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What drives the profitability of dairy processing firms in India? The results of decomposition analysis

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Abstract We study the profitability growth in the organized dairy processing sector in India from 1993 to 2017. Using a parametric approach, we decompose the change in profitability into price and non-price factors. The total factor productivity (TFP) grew, driven mainly by improvements in technical efficiency and technical change. The output grew, too. The growth in TFP and output increased profitability at 5.90% per annum. The study also analyses performance by firm size and finds that large firms performed better in terms of profitability growth, mainly due to the growth in output and efficiency in use of inputs.

Keywords Dairy industry, decomposition analysis, efficiency, profitability

JEL codes C33, L25

Many studies have analysed the growth in profitability, productivity, and efficiency of the organized dairy sector in India over the years to understand its trajectory and realize its potential. Mondal (2014) studies the profit margin and cost. Several researchers study total factor productivity¹ (TFP) and technical efficiency (Singh 2004; Elumalai and Birthal 2010; Mondal 2014; Ohlan 2013). Bhandari and Vipin (2016) study food processing companies in India from 2000 to 2015 and find that the technical efficiency of units producing dairy products and sugar is lower than in other sub-sectors but higher in those producing vegetable oil and related products. Globalization and liberalization affected the manufacturing industry in India in the 1990s (Goldar and Agarwal 2004; Kambhampati and Parikh 2003; Kalirajan and Bhide 2005), and the profit margin fell for many firms, but some improved it by adopting new technologies and products (Siggel and Agarwal 2009). Competition—domestic and foreign—has increased, and the profit margin has fallen but, we

argue, firms in the organized dairy industry, too, can improve efficiency and offset the fall.

Has the profitability of the dairy processing sector improved over the years? What factors contributed positively to profitability growth? How did the contributing factors change during different periods? Does firm size affect performance? We study large and medium-size firms in the organized dairy processing sector in India during the period from 1993 to 2017 in our attempt to answer these questions.

Database

The Centre for Monitoring Indian Economy (CMIE) manages Prowess, a query-based database that contains calendar-year firm-level financial data of active business entities, including registered companies. We make use of secondary data from Prowess.

The unit in this study is a dairy processing firm. We collected data on 138 dairy processing firms for 27

¹Total factor productivity (TFP) is constituted of technical change, scale change, and technical efficiency change.

years (1991–2017). Observations were not available for all the firms for all the years; therefore, the panel data is unbalanced.

We use the three-digit-level data of the Annual Survey of Industries (ASI) on firms' total income, expenses, assets, sales by product, production volumes, unit prices, and profits. Some observations were missing, and the data on all the intended variables was not available. Information on "the number of employees" was available, for example, but the observations were not sufficient for the analysis.

We approximated the value of some variables. The information on the number of employees was available for only a few firms; so, we constructed the "efficient units of labour" measure, as in Balakrishnan, Pushpangadan, and Babu (2000), by dividing the total expense on salaries by the average wage rate of the Indian dairy industry from the three-digit-level ASI data for each year.

The database classifies firms by decile. We arranged the firms in descending order of the 2018 triennium ending (TE) average of total incomes and assets. And we grouped the firms—into small, medium-size, and large—to compare performance by firm size.

Large firms made up 31.88% of the firms in the database, medium-size firms 44.93%, and small firms made up 23.19%. The firms in the sample were located in 19 states: 44 (31.40%) in Maharashtra, 22 (15.70%) in Delhi, 11 (7.80%) in Gujarat, and 63 (45.00%) in the other 16 states. The firms produce 1–15 types of dairy product; the average is 4.

Methodology

Kumbhakar, Wang, and Horncastle (2015) developed a parametric approach. Using this method lets us decompose the change in profitability over a period into the three components of TFP—technical change,² scale change,³ and technical efficiency change⁴—and the changes due to input prices, output prices, and

output growth. We use this approach to decompose the change in profitability of the organized dairy processing industry in India.

We use econometric methods to estimate technical change, scale change, and technical efficiency change. We calculate the change due to input prices, output prices, and output growth components from the observed data. We follow the cost function approach to econometrically estimate the components. The cost function approach explicitly assumes cost minimization, implying that firms try to minimize their production cost.

The dual cost function of a production technology (Kumbhakar, Wang, and Horncastle 2015) can be specified as

$$C = C(w, y, t) e^{\eta} \quad (1)$$

where w is the vector of input prices,

y is the output,

t is the time period, and

$\eta \geq 0$ is the input-oriented technical inefficiency.

