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RESEARCH NOTES

Productivity and Efficiency in Indian Meat Processing Industry: A DEA Approach

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I

INTRODUCTION

Food processing is a sunrise industry of the Indian economy and has been identified as a thrust area for development. Food processing sector covers a wide range of items like fruits and vegetables; meat and poultry; milk and milk products, alcoholic beverages, fisheries, plantation, grains, confectionery, chocolates and cocoa products, mineral water, high protein foods etc. Based on the basic raw material usage, food industry can broadly be classified into plant-based and animal-based industry. Meat industry is one of the important segments of food processing industry in general and livestock/animal-based industry in particular. India has immense potential for production, consumption and export of meat due to sufficient production resources, available markets and huge livestock population.

Over the last two decades, the value of meat output has been increasing at a rate of about 5 per cent per annum. Rising demand for meat has been the driving force behind it. While the per capita consumption of foodgrains has almost stagnated during 1990s, consumption of high value commodities like fruits, vegetables, milk, meat, eggs and fish has been rising fast in the recent decade (Kumar, 1998; Bhalla and Hazell, 1998; Bhalla *et al*., 1999; Delgado *et al*., 1999; Kumar *et al*., 2003; Kumar and Birthal, 2004). The increase in meat and meat products' demand has been accompanied by increase in production. Total meat production increased from 2.7 million tonnes in 1980 to 6.3 million tonnes in 2005 with an annual growth of 3.44 per cent. The structure of meat production, however, is undergoing a gradual shift from ruminant (cattle, buffalo, sheep and goat) to non-ruminant (pig and poultry) meat production. The share of non-ruminant meat production increased from 15 per cent in 1980 to 37 per cent in 2005.

Apart from this, the emerging global market opportunities for Indian meat industry have significantly induced private investment in meat processing through state-of-art technology of integrated plants. These plants are successfully adding value not only by improving the quality of meat, but also by utilising each and every

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part of the carcass efficiently which otherwise was being wasted at local slaughter houses. Therefore, technology is the key to improve the growth and efficiency in meat processing sector. Empirical evidences on the contribution of technology to growth of meat processing industry in India are scarce. However, the evidences from food industry as a whole indicate varied contribution of technology and production efficiencies to growth of food processing industry (Goldar, 1986; Ahluwalia, 1991; Mitra *et al.*, 1998; Mitra, 1999; Goldar and Kumari, 2002; Trivedi *et al*., 2002 and Pattnayak and Thangavelu, 2003).

This paper evaluates the performance of Indian meat processing industry in terms of total factor productivity (TFP) and efficiency changes using Data Envelopment Analysis (DEA) technique for the period of 1980-81 to 2002-03. This study also analyses the sources of inefficiency due to excessive use of factors of production and identifies policy implications for strengthening meat processing industry in the country.

II

DATA AND METHODOLOGY

The data on input and output related to registered/organised meat manufacturing units has been compiled for a period of 1980-81 to 2002-03 from *Annual Survey of Industries* published by the Central Statistical Organisation, Ministry of Statistics and Programme Planning, Government of India. The data on value of output and inputs of meat processing units is converted into constant prices considering 1993-94 as the base year by using appropriate price index of respective commodity groups and inputs. A brief definition of variables used for estimating Total Factor Productivity (TFP) change and efficiency is given in Box 1.

BOX 1: VARIABLE DEFINITIONS

Output: Gross output is defined as ex-factory value of products and by-products manufactured during the accounting year.

Capital: User's cost of capital, i.e., a sum of depreciation, interest payment and rent is used to estimate the capital use in food processing industry.

Labour: The Annual Survey of Industry provides two categories of labour employment in food processing industry, i.e., employees and workers. The data available on number and payment to employees and workers is used in the study.

Raw Material: Raw material is the major input used in food processing basically constituting raw agricultural produce of respective food units like meat, spices, edible oils, vegetables, chemicals, ice and packing materials etc.

Energy: Values/costs of different types of energy, mainly includes electricity, diesel and petrol used in food processing units.

Source: Annual Survey of Industries, Central Statistical Organisation, Government of India.

