Indian Journal of Animal Sciences **91** (3): 230–234, March 2021/Article
https://doi.org/10.56093/ijans.v91i3.114149

Technical efficiency and its determinants in the Indian meat processing industry

ABDULLA[1]✉ and SHIV KUMAR[1]

ICAR-National Institute of Agricultural Economics and Policy Research, Pusa, New Delhi 110 012 India

Received: 15 September 2020; Accepted: 12 July 2021

ABSTRACT

The stochastic frontier approach captures the technical efficiency and its determinants of meat processing industry using unit level data from 2002–2016 of annual survey of industries in India. The study concludes substantial (73%) scope of improvement in technical efficiency. Better management of inputs by private limited firms have achieved higher technical efficiency compared to firms of other sectors. Cross learning among best performing states and worst performing states would bridge the gap of technical efficiency in meat processing industry. The matching skill set of labour force with state of art technology is the way out to arrest the deterioration of technical efficiency in the industry.

Keywords: Determinants, Meat, Processing industry, Technical efficiency

The potential growth of the meat processing and preserving industry was restrained due to major challenges on technology, institution, and infrastructure levels. The global meat trade in liberalised regime has brought new opportunities and challenges before meat processors through a competitive market environment. To overcome the constraints faced by the sector, both domestic and overseas processing organizations attempted to capture growing food market by adopting sophisticated technologies to facilitate innovations in meat product development and packaging. The Government of India provided a number of fiscal reliefs and incentives, automatic approval of foreign investment and technologies transfer and imports to strengthen the food manufacturing sector, including meat processing (MoFPI 2017). The technology injection in meat processing industry supported by the investment in processing, infrastructure, markets and institutions played a key role in enhancing productivity and meat product supplies in India and contributed to foreign exchange earnings through exports.

India's livestock population is 535.78 million (20th Livestock Census). The current processing levels for meat is 21% (MoFPI 2017). India produces around 7.4 million MT of meat annually. India is the largest producer of buffalo meat and 2nd largest producer of goat meat. India exports both frozen and fresh chilled meat to more than 60 countries of the world. The Indian bovine meat trade faced economic shocks in world market in 2014–15 but gained momentum after two years of world trade contractions and meat exports picked later on. By 2050, increase in meat production and its demand is expected to take place mainly in developing countries. Between 1995 and 2020 they will account for almost 85% of the increase in global demand as against 25% in developed countries (IFPRI, 1999). To meet the increased demand, the latest state of the art processing technology and associated infrastructure needs to be improved, for which the key lies at improving technical efficiency in processing industry. In this backdrop, it becomes essential to quantify the technical efficiency and its determinants. The knowledge emanating from this study would decipher level of technical efficiency and its determinants at five digit NIC code using a data series from 2002 to 2016–17.

Present address: [1]ICAR-National Institute of Agricultural Economics and Policy Research, Pusa, New Delhi. ✉Corresponding author email: abdullahalig007@gmail.com

MATERIALS AND METHODS

Data and variable selection: In this paper, we have used unit level panel data from the Annual Survey of Industries (ASI). The ASI provides information on outputs of manufacturing firms, i.e. value of output. Value of output (VOP) comprises the total ex-factory value of meat 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, fuel consumed as input variables to assess the productivity and efficiency of Indian meat processing 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).

Empirical strategy: Previous studies have applied two stage estimation methods, primarily, estimating frontier production function and predict the efficiencies of firms and then estimate, inefficiency effect model in the later stage in order to determine the factors of variations in efficiencies among firms (Kumbhakar 1991, Reifschneider and Stevenson 1991). Present study utilized the Battese and Coelli (1992) specification for unbalanced panel data which may be expressed as:

$$Y_{it} = f(X_{it}; \beta) + \epsilon_{it}; \quad \text{... (1)}$$

where, $\epsilon_{it} = V_{it} - U_{it}$ and $V_{it} \sim (0, \sigma_v^2)$, and $U_{it} \sim N^+(\mu+\sigma_u^2)$ with $U \geq 0$, i = 1, ..., N; t = 1, ..., T

