltd.	1.12	1.37	1.01	0.95	1.11	1.01	1.18	1.23	1.00	0.87	0.93	1.00	1.36	1.32	1.00
13	Mahaan Foods Ltd.	1.07	0.89	1.17	0.94	1.10	1.03	1.14	0.81	1.14	1.14	0.81	1.25	1.00	1.00	0.92
14	Milkfood Ltd.	1.00	1.05	1.01	0.96	1.09	0.99	1.04	0.96	1.02	1.03	0.96	1.03	1.01	1.01	0.99
15	Modern Dairies Ltd.	1.06	1.02	1.02	0.95	1.11	0.98	1.11	0.92	1.03	1.12	0.91	1.04	1.00	1.00	1.00
16	Nestle India Ltd.	1.00	0.95	1.02	0.94	0.98	1.06	1.07	0.97	0.97	1.00	1.00	1.00	1.07	0.97	0.97
17	Umang Dairies Ltd.	1.04	1.02	1.01	0.96	1.10	1.03	1.08	0.93	0.98	1.09	0.92	0.98	1.00	1.00	1.00
18	Vadilal Industries Ltd.	0.99	0.97	1.03	0.98	1.01	1.07	1.02	0.96	0.97	1.02	0.96	0.97	1.00	1.00	1.00
19	Virat Crane Inds. Ltd.	0.93	1.02	0.90	0.97	0.96	1.00	0.96	1.06	0.90	1.00	1.00	0.91	0.96	1.06	0.99
20	Dharani Sugars&Chemicals Ltd.	1.15	0.94	0.97	0.97	1.11	1.01	1.18	0.85	0.96	1.20	0.84	0.97	0.99	1.01	1.00
21	Indian Sucrose Ltd.	0.97	0.85	1.08	0.98	1.08	1.01	0.99	0.79	1.07	1.04	0.79	1.07	0.95	1.01	0.99
22	Jeypore Sugar Co. Ltd.	1.25	0.95	1.05	1.03	1.01	1.05	1.21	0.95	1.00	1.21	0.95	0.99	1.00	1.00	1.01
23	Kesar Enterprises Ltd.	0.95	0.93	0.98	0.96	0.98	1.00	1.00	0.94	0.97	0.87	0.85	0.96	1.14	1.11	1.01
24	Kothari Sugars&Chemicals Ltd.	0.93	1.06	0.97	0.93	1.07	1.03	1.00	0.99	0.94	0.87	0.99	0.94	1.14	1.00	0.99