Differentiating Equation 1 totally with respect to time gives

$$\dot{C}a = \sum_j \frac{\partial \ln C}{\partial \ln w_j} \dot{w}_j + \frac{\partial \ln C}{\partial \ln y} \dot{y} + \frac{\partial \ln C}{\partial t} + \frac{\partial \eta}{\partial t} \quad (2)$$

where

$\dot{C}a$ is the rate of change in actual cost and

j is the inputs used ($j = 1, 2, \dots, J$).

Using Shepherd's lemma, the first term in Equation 2 can be rewritten as

$$\frac{\partial \ln C}{\partial \ln w_j} = \frac{w_j}{C} x_j = S_j^a \text{ showing the cost share of } j^{\text{th}} \text{ input on total cost}$$

²Technological progress, organizational management, and other such factors change production technologies and shift frontiers. Such shifts are indicated by *technical change*. Any technical change that reduces production cost will improve profits.

³Economies or diseconomies of scale change profitability; the *scale component* indicates the extent of profitability. Profitability improves if the returns to scale (RTS) increase ($RTS > 1$) and if the aggregate input growth rate is positive.

⁴For any given level of output, firms try to use inputs efficiently to minimize costs and improve profits; in other words, firms aim for positive input-oriented *technical efficiency change*.

Hence, Equation 2 becomes

$$\dot{Ca} = \sum_j S_j^a \dot{w}_j + \frac{1}{RTS} \dot{y} - TC - TEC \quad (3)$$

where,

$$\frac{1}{RTS} = \frac{\partial \ln C}{\partial \ln y}, \text{ technical change } (TC) = -\frac{\partial \ln C}{\partial t}, \text{ and}$$

$$\text{technical efficiency change } (TEC) = -\frac{\partial \eta}{\partial t}.$$

Differentiating $Ca = w'x$ gives

$$\dot{Ca} = \sum_j S_j^a (\dot{w}_j + \dot{x}_j) \quad (4)$$

Equating Equations 3 and 4 gives

$$S_j^a \dot{x}_j = \frac{1}{RTS} \dot{y} - TC - TEC \quad (5)$$

Using the Divisia Index, we can write

$$TFP = \dot{y} - \sum_j S_j^a \dot{x}_j \quad (6)$$

Substituting Equation 4 in Equation 5 yields

$$TFP = \dot{y}(1 - RTS^{-1}) + TC + TEC \quad (7)$$

where,

$\dot{y}(1 - RTS^{-1})$ is scale efficiency,

$-\frac{\partial \ln C}{\partial t}$ is technical change, and

$\frac{\partial \eta}{\partial t}$ is the TEC component.

We can use the cost function to estimate the technical change, scale change, and technical efficiency change, but we cannot correctly infer firm profitability from the cost function, because a positive change in TFP does not confirm that profit increases over the period.

The percentage change in profit will be negative if the profit is negative even if there is an improvement over the previous year. This can be solved by expressing profitability change as a change in cost or revenue. We can relate the change in profitability and in TFP by differentiating profit with respect to time totally, $\pi = py - w.x$ and then dividing both sides by C

$$\frac{1}{C} \frac{d\pi}{dt} = \frac{py}{C} \{\dot{P} + \dot{Y}\} - \left\{ \sum_j S_j^a \dot{W}_j + \sum_j S_j^a \dot{X}_j \right\} \quad (8)$$

From Equations 5 and 8, after some algebraic manipulations, we get

$$\frac{1}{C} \frac{d\pi}{dt} = \frac{R}{C} \dot{P} + \left\{ \frac{R}{C} - 1 \right\} \dot{y} - \sum_j S_j^a \dot{w}_j + TFP \quad (9)$$

Equation 9 decomposes the change in profitability into output, output price changes, and input prices.

Substituting Equation 6 in Equation 9 yields all seven components of profitability change

$$\begin{aligned} \frac{1}{C} \frac{d\pi}{dt} = & \frac{R}{C} \dot{P} + \left\{ \frac{R}{C} - 1 \right\} \dot{y} - \sum_j S_j^a \dot{w}_j + \dot{y}(1 - RTS^{-1}) \\ & + TC + TEC \end{aligned} \quad (10)$$

The additional components in Equation 10 are output

price change $\left(\frac{R}{C} \dot{P} \right)$; output change $\left(\left\{ \frac{R}{C} - 1 \right\} \dot{y} \right)$; and

input price change $\left(\sum_j S_j^a \dot{w}_j \right)$.

Improvements in all components over the time period increase profit, except for growth in input prices (Kumbhakar, Wang, and Horncastle 2015). We analyse large and medium-size firms, but the data for some variables is missing, and so the period varies.

For our analysis, we use a translog cost function with three inputs—capital (K), labour (L), and raw materials (R)—and one output. We include in our model only three input variables—raw material, labour, and capital.

