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Dynamics of productivity growth in Indian dairy products manufacturing industry

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ABSTRACT

The study assesses the total factor productivity of dairy products manufacturing industry of the year 2009–13 using stochastic frontier production approach. The study concludes that the change in total value of output of industry is due to adoption of efficient and best practices by processors. The TFP growth of dairy industry is 4.3% mainly driven by technical change over time. Temporarily, the dairy industry is moving towards overcoming the constraints in TFP growth. There is more need to augment capital which is energy efficient and accordingly capacity building of emerging skill sets in the industry.

Keywords: Dairy, Growth, Processing, Productivity

Dairy processing today is a technology-driven and highly complex global industry (Thornton 2010). Dairy processors combine agricultural inputs, labour, and capital to form dairy food products. Dairy manufacturers are firms that transform animal material into intermediate or edible products (Connor and Schiek 1997). Manufacturing and preserving of dairy products constitute dairy industry. This is largest segment of the food industry and comprises of 37% of value added in overall food industry group. The contribution of livestock to the total GDP has been around 4% during 2017–18 (DAHDF 2019). It is not surprising that dairy processors take on many of the qualities typically associated with a general manufacturing company. The dairy processing industry operates at a tremendous volume, employing over about 8.47 million people on yearly basis out of which 71% are women. It generates worth over ₹ 2,422.85 crores (345.71 USD Millions) exporting dairy products of 1,13,721.70 MT to the world during the year 2018–19. (ASCI 2015).

The socio-economic-legal reforms at domestic and international level have brought several major structural changes in dairy sector after World Trade Organization (WTO) regime. The Government of India allowed 100% foreign direct investment in food processing industries under the automatic route, Food Safety and Standards Act (2006) emphasizing on hygienic requirements in food processing establishments as per the Bureau of Indian Standards (BIS), AGMARK standards, alignment of domestic food laws with global standards etc. Besides, the Ministry of Food Processing Industries has implemented scheme for technology up-gradation, establishment and modernization of food processing facilities (FSSAI 2008). The WTO regime has exerted more pressure on dairy processing industry to be efficient to meet the challenges of global competition. This pressure will lead to increase in output sophistication in production and jobs. This industry, with high increasing returns, high incidence of technological change and innovations and high synergies and linkages arising from labour division strongly induce economic development (Reinert 2009).

Dairy processing industry comprises of organized and unorganized sectors and contribution of more than 75% comes from unorganized sector. The organized dairy sector refers to the dairy units registered under the Milk and Milk Products Order, 2002 (MMPO). These dairies have each capacity of handling over 10,000 litres of milk per day. These organized dairies are under co-operative, private or other (like government dairies) sector (Annual Report 2018–19, DAHDF). Dairy firms play a critical role in forming the derived demand faced by agricultural producers. The growth of dairy manufacturing industry has backward and forward linkage with livestock sector. Dairy farmers are often part of a vast network of suppliers coordinated by a large dairy manufacturer (Knoeber 1989; Ménard and Klein 2004). Therefore, the strategies of dairy producers are dictated in large part by the actions of dairy food products manufacturing companies.

Processors must stay abreast of current shifts in tastes, demographics, and health concerns (Barkema and Schertz 1994). The dairy food supply chain is being reengineered, further complicating tasks for the dairy manufacturer. New technologies, business practices, and market conditions are all causing significant changes in companies' operations (King and Phumpiu 1996). The retail firms are gradually

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concentrating (Connor and Schiek 1997). All of these factors are relevant in agricultural markets to the extent they alter food processor decisions. The new technological development can strengthen the viable place of processors in the global market. There are very few empirical evidences regarding the contribution of technology to the growth of the dairy products industry at the disaggregated level. The level and structure of the industry reveals that dairy processing and preserving food is essentially guarded due to lack of productivity augmenting technologies. To meet the emerging challenges, technology is the key to improvement in the growth and efficiency of the dairy manufacturing industry. This study assesses the total factor productivity (TFP) of dairy products manufacturing industry over the period of 2009–2010 to 2013–2014. Using the Stochastic frontier approach, this study decomposes the TFP change in the disaggregated dairy products manufacturing firms into technical, allocative and scale efficiency changes. The study also indicates practical policy directions for strengthening and accelerating the growth of dairy manufacturing products industry.

MATERIALS AND METHODS

Analytical framework: TFP becomes important when it is recognised that growth in output cannot be sustained by inputs alone because of the diminishing returns to input use in the long run. Thus, TFP reflects potential for growth. There is continuous improvement in technology that leads to changes in the stock of quasi-fixed factors. This dynamic role of capital in industrial growth can be appropriately captured by employing the stochastic frontier production (SFP) function.