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25	Modi Industries Ltd.	1.04	1.04	0.97	1.00	0.98	1.05	1.04	1.06	0.92	0.92	1.00	0.91	1.13	1.06	1.02
26	Prudential Sugar Corpn. Ltd.	0.99	0.92	0.98	0.97	1.09	1.02	1.03	0.85	0.96	1.11	0.87	0.94	0.93	0.98	1.01
27	RajshreeSugars&Chemicals Ltd.	0.99	0.97	0.96	1.03	0.95	1.05	0.96	1.02	0.92	0.96	1.03	0.92	1.00	1.00	1.00
28	Rana Sugars Ltd.	1.13	0.94	1.05	0.95	1.06	1.01	1.19	0.89	1.04	1.18	0.87	0.97	1.01	1.02	1.07
S. No.	**Name of the Firm**	**TFPG**			**TC**			**TEC**			**PTEC**			**SEC**		
		1995-01	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**
29	Riga Sugar Co. Ltd.	0.88	1.08	0.93	0.94	0.99	1.03	0.94	1.08	0.91	0.93	1.08	0.90	1.01	1.01	1.01
30	Thiru Arooran Sugars Ltd.	1.38	0.91	0.96	1.01	1.07	1.04	1.37	0.85	0.92	1.38	0.85	0.88	0.99	1.00	1.04
31	Ugar Sugar Works Ltd.	0.87	1.09	0.99	0.98	1.00	1.06	0.89	1.10	0.93	0.86	1.02	0.92	1.04	1.07	1.01
32	United Provinces Sugar Co. Ltd.	1.26	0.86	0.92	0.95	1.06	0.99	1.33	0.81	0.93	1.35	0.80	0.93	0.99	1.01	1.00
33	Andrew Yule & Co. Ltd.	1.02	0.99	0.93	0.95	0.97	0.96	1.07	1.02	0.97	0.94	1.01	0.88	1.14	1.00	1.10
34	B & A Ltd.	1.06	0.96	1.00	0.99	0.95	0.97	1.08	1.01	1.03	1.09	1.00	0.97	0.99	1.01	1.06
35	Goodricke Group Ltd.	0.75	0.92	0.93	0.75	0.95	0.98	1.00	0.98	0.95	1.00	1.00	0.87	1.00	0.98	1.09
36	Ledo Tea Co. Ltd.	1.16	0.93	1.00	1.04	0.96	0.95	1.12	0.98	1.05	1.17	0.86	1.06	0.96	1.13	1.00
37	Neelamalai Agro Inds. Ltd.	1.14	0.84	0.99	1.06	0.94	0.97	1.08	0.89	1.02	1.08	0.89	0.98	1.00	1.00	1.04
38	Rossell India Ltd.	0.93	0.87	0.86	0.92	0.82	0.90	1.00	1.06	0.96	1.01	1.04	1.00	0.99	1.02	0.96
39	StanesAmalgamatedEstates Ltd.	1.03	0.97	1.10	0.95	0.96	0.98	1.09	1.01	1.13	1.15	0.94	1.12	0.95	1.07	1.01
40	Agro Tech Foods Ltd.	0.95	1.19	0.85	0.99	1.13	1.02	0.97	1.06	0.83	1.00	1.00	0.83	0.97	1.06	1.00
41	Ajanta Soya Ltd.	1.04	1.14	1.02	0.97	1.20	0.98	1.07	0.95	1.04	1.07	0.95	1.05	1.00	1.00	1.00
42	Avanti Feeds Ltd.	1.03	1.00	1.03	0.97	1.15	1.01	1.07	0.87	1.03	0.94	0.87	1.10	1.14	1.00	0.94
43	Cian Agro Inds.&Infrastructure Ltd.	0.97	1.14	0.85	0.89	1.14	1.04	1.09	1.00	0.82	1.11	1.01	0.95	0.99	1.00	0.86
44	Jayant Agro-Organics Ltd.	0.84	1.15	0.87	0.88	1.13	1.00	0.95	1.02	0.87	0.95	1.03	0.82	1.00	0.99	1.06
45	Khandelwal Extractions Ltd.	0.91	1.04	0.97	0.97	1.12	1.05	0.93	0.93	0.92	1.08	0.85	1.07	0.87	1.10	0.86
46	Marico Ltd.	1.06	1.03	0.98	0.97	1.06	1.06	1.09	0.97	0.93	1.00	1.05	1.00	1.09	0.93	0.93
47	Pioneer Agro Extracts Ltd.	1.07	1.07	0.89	1.05	1.16	1.00	1.02	0.92	0.89	1.02	0.94	0.98	1.00	0.98	0.90
48	Prima Agro Ltd.	1.01	1.33	1.10	0.93	1.13	1.01	1.08	1.18	1.10	1.09	1.15	1.09	0.99	1.03	1.01
49	Sarda Proteins Ltd.	0.98	1.07	0.92	0.98	1.11	0.99	1.00	0.96	0.93	1.05	0.96	1.12	0.95	1.01	0.83
50	Vijay Solvex Ltd.	1.05	1.05	0.99	0.96	1.13	0.98	1.09	0.93	1.00	1.11	0.97	1.01	0.99	0.96	1.00