Other inputs, too, may affect firm profitability, but raw material, labour, and capital constitute most of the cost of dairy processing firms, and we assume that the changes in profitability and the other contributing components accurately represent the actual trend.

To make the function linear and homogeneous with respect to input prices, we normalize the total cost and input prices using the price of raw materials. The price of capital (w_k), price of labour (w_l), and total cost (tc) were normalized with the price of raw materials (w_r) as $lwkd = \ln(w_k/w_r)$, $lwld = \ln(w_l/w_r)$, and $ltcd = \ln(tc/w_r)$, respectively.

The translog cost function for the estimation was specified as

$$\begin{aligned} ltc_d = & \alpha_i + \beta_y lny_{it} + \beta_{yy} lny_{it}^2 + \beta_k lwk_{it} + \beta_l lwld_{it} + \beta_t t \\ & + \frac{1}{2} \beta_{kk} lwk_{it}^2 + \frac{1}{2} \beta_{ll} lwld_{it}^2 + \frac{1}{2} \beta_{tt} t^2 + \beta_{kl} lwkld_{it} \\ & + \beta_{yl} lny_{it} lwld_{it} + \beta_{yk} lny_{it} lwk_{it} + \beta_{yt} t lny_{it} \\ & + \beta_{tk} t lwk_{it} + \beta_{tl} t lwld_{it} + v_{it} - u_{it} \end{aligned}$$

where,

$v_{it} \sim iid N(0, \sigma_v^2)$ was the random-noise error component,

$u_{it} \geq 0$ was the technical inefficiency error component, and it was assumed to follow half-normal distribution $u_{it} \sim iid N^+(0, \sigma_u^2)$.

Variables in decomposition: a description

Output

A firm produces more than one product. Therefore, we averaged the price of all the products and divided the total sales value by the average product price per kilogram to obtain the output in kilogram.

Capital

The Prowess database provides data on gross fixed assets (rupees in million). We used this data as the capital variable. We deflated the data using an implicit deflator at 2004–05 prices. We derived the deflator using a gross fixed capital formation series at constant and current prices from the National Account Statistics.

Labour

We used efficient units of labour. We obtained these by dividing the total employee compensation (in the Prowess database) by the average compensation per worker (from the ASI data).

Raw material

Milk is the primary input in dairy processing. We obtained the quantity of raw material (in kilogram) by dividing the total raw material expenditure by the milk price. Some firms had not provided the price information; so, we averaged the milk price for firms in a particular year.

Price of output (INR per kg)

We averaged the prices of different products to obtain the output price; we deflated it with the Wholesale Price Index (WPI) of dairy products at 2004–05 prices.

Price of capital (%)

Sugathan et al. (2013) obtained the expense on capital by summing the interest share of capital and depreciation; and they calculated the interest share of capital as (annual interest on long-term debt) \times (fixed assets) \div (long-term debt). We, too, consider the ratio of the expense on capital to gross fixed assets as the price of capital, but we assume that a large percentage of long-term debt is incurred to create fixed assets, and we sum the interest rate and depreciation.

Price of labour (INR per worker per year)

Only a few firms make the information on their number of employees available. We obtained the compensation per worker from the ASI. We deflated the price series by the Consumer Price Index (CPI) for industrial workers at 2001–02 prices. Finally, we divided the total compensation by the number of employees to obtain the price of labour.

Price of raw material (INR per kg)

No information was available on prices for some firms, but the database lists the unit prices of raw materials, and we plugged the average price of milk in a particular year across different firms into the series as price information. To obtain the deflated price series, we divided the price series by the WPI of milk at 2004–05 prices.

We calculated the total revenue (in INR) by multiplying the price with the quantity. We obtained the total cost (in INR) by summing the cost of all three inputs.

Results and discussion

Decomposing profitability change in the dairy industry

To understand the dynamics of growth in the TFP of the dairy industry, we split the 24-year period (1993–2017) under study ad hoc into 1993–99,⁵ 2000–08, and

⁵The second sub-period (2000–08) is nine years long, as is the third sub-period (2009–17), but the first sub-period (1993–99) is only seven years long, because the data for the years 1991 and 1992 was available for so few firms—too few for our analysis—that we had to exclude the data for those years.