Changes in TFP may occur due to technical change, efficiency in input use, scale of production and prices of both inputs and outputs. Thus, a decomposition of TFP into these components can be introduced in the production function. Aigner *et al*. (1977) and Van Den Broeck *et al*. (1994) independently proposed stochastic frontier production function. Considering a single output production function, which with panel data and output oriented technical inefficiency, can be defined as

$$y_{it}=f(x_{it}, t)\exp(-u_{it}) \quad \text{... (1)}$$

where, $y_{it,}$ maximum possible output produced by i^{th} firm (i=1, 2, ..., N) in the t^{th} time period (t = 1, ..., T); f(.), a production function, x_{it} , input vector; t, time trend and serve as a proxy for technical change and $u_{it} \geq 0$ is the output oriented technical inefficiency.

Following Coelli *et al*. (2005) and Kumbhakar *et al*. (2015) we take logarithm of *y* and totally differentiate equation (1), with respect to t.

$$\dot{y}=\frac{d\ln f(x_{it}, t)}{dt}-\frac{\partial u}{\partial t}=\frac{\partial \ln f(x_{it}, t)}{\partial t}+\frac{\partial \ln f(x_{it}, t)}{\partial x_j}\frac{\partial x_j}{\partial t}-\frac{\partial u}{\partial t} \quad \text{... (2)}$$

In equation (5) the first and second terms on the right hand side provide the change in frontier output caused by technical progress (TP), and change in input use, respectively. Using output elasticity of input j,

$\varepsilon_j=\frac{\partial f(x_{it}, t)}{\partial \ln x_j}$, the second term can be expressed as $\sum_j \varepsilon_j \dot{X}_j$

The . indicates the rate of change. The overall productivity change is not only influenced by TP and change in input use, but also by change in technical inefficiency changes (TE). The exogenous technical change shifts the production frontier upward (downward) for a given level of input if the TP is positive (negative).

If TE improves (deteriorates), then $\frac{\partial u}{\partial t}$ is negative (positive). The rate at which inefficient producers catch up with production frontier is interpreted as $-\frac{\partial u}{\partial t}$. Thus, equation (2) can be rewritten as:

$$\dot{y}=\frac{d\ln f(x_{it}, t)}{dt}-\frac{\partial u}{\partial t}=TP+\sum_j \varepsilon_j \dot{x}_j-\frac{\partial u}{\partial t} \quad \text{... (3)}$$

The classical definition of total factor productivity (TFP) growth is defined as output growth unexplained by input growth:

$$T\dot{F}P=\dot{y}-\sum S_j \dot{x}_j \quad \text{... (4)}$$

where, S_j is input j's share in production cost. Substituting equation (3) in equation (4) we get

$$T\dot{F}P=TP-\frac{\partial u}{\partial t}+\sum_j \varepsilon_j \dot{X}_j-\sum S_j \dot{x}_j=TP-\frac{\partial u}{\partial t}+\sum_j (\varepsilon_j - S_j)\dot{X}_j \quad \text{... (5)}$$

$$=TP-\frac{\partial u}{\partial t}+(RTS-1)\sum_j \lambda_j \dot{x}_j+\sum(\lambda_j - S_j)\dot{x}_j \quad \text{... (6)}$$

where, $RTS=\left[\sum_j \varepsilon_j\right]$ denotes the returns to scale, and

$$\lambda_j=\frac{f_j x_j}{\sum_j f_i x_i}=\frac{\varepsilon_j}{\sum_i \varepsilon_i}=\frac{\varepsilon_j}{RTS}$$

when f_j, marginal product of input x_j and ε_j are input elasticities defined at the production frontier. The last component in equation (6), i.e. $[\Sigma(\lambda_j - S_j)\dot{x}_j]$ measures inefficiency in resource allocation resulting from the deviations of input prices from the value of their marginal product. Thus, in equation (6) TFP growth can be decomposed into TP, the technical efficiency change (TEC) $-\frac{\partial u}{\partial t}$, $SC=(RTS-1)\Sigma\lambda_j \dot{x}_j$ scale change, and the allocative efficiency change denoted by $[\Sigma(\lambda_j - S_j)\dot{x}_j]$. The decomposition formula in equation (6) is follows from Kumbhakar *et al*. (2015).