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51	Vimal Oil & Foods Ltd.	0.91	1.24	0.99	0.91	1.24	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
52	Vippy Industries Ltd.	1.05	1.11	0.97	0.99	1.15	0.99	1.07	0.96	0.98	1.12	0.95	0.91	0.95	1.01	1.07
53	Waterbase Ltd.	1.08	1.01	0.93	1.02	1.00	1.03	1.06	1.02	0.91	1.07	1.01	0.90	1.00	1.00	1.01
54	Britannia Industries Ltd.	1.06	0.94	1.03	0.99	1.03	1.02	1.07	0.91	1.01	1.00	1.00	1.00	1.07	0.91	1.01
55	Lotus Chocolate Co. Ltd.	1.00	1.02	0.96	0.95	1.04	1.05	1.06	0.99	0.91	1.13	0.93	0.95	0.93	1.07	0.96
56	Mondelez India Foods Pvt. Ltd.	1.02	0.98	0.99	0.98	0.99	1.05	1.04	0.99	0.94	1.03	1.01	0.98	1.01	0.98	0.96
57	Ravalgaon Sugar Farm Ltd.	1.14	1.00	1.11	1.03	0.99	1.01	1.11	1.01	1.10	1.11	1.01	1.08	1.00	1.00	1.02
58	Sampre Nutritions Ltd.	1.11	1.09	0.86	0.93	1.01	1.07	1.19	1.08	0.81	1.34	0.99	0.81	0.89	1.09	1.00
S. No.	**Name of the Firm**	**TFPG**			**TC**			**TEC**			**PTEC**			**SEC**		
		1995-01	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**	**1995-01**	**2002-08**	**2009-16**
59	Uniroyal Marine Exports Ltd.	0.92	1.00	0.97	0.89	1.05	1.06	1.03	0.96	0.92	1.06	0.91	0.97	0.97	1.06	0.95
60	Delhi Flour Mills Co. Ltd.	0.97	1.03	0.97	0.95	1.10	1.01	1.02	0.94	0.96	1.02	0.95	0.96	1.00	1.00	0.99
61	K L R F Ltd.	0.97	1.09	1.02	0.94	1.09	1.03	1.03	1.01	0.99	1.03	0.99	1.00	1.00	1.02	0.99
62	National Cereals Products Ltd.	0.99	1.00	1.29	0.90	1.01	1.05	1.10	0.99	1.23	1.28	0.89	1.26	0.86	1.11	0.97
63	Sunil Agro Foods Ltd.	1.00	1.01	1.00	0.97	1.13	0.99	1.03	0.90	1.01	1.05	0.90	1.02	0.99	0.99	0.99
64	A D F Foods Ltd.	0.75	1.07	0.97	0.93	0.99	1.06	0.80	1.08	0.92	0.83	1.04	0.92	0.97	1.04	1.00
65	Chordia Food Products Ltd.	0.96	0.95	0.97	0.96	0.99	1.06	1.00	0.95	0.91	1.04	0.91	0.94	0.96	1.05	0.97
66	D F M Foods Ltd.	0.99	1.02	0.95	0.96	1.02	1.06	1.03	1.00	0.89	1.04	0.99	0.89	1.00	1.01	1.00
67	Foods & Inns Ltd.	1.05	1.01	0.97	1.00	1.02	1.05	1.06	0.99	0.92	1.07	0.98	0.93	0.98	1.01	0.99
68	Freshtrop Fruits Ltd.	0.99	0.99	0.94	0.92	1.15	1.07	1.07	0.86	0.89	1.06	0.82	0.90	1.01	1.05	0.98
69	Kore Foods Ltd.	0.97	1.13	0.73	0.98	1.00	0.98	0.99	1.13	0.74	1.00	1.09	0.89	0.99	1.03	0.83
70	KothariFermentation& Biochem Ltd.	0.76	1.06	0.99	0.97	1.03	1.07	0.78	1.03	0.93	0.86	0.99	0.93	0.91	1.04	1.00
71	Tasty Bite Eatables Ltd.	1.18	0.94	0.99	0.93	1.00	1.05	1.27	0.94	0.94	1.34	0.91	0.93	0.94	1.04	1.01
72	Gayatri Bioorganics Ltd.	0.74	1.03	1.03	0.96	1.04	1.07	0.77	0.99	0.96	0.79	0.94	0.97	0.96	1.05	1.00
73	Sayaji Industries Ltd.	1.00	1.01	0.99	0.93	1.03	1.07	1.09	0.98	0.93	1.05	0.98	0.93	1.03	1.00	1.00
74	Tirupati Starch&Chemicals Ltd.	1.01	1.02	1.05	0.95	1.02	1.06	1.07	1.00	1.00	1.11	0.97	1.01	0.97	1.03	0.99
75	Universal Starch-Chem Allied Ltd.	1.08	1.03	0.99	0.98	1.03	1.04	1.11	1.00	0.95	1.12	0.98	0.96	0.99	1.02	0.99

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Averages	**1.00**	**1.02**	**0.98**	**0.96**	**1.05**	**1.02**	**1.05**	**0.97**	**0.96**	**1.05**	**0.96**	**0.97**	**1.00**	**1.02**	**0.99**