Table 1 Summary statistics of variables overall

Variables (per firm)	Mean			
	1993–99 (SD)	2000–08 (SD)	2010–17 (SD)	Overall (SD)
Output (000' tonnes per year)	10.90 (32.50)	22.10 (54.60)	43.80 (91.10)	34.10 (78.10)
Raw material (000' tonnes per year)	41.70 (55.3)	70.80 (102.00)	164.00 (314.00)	124.00 (251.00)
Labour (efficiency units per year)	205.19 (261.00)	915.88 (2,694)	1,451.18 (3,872.79)	1,194.03 (3,396.37)
Capital (INR million per year)	353.06 (434.68)	511.41 (888.53)	997.52 (1,596.23)	787.77 (1,359.83)
Price of output (INR per kg)	123.25 (12.03)	93.64 (8.37)	83.97 (20.05)	89.43 (18.63)
Price of capital (ratio)	0.15 (0.07)	0.12 (0.08)	0.14 (0.12)	0.13 (0.10)
Price of raw material (INR per kg)	29.76 (24.18)	20.92 (21.52)	15.30 (5.49)	18.07 (15.14)
Price of labour (INR per worker per year)	93400.47 (48,496.80)	52,645.46 (1,035.82)	56,377.19 (4,062.39)	56,814.00 (13,943)

Note Figures in parentheses are the standard deviations of the respective value in the given sub-period.

Source Authors' calculation

2009–17 (Table 1; see the coefficients of the cost frontier model in Table 1 in the Appendix).

The increase in population, urbanization, and per capita income led demand to surge during the study period; in response, output grew at 4.20% per annum, improving profitability by 5.90% and the TFP by 2.80% (Table 2).

The main contributor to the TFP growth rate was technical efficiency change, which grew at 2.50%, or close to the TFP growth rate, driven probably by improvements in knowledge, experience, and investment in research and development (R&D). The scale change was the second contributor to the TFP growth rate.

The dairy industry accrued economies of scale at 0.60% during the study period (1993–2017). The technical change component fell; technological regress led profitability to fall at 0.30%, due probably to the adoption of obsolete technologies. The output price fell at 3.70%; the real prices of products fell over the years, due potentially to an increase in competition—which forced firms to sell their products at competitive

prices—but the 2.60% fall in input prices contributed positively to the change in profitability. Any growth in output improves profitability, and any increase in output price increases profit; similarly, any increase in input price reduces profits and profitability. Thus, all the components of TFP except output price and technical change contributed positively to the change in profitability.

From 1993 to 1999, profitability grew at only 0.80%, but the TFP grew at a high 8.40%, driven mainly by high growth in technical efficiency (12.80%) and scale change (3.10%), and despite the 7.60% fall in technical change. The output grew at 3.60%, input prices increased by 4.50%, despite the 6.60% fall in output prices; both the changes, in input and output prices, negatively affected profitability.

The profitability growth rate improved in the second sub-period, 2000–08, mainly because output grew at 3.50%, almost the same rate as in 1993–99, the previous period. Price factors contributed—output prices fell, but at a lower rate (1.70%), and input prices increased (by 4.50%), resulting in a net price effect of 2.80%.

Table 2 Changes in profitability of dairy industry and its components (1993–2017)

Variables	Sub-period			Overall
	1993–99	2000–08	2009–17	
Total factor productivity (+)	0.084	0.013	0.034	0.028
Scale (+)	0.031	0.007	0.004	0.006
Technical change (+)	–0.076	–0.036	0.020	–0.003
Technical efficiency change (+)	0.128	0.042	0.010	0.025
Output change (+)	0.036	0.035	0.046	0.042
Output price change (+)	–0.066	–0.017	–0.047	–0.037
Input price change (–)	0.045	–0.045	–0.018	–0.026
Profitability change	0.008	0.076	0.050	0.059

Source Authors' estimates

Technical efficiency improved, although at a lower rate (4.20%) than earlier, in 1993–99 (12.80%)—as did the scale change (0.70%, compared to 3.10%)—and reduced the growth in TFP to 1.30%. The technical change fell—but at 3.60%, less than the 7.60% in 1993–99, the first sub-period—indicating that better technologies were adopted between 2000 and 2008, the second sub-period.

Between 2009 and 2017, the third sub-period, price factors changed and reduced the profitability growth to 5.00%. The output price fell (by 4.70%), as did input prices (1.80%), instead of growing as in the second sub-period, 2000–08. Output growth improved (4.60%); and TFP growth (3.40%) increased mainly because technological processes improved (2.00%), despite a fall in the growth rate of technical efficiency to 1.00% and of the scale component to 0.40%.

Throughout the study period (1993–2017), therefore, output growth contributed consistently to the dairy industry's growth in profitability, as did the fluctuations in the growth rate of output prices and input prices. The TFP of the organized food and beverages segment was low during the 1980s and early 1990s; it improved in the late 1990s but decelerated in 2014–15 (Bathla and Kannan 2020). The growth in the dairy industry's TFP fluctuated, but was positive, throughout the study period (1993–2017). In the first sub-period (1993–99) and in the second (2000–08), the TFP grew because technical efficiency improved, but in the third sub-period (2009–17) the TFP grew due to the improvement in technical change.