Data and variables: In this paper, we have used unit level panel data from the Annual Survey of Industries (ASI) published by the Central Statistical Organization –an offshoot of the Ministry of Statistics and Programme Implementation, Government of India. The data-set contains information on output and firm specific inputs. According to 4-digit National Industrial Classification (NIC) food manufacturing industry is divided into 14 industries. The NIC-2008 four digit classification have used to classify of each industry. The NIC-code for manufacturing of dairy products is 1050. Further, NIC-2008 has five digit classification that was used to identify the dairy manufacturing firms. This study used data for the period 2009 to 2013. Value of output (VOP) comprises the total ex-factory value of dairy and by-products produced by a firm, while net value-added (NVA) is calculated by deducting total intermediate inputs and depreciation from the total value of output. Relying on the previous studies VOP is considered an appropriate outcome variable, and the number of employees (wages and salary), fixed capital, fuels consumed as input variables to assess the productivity and efficiency of Indian dairy manufacturing industry. The output and inputs were deflated following double deflator measures. Gross outputs of different industry were deflated by respective wholesale price indices of manufacturing of food products. Likewise, costs of material inputs were deflated by the weighted average wholesale price indices of raw materials, fuel, power, light and lubricants. Wages, including provident funds and other benefits received by employees, were considered as labour input and were deflated by the consumer price index for industrial workers. The total fixed capital input is deflated by implicit deflator for gross fixed capital formation (GFCF) obtained from National Account of Statistics (NAS) Governoment of India. The summary of variables used in the study is presented in the Table 1.

Perusal of past literature reveals the use of following three inputs, viz. labour, capital and energy and one output as total production of dairy products. Table 1 reveals the average output of the dairy processing and preserving industry is ₹ 11049.21 lakh. The average wages and salary to its workers is ₹ 289.81 lakh and the average capital expenditure is 1279.81 lakh which indicates that on an average capital expenditure is higher than labour (expenditure in wages and salary). Moreover, on an average expenditure on energy used in the industry is ₹ 317.71 lakh. The average investment incurred on consumption of capital and energy among inputs used in dairy industry registered large variability of ₹ 3420.41 and ₹ 786.93 respectively.

Table 1. Summary statistics of variables used in Frontier Model (₹ lakh at constant price)

Variable	Mean	Std. Dev.	Min	Max
Output	11,049.21	24,774.52	–10,954.36	304,528.80
Labour	289.81	602.00	0.01	8,514.48
Capital	1,279.81	3,420.41	0.01	46,242.68
Energy	317.71	786.93	0.01	8,660.65

Source: Author's calculation based on unit level ASI data.

TFP was computed by using the translog production function and decomposed into three components, viz. technical change, scale change and allocative change. Table 2 shows the maximum likelihood estimates of output-oriented translog production function. The results of both time-invariant and time-variant models are reported separately. In the frontier model, time invariant model is preferred since the ç (eat) coefficient is insignificant (Battese and Coelli 1988). The result shows that the variance ratio parameter, i.e. gamma (γ) is statistically significant and greater than zero, implying that variation in the output of dairy products emanates mainly from differences in firms practices rather than random variability. The values of coefficients of labour, and energy are positive and statistically significant, means uses of these two inputs are directly related to increase in production of dairy products. A one percent increase in labour and energy will contribute

Table 2. Maximum likelihood estimates of Stochastic frontier model

Frontier	Parameter	Time Invariant	t-statistics	Time Variant	t-statistics
Labour	β_l	0.696***	(3.50)	0.699***	(3.51)
Capital	β_k	–0.248*	(–2.42)	–0.248*	(–2.41)
Energy	β_m	1.236***	(6.16)	1.233***	(6.12)
Labour × labour	β_{ll}	0.0581**	(2.69)	0.0577**	(2.67)
Capital × Capital	β_{kk}	0.0182***	(4.42)	0.0182***	(4.41)
Energy × Energy	β_{mm}	0.0510*	(2.05)	0.0516*	(2.07)
Labour × Capital	β_{lk}	0.0169	(1.41)	0.0171	(1.43)
Labour × Energy	β_{lm}	–0.0987***	(–4.83)	–0.0988***	(–4.84)
Capital × Energy	β_{km}	–0.00708	(–0.66)	–0.00733	(–0.68)
Time	β_t	–0.0656	(–0.51)	–0.0433	(–0.31)
Time × time	β_{tt}	0.00467	(0.23)	0.00549	(0.27)
Time × labour	β_{tl}	–0.0152	(–1.10)	–0.0157	(–1.13)
Time × Capital	β_{tk}	0.00916	(0.94)	0.00903	(0.92)
Time × Energy	β_{tm}	0.0122	(0.76)	0.0118	(0.73)
Constant	β_0	–0.210	(–0.13)	–0.231	(–0.14)
Gamma	γ	2.649***	(10.20)	2.649***	(10.25)
Mu	μ	–1.304	(–1.34)	–1.288	(–1.34)
Eta	ç			–0.00578	(–0.44)
N		2051		2051	

Source: Author's calculation based on ASI data. Note: ***significantly different from zero at the 1% level. **Significantly different from zero at the 5% level. *significantly different from zero at the 10% level.