In equation (1), Y_{it} is the output produced in a state i, X_{it} is the vector for production factors used (it includes labour, capital and fuel), t is time which is included to capture technical change and β is a vector of parameters defining production technology. V_{it} are assumed to be independent and identically distributed (i.i.d) random errors that having normal distribution with mean zero and unknown variance σ_v^2. The term U_{it} are non-negative random variables that associated with technical inefficiency of production, which are assumed to be independently distributed, such that U_{it} is obtained by truncation (at zero) of the normal distribution with mean μ_{it} and variance σ^2 (Battese and Coelli, 1995). Where μ_{it} is defined as:

$$\mu_{it} + \sigma z_{it} + \omega_{it} \quad \text{... (2)}$$

where, z_{it} is variables associated with technical efficiencies of production of firm. σ is the unknown parameters to be estimated. ω_{it} are unobservable random variables that are presumed to be i.i.d., obtained by truncation of the normal distribution with mean zero and ratio of unknown variance σ^2 such that U_{it} , and is defined by

$$U_{it} = U_i \{\exp[-\eta(t-T)]\} \quad \text{... (3)}$$

where U_i are assumed to be firm specific non-negative random variables. η is an unknown parameter to be estimated, which determines whether inefficiencies are time varying or time invariant.

RESULTS AND DISCUSSION

Perusal of past literature reveals the use of following three inputs, viz. labour, capital and fuel and one output as total production of meat products. Table 1 reveals that the average output of the meat processing and preserving industry is ₹ 5,720 lakh. The average wages and salary to its workers is ₹ 113 lakh and the average capital expenditure is ₹ 1,040 lakh which indicates that on an average capital

Table 1. Descriptive statistics (₹ lakh at constant price)

Variable	Mean	Std. Dev.	Min	Max
Output	5,720	15,100	0.162	145,000
Capital	1,040	2,890	0.010	65,200
Labour	113	253	0.029	4,580
Fuel	691	3,580	0.011	49,000

Source: Author's calculation based on annual survey of industries (ASI) data.

Table 2. Estimated parameters of output-oriented Stochastic Production Frontier Model

Variable	Parameter	Coefficients	z ratio
Constant	β_0	–2.059	–1.02
Log labour	β_1	1.860***	7.93
Log capital	β_2	–0.127	–0.76
Log fuel	β_3	–0.045	–0.24
Log labour*log labour	β_{11}	–0.053*	–2.14
Log capital*log capital	β_{22}	0.006	1.13
Log fuel*log fuel	β_{33}	–0.071***	–5.61
Log labour*log capital	β_{12}	–0.047***	–3.70
Log labour*log fuel	β_{13}	0.033*	1.98
Log capital*log fuel	β_{23}	0.049***	4.73
time	β_t	0.329***	4.05
time*time	β_{tt}	–0.009***	–5.97
time*log labour	β_{t1}	–0.021***	–3.22
time* log capital	β_{t2}	0.008	1.61
time*log fuel	β_{t3}	0.010*	2.05
Mu (K/L)		–0.129***	–5.61
constant	μ	3.724***	9.58
u-sigmas	σ_u	0.025	0.25
v-sigmas	σ_v	–0.894***	–23.60

Source: Author's calculation based on ASI unit level data; t statistics are in parentheses and *, **, ***indicates significant at 1, 5 and 10% respectively.

expenditure is higher than labour (expenditure in wages and salary). Moreover, on an average expenditure on fuel used in the industry is ₹ 691 lakh. The average investment incurred on consumption of capital and fuel among inputs used in meat processing industry registered large variability of ₹ 2,890 and ₹ 3,580 respectively.

To ascertain improvement in technical efficiency of meat processing industry during the study, output oriented translog production frontier model was used. The estimated results of the Maximum likelihood estimates of the output oriented translog production frontier model are presented in Table 2.

Coefficients of the parameters of translog function cannot be interpreted directly, but indicate the relative importance of different factors of production. The first-order (in short run) coefficient of labour is positive and significant at 1%. While the coefficients of capital and fuel are negative and insignificant. Notwithstanding, most of these variables when interacted with time trend appear positive and significant except labour. The negative coefficient on

Table 3. Factors determining technical efficiency of industry using Tobit Regression

Variable	Parameters	Coefficients	t ratio
Constant	δ_0	0.280***	(1543.04)
Age	δ_1	0.001**	(2.79)
Ratio of plant mech. and FC	δ_2	0.008***	(33.13)
Ratio of transport and FC	δ_3	0.011***	(28.09)
Ratio of computer and FC	δ_4	0.020***	(4.11)
Ratio of liability and assets	δ_5	–0.001***	(–12.52)
Ratio of MWD and TWD	δ_6	0.001	(0.21)
Ratio of supervisory staff and TS	δ_7	0.003***	(9.17)
Public Ltd. =1, 0 otherwise	δ_8	0.002***	(13.33)
Private Ltd. =1, 0 otherwise	δ_9	0.001***	(12.52)
Cooperative society = 1, 0 otherwise	δ_{10}	–0.289***	(–162.35)
Location (Rural=1, 0 otherwise)	δ_{11}	0.001***	(4.68)
sigma_u	σ_u	0.183***	(32.40)
sigma_e	σ_v	0.002***	(50.80)