The scale component fluctuated wildly over the years; it grew during the late 1990s but hovered around 0 (Figure 1). The growth in technical change was negative until 2008, but although its mean value was –0.30%, it improved steadily, though marginally. The rate of decrease in technical efficiency change increased initially but slowed down gradually; it tended towards 0 over the last few years. Therefore, input-oriented efficiency grew over the study period (1993–2017) but at a decreasing rate/extent of growth, indicating an increase in the overuse of inputs and a resulting increase in production cost.

Until the early 2000s, the TFP exhibited a decreasing trend, mainly because the scale component decreased and the technical efficiency change declined at an increasing rate. Later, the rate of decline in technical efficiency change decreased, and the scale component and technical change improved; as a result, the TFP improved. The study period (1993–2017) was marked by high variability in profitability and in the change in output price and in output and input prices, but no trends were noticeable.

Decomposing change in profitability by firm size

We analysed the firms by size to determine the variation in profitability growth by component (Table 3; see the coefficients of the cost frontier model in Table 1 in the Appendix). During the maximum likelihood estimation, convergence could not be achieved for small firms; so, we excluded small firms from our analysis.

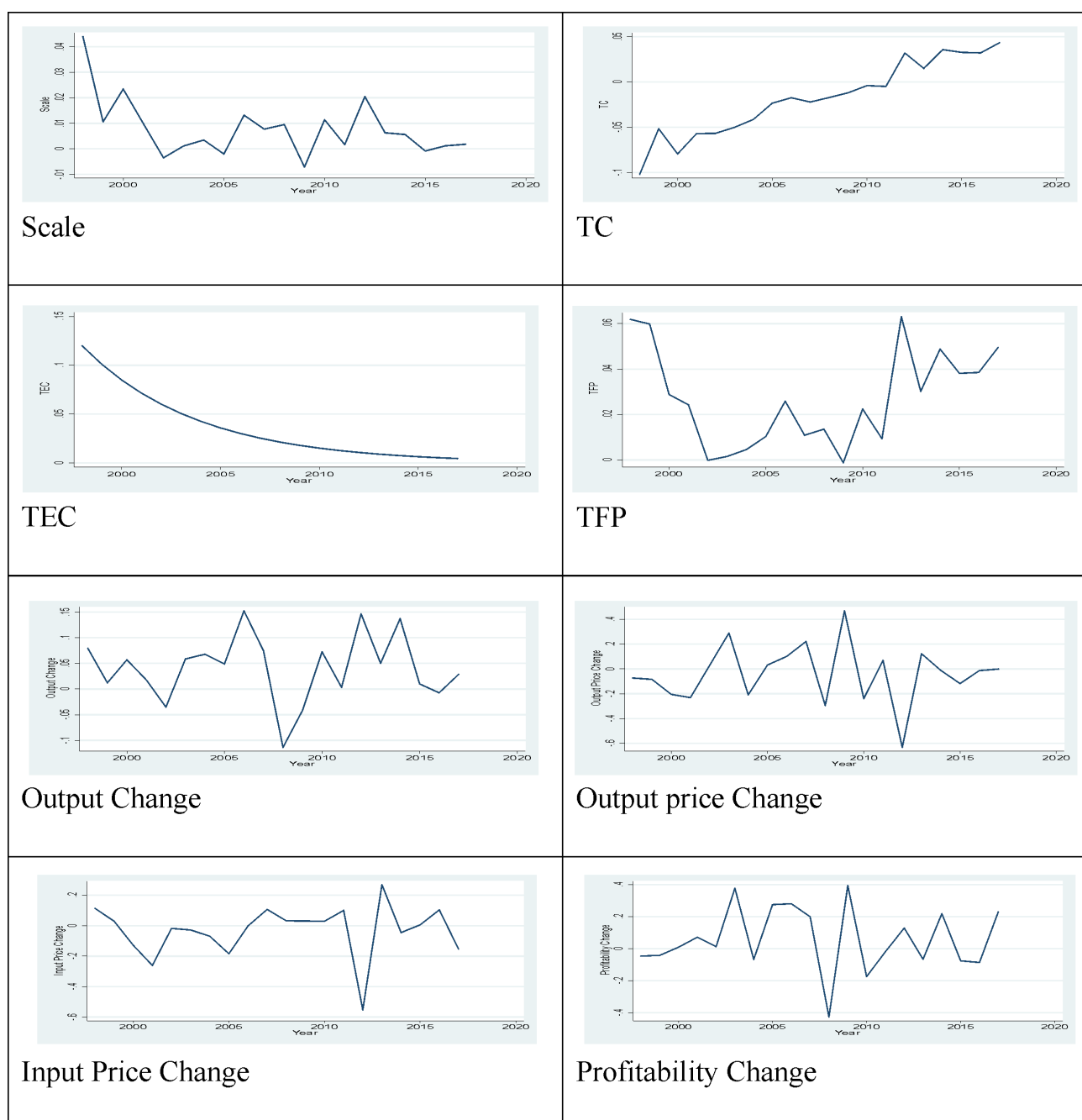


Figure 1 Annual variation in the change in profitability of the dairy industry (1993–2017)