0.696% and 1.236% increase in value of total output of dairy products. Similarly, second order parameters, viz. labour, capital and energy are significant and positively related to value of total output of dairy products. It indicates that these inputs would increase output of dairy products with lesser magnitude in long run. The interaction coefficients in table decipher the relative importance of the factors of production on value of total output. The coefficients of labour and capital though not significant but positive which means they have supplementary relationship. The value of coefficient of interaction of labour and energy shows substitution relationship, i.e. there is possibilities of replacement of labour with capital to maximize the total value of output of dairy products.

Most of these parameters when interacted with time capture the general improvement/deterioration *per se*. The negative value of over the time wages and salary of labour (time×labour) indicates a tendency to fall in the labour demand. However, the positive coefficients over the time capital and over the time energy suggest a tendency to increase in capital and energy over the time in contribution of value of total output of dairy products. The coefficient of ç is negative but insignificant shows a tendency of increase in inefficiency over the time in dairy products industry.

Table 3 shows average total factor productivity growth along with standard deviation of dairy manufacturing products industry. Interpretation after taking in to account mean values, the TFP in dairy products industry shows wide fluctuations and overall TFP of dairy industry is stagnated during study period. Considering the value of median, the total factor productivity (TFP) of dairy manufacturing products depicts a substantial improvement during 2010–2013. The TFP was 2.1% in 2010 which goes more than double (4.4%) in 2011 but witnessed a small dip in 2012 compared to previous year. In the last year 2013 total factor productivity reached its maximum around 7.6%. The overall average TFP growth was 4.3% during the study period. An anatomical structure of TFP growth of dairy manufacturing industry will ascertain the sources of growth thereof. The sources of growth of TFP could be pure technical change, price effect and scale change (Table 4).

Technical change refers to an improvement or deterioration of technical progress over the time. A process of technical progress originates in the substitution of less productive inputs through modernization and/ or widening of more productive inputs like capital stocks, technology-intensive input use in production that tend to grow through productivity. The technical change in dairy manufacturing industry has improved around 40% in period from 2009–2013. This improvement in technical efficiency has given boost to TFP. The scale change entails the utilization of capital/ installation of production unit and/or an increase in the effective production through move intense use of the capital already installed. The scale change in dairy manufacturing has shown its improvement around 67% during 2010–2013. This means the effects of input changes on output growth is improving. Moreover, the activity of dairy manufacturing industry has a tendency to overcome the constraining capacity utilization of the sector. Allocative change refers to relative price change of input use in production function. This change may originate from internal and external forces which may affect the demand and supply scenario in the dairy processing sector. The allocative change in the industry has improved more than double during 2010–2013. Though the overall scale change (–0.2%) and allocative change (–1.3%) have contributed in retardation of TFP growth during 2010–13 but improvements in scale and allocative change were observed in 2013 compared to year 2010. The results infer that increasing the efficiency of capital/ installed capacity, by adding technical progress to production as reflected in up-gradation effects, i.e. technical change would be the main driver of TFP growth in log run.

Table 3. Descriptive statistics of TFP for Dairy Manufacturing Industry (2010–2013)

Year	Mean	Median	Std. Dev.	Freq.
2010	–0.011	0.021	0.212	405
2011	0.020	0.044	0.244	418
2012	–0.044	0.031	0.304	469
2013	0.033	0.076	0.341	738
Overall average	0.000	0.043	0.294	2,450

Source: Author's calculation based on unit level ASI data.

Table 4. The pattern of technical change, scale change, allocative change and total factor productivity of dairy manufacturing industry (2009–2013)

Year	Technical change	Scale change	Allocative change	Total factor productivity
2009	0.045			
2010	0.047	–0.006	–0.008	0.021
2011	0.052	–0.002	–0.008	0.044
2012	0.060	0.001	–0.044	0.031
2013	0.063	–0.002	0.009	0.076
Overall average	0.053	–0.002	–0.013	0.043

Source: Author's calculation based on unit level ASI data.