Source: Author's calculation based on ASI unit level data; Note: *, **, ***indicates significant at 1, 5 and 10% respectively, PM, Plant and Machinery, FC, Fixed Capital and TS, Total Staff, MWD, Manufacturing working days; TWD, Total working days.

interaction of time trend with labour is expected as the supplies or quantities of these inputs are almost fixed. Furthermore, coefficients on interactions of these inputs among themselves are either positive or negative suggesting the possibilities of input substitution or complementarity. For example, capital and labour appear to be substitute.

Contrary to our expectation, the first order coefficient on time trend is positive. This indicates that the neutral part of technical change has a positive effect on production. This can happen as in the beginning policies to restructure industry which may retard technical progress due to changes in relative prices that may adversely affect the choice of factor inputs. However, the second-order (long run) coefficient on time trend is also positive, indicating acceleration in technical progress. Also, the interaction of time trend with labour inputs is negative and significant suggesting that the non-neutral part of technical progress tends to offset the negative effects of neutral part of the technical change.

The coefficient on 'K/L', the logarithm of the initial capital to labour ratio, is 0.13 and implies that firms with a higher initial capital labour ratio will grow at a higher rate (for a 1% increase in initial capital labour ratio, the growth rate will accelerate by 0.13%).

Evaluation of factors responsible for technical efficiency of meat processing industry provides clues to policy makers and planners to pinpoint the line of action to boost growth. The coefficients of the inefficiency effects (Fixed Effect Tobit) model are presented in Table 3. The coefficient of age of firms (number of year in operation) is significant at 5% level. Although the coefficient of age is positive which reveals a direct relationship between technical efficiency and number of years in operation. This could be as most of the mills operating are mostly aged. The value of the coefficient of plant and machinery over fixed capital indicates the extent of operational use of investment in plant and machinery in production process which is positively significant. This establishes the fact that ratio of plant and machinery over fixed capital is directly related to the technical efficiency of the industry. This implies that there is need to increase investment in plant and machinery to reduce the inefficiency of the firms. The ratio of expenditure on ratio of transportation over fixed capital is directly related to technical efficiency of the firms. The effect of transportation infrastructure has a positive effect on price efficiency (Birthal *et al*. 2018, Wang *et al*. 2018). The computerization and integration of the industry with internet has proved to be positively associated with improvement of technical efficiency of the firms. Industry has 4.0 principles, viz. the Internet of Things, additive manufacturing, man-to-machine communication, smart manufacturing, and artificial intelligence, etc. that will reduce cost substantially by automation. The ratio of liability and assets depicts the solvency of the firms. This is positively associated with improvement in technical efficiency of the firms. Therefore, there is an urgent need to reduce the load burden by providing financial help. The ratio of manufacturing working days over total working days is positively significant which indicates the need to increase the number of working days for better performance of the processing firms (Khan and Abdulla 2019). The ratio of investment on supervisory staff over total staff indicates the management of the processing firms. This is positively and significantly associated with improvement in technical efficiency. The firms can improve their technical efficiency by improving the quality of management practices (Bartz-Zuccala *et al*. 2018).

The coefficient of dummy variable of Public Ltd. and Private Ltd. firms are positive and statistically significant contrary to the case of Cooperative sector. This confirms that technical efficiency of the Public Ltd. and Private Ltd. firms is on higher side compared to Cooperative sector. This might be due to low technology absorption capacity

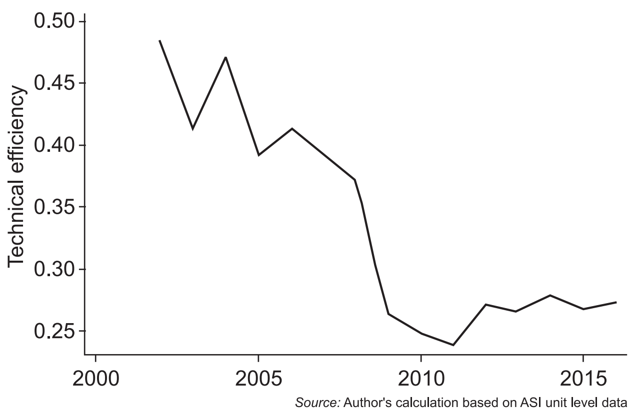

Fig. 1. Temporal technical efficiency of Indian meat processing industry over the period (2002–2016).

in cooperative sector. Therefore, from policy prospective, the Cooperative firms could either merge into Public Ltd./ Private Ltd. firms, or advance operational scale to improve the technical efficiency (Abdulla and Ahmad 2017).