Source Authors' calculations

During the study period (1993–2017), the profitability of large firms increased at 6.10% per annum, primarily because of the 4.20% growth in output (Table 4). The profitability of medium-size firms increased, too, though at a lower 4.90%, and also primarily because output grew (at 3.70%). The output growth and profitability may have been higher for large firms

because these can produce larger volumes and sell higher quantities. The second-largest contributor to profitability was TFP; it grew at 3.00% for large firms and at 2.40% for medium-size firms.

The technical efficiency change grew at 3.20% for large firms and at 1.50% for medium-size firms. Large firms

Table 3 Summary statistics of variables by firm size (1993–2017)

Variables (per firm)	Large	Medium
Output (000' tons per year)	67.60 (105.00)	6.13 (7.35)
Raw material (000' tons per year)	238.00 (334.00)	28.80 (39.20)
Labour (efficient unit per year)	2321.92 (4737.07)	246.01 (315.42)
Capital (INR in million per year)	1465.69 (1753.70)	224.35 (240.31)
Price of output (INR per kg)	89.56 (19.05)	89.58 (18.42)
Price of capital (ratio)	0.14 (0.12)	0.13 (0.09)
Price of raw material (INR per kg)	18.87 (17.41)	17.56 (13.74)
Price of labour (INR per worker per year)	56916.01 (14428.01)	56609.53 (13363.95)

Note Figures in parentheses are the standard deviations of the respective value in the given sub-period

Source Authors' calculations

Table 4 Change in profitability and components by firm size

Component	Large	Medium
TFP (+)	0.030	0.024
Scale (+)	0.018	−0.009
TC (+)	−0.019	0.018
TEC (+)	0.032	0.015
Output change (+)	0.042	0.037
Output price change (+)	−0.032	−0.045
Input price change (−)	−0.020	−0.034
Profitability change	0.061	0.049

Source Authors' estimates

have economy of scale and can use resources efficiently; that is why their growth in technical efficiency was so high. Technical change, on average, reduced the profitability of large firms (at 1.90%) and improved it for medium-size firms (at 1.80%). The scale component of large firms grew at 1.80% but fell at 0.09% for medium-size firms; growth due to economies of scale was higher for large firms.

Output prices fell 3.20% for large firms but by 4.50% for medium-size firms because the product mix

differed. Input prices fell 2.00% for large firms but by 3.40% for medium-size firms and improved profit.

Throughout the study period (1993–2017), the changes in profitability, output, and input and output prices fluctuated wildly for large firms (Figure 2) and medium-size firms (Figure 3). The TFP increased for large and medium-size firms from 2008 to 2017, driven mainly by technological change, and technical efficiency fell continually.

Conclusions

The growth of an industry depends on the availability of resources, policies and regulations, competition between firms, and the adoption of modern technologies. Profitability is affected by location parameters, like access to input and output markets, the number of firms in an area, and fiscal policy (Asiseh et al. 2010); any change in these factors over a period may affect firm productivity, efficiency, and profitability. And industry competitiveness is hindered by large inefficiencies in resource use; high cost of production and packaging; safety and quality issues; irregular access to finance; and inadequate investment in the marketing, transport, and cold chain infrastructure for perishables (Bathla and Kannan 2020).