The spatial variation in TFP growth of dairy products manufacturing industry along with components of TFP depicts in the Table 5. Across states, technical change contributes maximum in TFP growth of dairy manufacturing in India during the study period. First five states according to technical change ranking are: Uttar Pradesh, Haryana, Himachal Pradesh, Goa and West Bengal. However, the states having least technical change in the industry falling in bottom five ranked states are, viz. Chandigarh, Chhattisgarh, Tripura, Uttarakhand, Orrisa and Andhra Pradesh. Scale change is another component of TFP that has an adverse impact on the TFP growth across states except Uttarakhand, Delhi, Chhattisgarh and Maharashtra. Similarly, price effect has negatively contributed to TFP

Table 5. State wise average technical change, scale change, Allocative change and total factor productivity of Dairy Manufacturing Industry (2009–2013)

State	Technical change	Scale change	Allocative change	Total factor productivity	TFP rank
Jammu and Kashmir	0.054	–0.001	–0.027	0.025	20
Himachal Pradesh	0.065	–0.043	0.075	0.140	2
Punjab	0.059	–0.004	–0.001	0.054	12
Chandigarh (UT)	0.049	–0.010	–0.014	0.050	14
Uttarakhand	0.041	0.007	0.065	0.110	3
Haryana	0.069	–0.001	–0.017	0.051	13
Delhi	0.063	0.019	0.008	0.092	4
Rajasthan	0.060	–0.006	–0.005	0.059	10
Uttar Pradesh	0.072	0.004	–0.002	0.077	6
Bihar	0.055	–0.006	–0.002	0.043	15
Sikkim	0.046	–0.025	–0.142	–0.152	26
Tripura	0.036	–0.005	0.120	0.156	1
Assam	0.050	–0.001	–0.071	–0.006	25
West Bengal	0.064	–0.001	0.004	0.073	8
Jharkhand	0.060	–0.008	–0.015	0.019	21
Odisha	0.044	–0.001	0.022	0.078	5
Chhattisgarh	0.035	0.003	–0.002	0.018	22
Madhya Pradesh	0.061	–0.009	–0.012	0.041	17
Gujarat	0.060	–0.011	–0.015	0.042	16
Daman and Diu	0.052	–0.036	–0.210	–0.196	27
Maharashtra	0.060	0.000	–0.029	0.032	19
Andhra Pradesh	0.045	–0.004	0.011	0.058	11
Karnataka	0.056	–0.003	–0.030	0.014	23
Goa	0.064	–0.001	–0.098	0.004	24
Kerala	0.055	–0.001	0.020	0.074	7
Tamil Nadu	0.048	–0.001	–0.011	0.035	18
Puducherry	0.057	–0.005	0.002	0.063	9

Source: Author's calculation based on unit level ASI data.

growth in all states except Himachal Pradesh, Uttarakhand, Delhi, Tripura, West Bengal, Odisha, Andhra Pradesh, Kerala and Puducherry. The five top ranked states in TFP growth of dairy manufacturing products are, viz. Tripura, Himachal Pradesh, Uttarakhand, Delhi and Orrisa and the rock bottom states registered with least TFP growth are, viz. Daman & Diu, Sikkim, Assam, Goa, and Karnataka during the study period.

Derived demand faced by agricultural producers is formed by dairy firms. The integrated dairy food system has become more cost focused besides sensitive to quality control. The dynamism of dairy processing could be reflected in realigning the positions of stakeholders in dairy value chains and strengthening the viable place of processors in the market. The study provides empirical evidence on total factor productivity change of the dairy manufacturing industry over a period of 2009 to 2013, which evidently draw the total factor productivity of dairy manufacturing units at disaggregated level. In addition, the variation in the output of dairy products is strictly due to adoption of prevailing best practices of the processors rather than random shocks. The overall total factor productivity of dairy manufacturing industry is 4.3% during 2009–13. In short run, the uses of inputs, viz. labour and energy, have directly contributed in increase in production of dairy products. With one percent change, the contribution of energy is almost double than that of labour in value of total output of dairy products. But the contribution of capital is inversely related to output. In long run, the uses of labour, capital and energy contribute directly in growth in value of output but with a lesser magnitude. The up-gradation effect of capital yields output with more efficient use of energy in long run. The effect of more modern and sophisticated technology over tradition technology, i.e technical progress has given boost to TFP of dairy products manufacturing industry. The effects of input changes (scale effect) and allocative change (price effect) on output growth have improved. The industry has gained momentum in the direction of overcoming the constraints of TFP growth. This suggests that to boost TFP growth, the dairy processing and preserving industry needs to be is on track of competing the most efficient processors in the world, benefiting consumers lowering the per unit cost of dairy products. In formal sector, this could be possible by pumping money in capital augmentation and developing state of art technology to match with efficient dairy products manufacturing industry in world market.

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