Source: Author's Calculations

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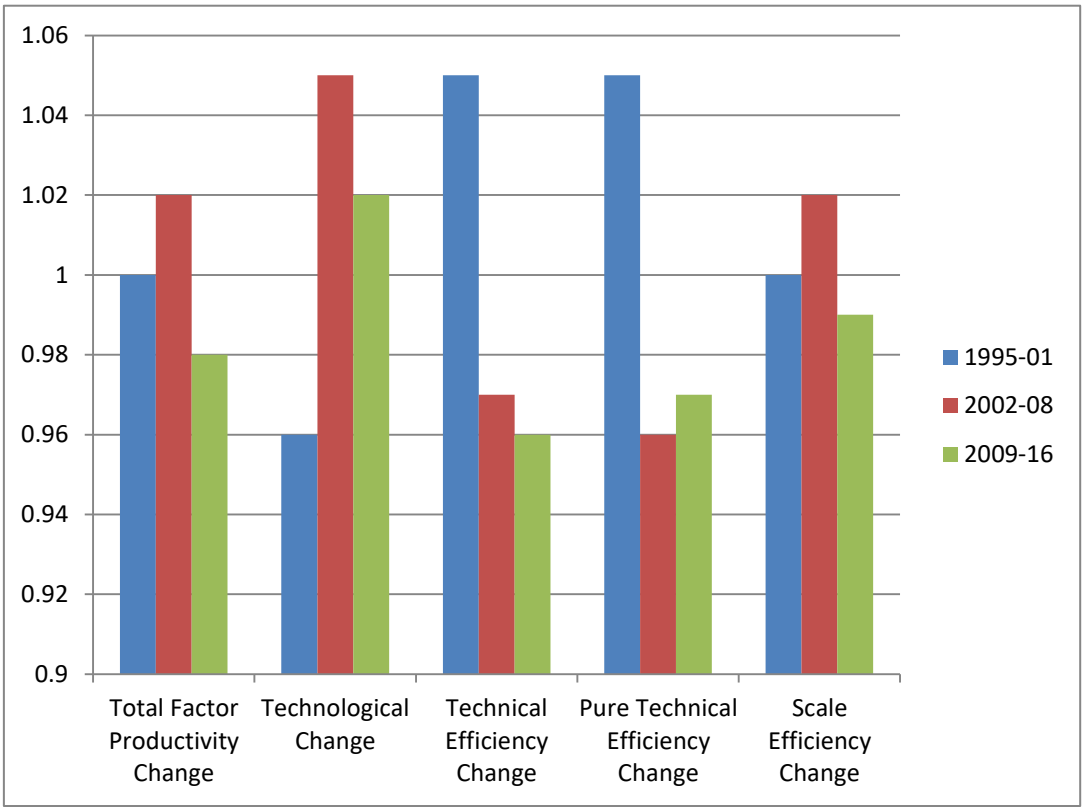
Figure 6.3 TFPG, TC, TEC, PTEC and SEC in 75 firms under Agro Food Firms.



Therefore, the main reason for the rise in Total Factor Productivity, in this time period, was rise in Technological Progress. Out of 75 firms, 48 firms had shown rise in productivity in 2002-08, as their productivity index was more than one.

Contrary to the previous time period, TFPG score declined during 2009-2016 and was recorded at 0.98. The average score of Technological Change and Technical Efficiency change had also declined to 1.02 and 0.96 respectively. Technical Efficiency changes had shown a continuous declining trend from 1995-2016 and this decline was also the main reason of decline in TFPG during the time period 2009-2016. Further, decline in Technical Efficiency change was also due to negative change in Scale Efficiency, which had fallen to 0.99 from the previous level of 1.02.

Thus, it can be concluded that Technical Efficiency changes had shown a continuous declining trend mainly because of pure technical efficiency change. TFPG had increased till 2008 due to positive changes in Technological Progress, while there was decline in Technical Efficiency in same time period. TFPG had declined in 2016 due to negative changes in Technological Progress as well as in Technical Efficiency. Low Technical Efficiency may be because of the several constraints like inadequate supply of raw material, poor quality of much of raw material, obsolete technology, and government regulations and lack of finance and there is a need for new indigenous models to emerge for the organization of agro industry. Government models alone do not show a good record of performance (Gandhi, et.al 2001). Thus it can be concluded that Technological changes had played a major role in keeping the TFPG index high during 2002-08 and 2009-16.

4. Conclusions and Policy Implications

On the basis of empirical analysis, the following conclusions can be drawn:

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- On the basis of frequency distribution of Technical Efficiency it can be concluded that OTE and PTE scores of most of the firms were concentrated around very less efficient category of firms. Whereas SE scores of majority of firms were concentrated around the category of relatively efficient firms. Broadly, this implies that the there was considerable increase in locally efficient firms especially in 2000-01 and 2007-08. Further, Highest number of efficient firms, for all groups, was recorded in 2000-01 and 2007-08. Specifically, during this period, the first and second generation reforms were underway and the manufacturing sector was performing exceptionally well. Furthermore, number of efficient firms again dipped after 2008 as shown by the percentage of firms in 2015-16. This may be due to the global meltdown and overall fall in demand for exports. Furthermore, analysis of returns to scale showed that most of the agro-food firms in India were operating under increasing returns to scale. There was increase in firms operating DRTS in 2015-16. This implies that there is larger scope to improve OTE on account of Managerial Efficiency, availability of better infrastructure and progressive policy reforms. New investments in such firms can be made after proper project appraisals. That is firms should able install new technology and should have skill to exploit such a technology.
- On the basis of analysis of TFPG, it can be concluded that economic reforms significantly contributed the productivity growth. Improvement in the TFPG was noticed especially during 2002-08 as the number firms with improvement in TFPG score has increased significantly. This may be due to Technological change during the second generation reforms. But they failed to capitalize on it as there was fall in Technical Efficiency in these firms. It may also be due to reluctance on the part of producers to upgrade the plants due to non-availability of skilled labour, non-availability of quality raw material, infrastructural deficiencies etc. A steep fall in productivity growth during 2009-16 may be on account of global meltdown and overall fall in demand for exports. This implies that the agro-food firms in India should able adapt to the new technology to produce quality products at par with products in the international markets.

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