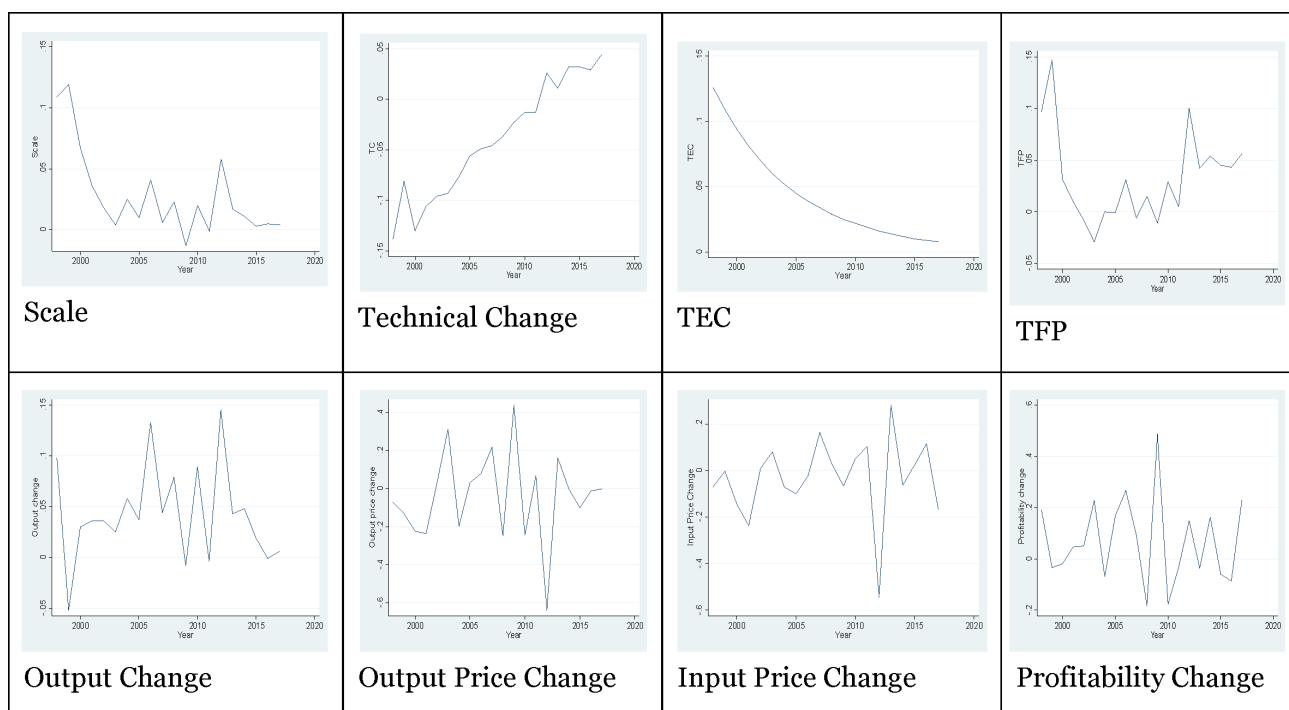


Figure 2 Large firms' profitability change (annual variation, 1998¹–2017)

Note ¹When we divided the total sample into categories, we were getting convergence only with data from 1998 to 2017, because the number of observations prior to 1998 is insufficient. However, for the industry overall, we clubbed the observations of all firm categories together, and we could get convergence with the data from 1993 to 2017 because the number of observations is sufficient.