There are a lot of fluctuations in efficiency scores observed. This might be due to entry of domestic and international forces like global inflation, demonetization policy, etc. which directly and indirectly affected the economy. A higher decline in technical efficiency level of meat processing firms has been observed in 2012. This might be attributed to global food inflation, 2012. The improvement in technical efficiency of modern state of art technology in meat processing will be immune to disturbances in external markets. The apt option is to translate technical inefficiency to technical efficiency with the appropriate mix of technology, policy and intuitions. This is a chance of improvement in technical efficiency by 73% with the re-allocation to input resources.

The state-wise analysis of Technical efficiency reveals that during the entire study period, the average Technical efficiency was 27%. The state of Jharkhand had the maximum average Technical efficiency (71%). The states of Orrisa and Delhi have more than 50% average technical efficiency during study period. The states, viz. Uttarakhand, Haryana, Bihar, Tripura, Assam, Andhra Pradesh, Goa, Kerala, Tamil Nadu and Pondicherry were found to be operating with below all India average technical efficiency. The state of Jharkhand recorded highest technical efficiency and state of Tripura recorded least technical efficiency.

The sub-group specific Technical efficiency of meat processing industry (Table 4) reveals that Beef-slaughtering and preparation firms registered highest technical efficiency followed by production, processing of animal offal firms by 49.0% and 47%, respectively. Furthermore, the Production, processing and preservation of other meat and meat products firms registered least technical efficiency (23%). The Mutton slaughtering and preparation firms and

Table 4. Sub-group specific average technical efficiency of Indian meat industry (2002–2016)

Meat industry sub-group	Average technical efficiency
Mutton slaughtering and preparation	0.28
Beef-slaughtering and preparation	0.49
Pork-slaughtering and preparation	0.24
Poultry and other slaughtering and preparation	0.27
Preservation, processing and canning of meat	0.25
Production of hides and skins originating from slaughterhouses	0.38
Production and processing of animal offal	0.47
Production, processing and preserving of other meat and meat products	0.23
Mean technical efficiency Indian meat industry	0.27

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

Pork-slaughtering and preparation firms have technical efficiency of 28% and 24% respectively. The average technical efficiency of Indian meat industry is around 27%.

The overall technical efficiency of meat processing industry is 27% and left over is technical inefficiency (around 73%) in the industry. This technical inefficiency needs to be translated into technical efficiency with the support of technology, policy and institutions. This will not only reduce wastage of resources used but also reduce cost of production. The technical efficiency of private limited firms is higher than other category. This indicates that private limited has comparatively managed its inputs use efficiently. The best practices of private sector needs to be assimilated in other sectors of the meat processing industry. In addition, there could be possibilities of disinvestment of least technically efficient firms (cooperative society) or mergers and acquisition of Private or Public Ltd. firms. This would reverse the decreasing technical efficiency of the firms. There is a significant scope for increasing the output without using any additional inputs.

Spatially, the technical efficiency of meat processing industry revealed large variability. Jharkhand state has recorded a highest technical efficiency and Tripura has lowest technical efficiency during study period. There is need to increase the pace of catching up the high performing states with laggard states by imbibing best practices and efficient use of modern technology in processing industry. Beef-slaughtering and preparation firms registered highest technical efficiency while production, processing and preservation of other meat and meat products firms registered least technical efficiency of 23%. The falling technical efficiency of meat industry might be due to old and obsolete technology. There is need to transform the meat processing industry with changing socio-economic and legal framework. This can be possible when there would be replacement of obsolete and old technology with modern state of the art technology at all levels in the sector.

The first order coefficient of labour discerns the fact that the meat processing industry has become more labour intensive due to presence of large number of small firms which lack use of modern state of the art technology as per emerging economic and business environment in liberalised policy regime. To arrest the deterioration of technical efficiency and making labour more productive, there is need for more capital augmentation in the industry for production of safe, hygienic and wholesome food for consumers. The future labour force working in meat processing sector has to acquire new skill set to work with machines. The emerging technological trends need to be monitored to ascertain the future demand of requisite skill set of labour for the sector. This necessitates the collaboration and linkages between the industry-academia for efficient functioning of meat industry. The Government of India has to develop a framework and put in place an intelligence mechanism not only to monitor the merging threats and opportunities but also effective and efficient management of the meat processing sector.

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