Source Authors' estimates

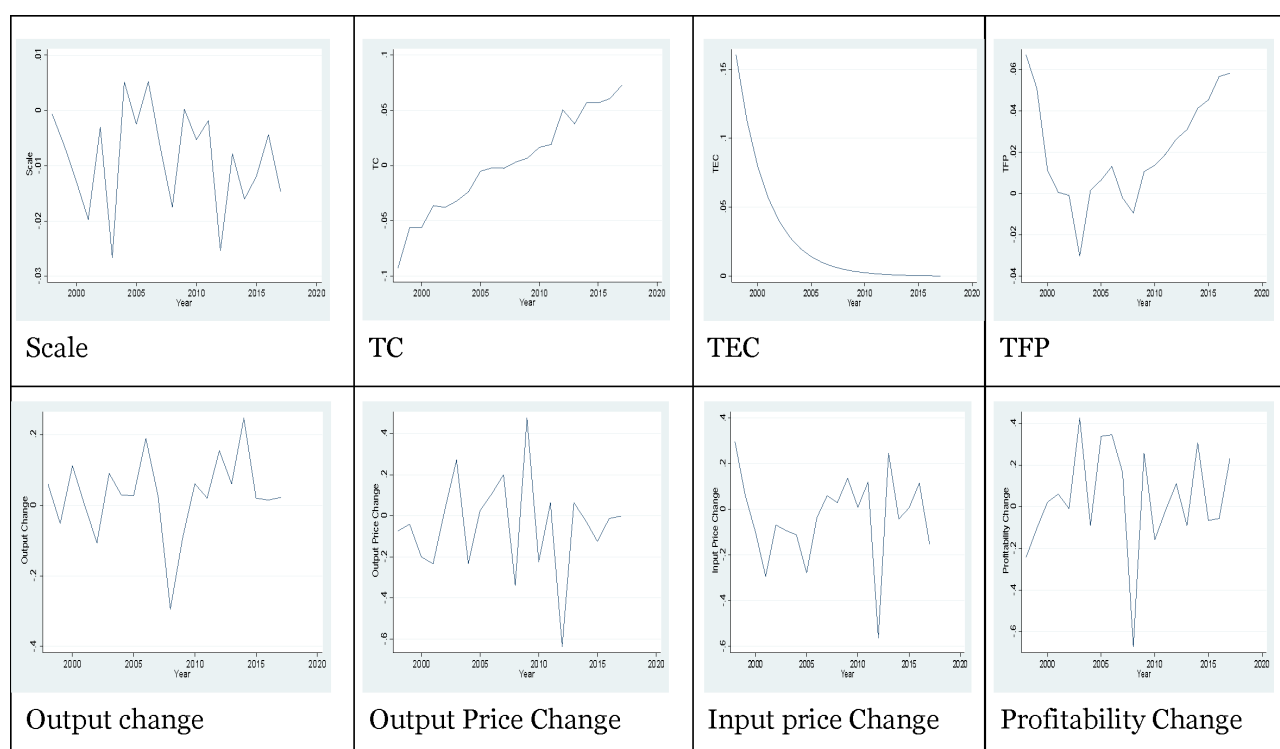


Figure 3 Medium-size firms' profitability change (annual variation, 1998–2017)

Source Authors' estimates

The population is increasing, as are urbanization and per capita income, and the demand for milk and milk products is growing in response. Therefore, there is enormous potential for the organized sector to process milk and add value. That is important particularly because value addition can help farmers access remunerative pricing and markets; and the dairy industry provides food, nutrition, and livelihoods to millions of people and plays a pivotal role in socio-economic development.

At the individual producer level, a firm aims to maximise profit, but profitability can be maximized even with suboptimal productivity; therefore, the profitability measure alone may not indicate an industry's productivity and efficiency. Besides, firm profitability may be affected not only by firm-level factors but also by exogenous factors like price factors (input prices, output prices, and mark-up) and non-price factors (efficiency, technical change, returns to scale, and output growth (Kumbhakar and Lien 2009). And firms may be inefficient (overuse inputs for a given level of output and incur additional costs) or efficient (use inputs efficiently, reduce cost, and improve profit). The technical efficiency change is positive for efficient firms and negative for inefficient firms. In addition, output change indicates the growth in the quantity of output.

From 1993 to 2017, the dairy industry's profitability grew at 5.90% per annum, driven largely by the growth in output and TFP, the growth in TFP driven mainly by increases in technical efficiency and technical change. The rate of growth in technical change increased for large and medium-size firms and growth in technical efficiency declined. Firms should use inputs efficiently and improve input-oriented technical efficiency to raise profitability.

The change in input and output prices was negative for most categories. The fall in input prices improved profitability. The trends for the sub-periods show that during the 1990s, TFP and technical efficiency change contributed to the change in profitability, and both these indicators registered a decrease over the time period.

Dairy firms, whether large or medium-size, cannot use modern technologies and resources. That may be why, over time, technical inefficiencies increase and the TFP falls. Firms need to scale investment to adopt modern

technologies and improve their input-oriented technical efficiency to reduce costs and improve profitability and growth. A stable price environment would incentivize firms to scale investment and production.

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Table A1 Coefficients of cost frontier model for dairy industry (overall and by firm size)

Variables	Overall		Large		Medium	
	Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error
ltd						
ly	1.67***	0.27	3.79***	0.49	0.55	0.59
ly ²	−0.01***	0.01	−0.10***	0.01	0.09***	0.02
lwkd	−0.87	0.76	−2.27**	1.05	0.43	0.99
lwld	3.13***	1.46	4.90**	2.07	3.56*	2.08
lwkd ²	−0.02	0.04	−0.13***	0.05	0.08*	0.05
lwld ²	−0.08	0.13	−0.12	0.18	0.08	0.16
lwkld	0.09	0.07	0.08	0.09	0.06	0.09
lylwkd	0.04***	0.01	0.09***	0.02	0.00	0.03
lylwld	−0.05**	0.03	−0.14***	0.04	0.11*	0.06
t	0.17*	0.09	0.00	0.12	0.14	0.13
tt	−0.01***	0.00	−0.01***	0.00	0.01***	0.00
tly	0.01***	0.00	0.02***	0.00	0.00	0.00
tlwkd	−0.02***	0.00	−0.03***	0.01	0.02***	0.01
tlwld	−0.03***	0.01	−0.04***	0.01	0.02*	0.01
Constant	−21.99***	8.55	−49.13***	12.73	11.79	12.74
N	1025		475		471	
Model significance	Wald Chi2 = 23391.84, Log likelihood = −435.60, Prob > chi2 = 0.000		Wald Chi2 = −8479.71, Log likelihood = −74.8, Prob > chi2 = 0.000		Wald Chi2 = −6091.2, Log likelihood = −166.905, Prob > chi2 = 0.000	

Source Authors' estimates