The Data Envelopment Analysis (DEA) Approach is used for measuring productivity and efficiency changes in Indian meat processing industry over a period of 1980-81 to 2002-03. The DEA methodology was initiated by Charnes *et al.* (1978) which is largely based on the frontier concept pioneered by Farrell (1957). Thus, the DEA is a methodology directed to frontiers rather than central tendencies (Seiford and Thrall, 1990). This method attempts to measure efficiency of Decision Making Units (DMUs)/firms through linear programming techniques, which 'envelop' observed input–output vectors as tightly as possible (Boussofiane *et al.*, 1991). The original model developed by Charnes, Cooper and Rhodes (CCR model) was applicable when technologies were characterised by constant returns to scale (CRS) and all firms operate at an optimal scale (Coelli *et al.*, 1998). But, imperfect competition may cause a *DMU* not to operate at optimal scale (Coelli, 1996). Therefore, input-oriented variable returns to scale (VRS) Data Envelopment Analysis Model extended by Banker *et al.* (1984) has been used for measuring technical and scale efficiency.

For estimating TFP change in Indian meat processing industry, Malmquist productivity index is used. This is defined as the ratio of two output distance functions (Caves *et al.*, 1982). In other words, the Malmquist TFP index measures the TFP change between two data points by calculating the ratio of the distances of each data point relative to a common technology. The input-output variables used include cost of capital, labour, raw material consumed, energy used and gross value of output. Malmquist TFP index and efficiency scores have been obtained by using DEAP software (version 2.1) developed by Coelli (1996).

III

INDIAN MEAT INDUSTRY: AN OVERVIEW

The structure of meat industry is highly unorganised and only a meagre quantity of meat is processed for value addition. Most of the meat produced in the country comes from traditional slaughterhouses. There are about ten thousand slaughterhouses in the country of which 60 per cent are unregistered. Most of these slaughterhouses have poor hygiene and sanitation facilities resulting in poor meat quality and environmental degradation (Ali, 2004). The organised sector of meat industry constitutes very few modern meat processing units in the country. The country has nine modern abattoirs and 171 meat processing units licensed under Meat Products Order. Annual Survey of Industries (ASI) data show that only 59 meat processing units are registered under Factories Act. A few modern pork processing plants are also coming up in the country. Poultry processing is still in its infancy. There are only seven modern integrated poultry processing plants. However, there are a good number of small poultry processing units engaged in the production of poultry meat products.

The performance of Indian meat industry has been measured by exponential growth rate in terms of production, value of output from meat, domestic consumption and export earnings during the last two decades (Table 1). Meat production in India has increased significantly over the last two decades at a rate of 3.44 per cent a year. The growth in contribution from different species, however, varied widely. Maximum growth occurred in poultry meat (11.23 per cent) followed by pork (2.46 per cent), buffalo meat (2.41 per cent), beef and veal (2.38 per cent), goat meat (1.71 per cent), mutton and lamb (1.69 per cent) and processed meat (1.14 per cent). The growth in meat production was higher during 1980-81 to 1990-91 as compared to 1990-91 to 2002-03. Growth in total meat production has improved slightly in recent years mainly because of acceleration in growth contributions from buffalo, sheep and poultry.

TABLE 1. PERFORMANCE OF MEAT SECTOR IN INDIA

(per cent)

Species	Annual Growth Rate				
	Production[1] (000' tonnes)	Animal slaughtered[1] (Nos.)	Value of output[2] (Rs.)	Consumption [1] (000' tonnes)	Export earnings[1] (US$)
Period of growth (1)	1980-2005 (2)	1980-2005 (3)	1980-2003 (4)	1980-2003 (5)	1980-2004 (6)
Beef and veal	2.38	1.64	2.96*	2.18*	17.39
Buffalo meat	2.41	2.41	--	--	10.18
Goat meat	1.71	1.71	3.79**	1.83**	6.54
Mutton and lamb	1.69	1.69	--	--	1.32
Pig meat	2.46	2.46	6.27	2.69	21.45
Poultry meat	11.23	11.16	5.87	11.20	11.12
Processed meat	1.14	--	3.06	--	-4.65
Meat, Total	3.44	--	4.79	3.83	7.91

Source: Ali, 2006; 1. *FAO Production and Trade Yearbook* (various issues). 2. *National Account Statistics* (various issues), Central Statistical Organisation, Ministry of Statistics and Programme Implementation, Government of India.

*Also includes buffalo meat.

**Also includes mutton and lamb.

In India, slaughter of cattle is banned in majority of the states (except in the states of Kerala, West Bengal and some Northeastern states). Cattle are considered to be sacred by majority of the Hindu population. Buffaloes are not subjected to any religious sensitivity and are slaughtered at a variety of weights and ages (World Bank, 1999). With increasing mechanisation of agricultural sector, the demand for draught animals is going down drastically resulting in surplus male cattle and buffaloes, which are slaughtered at birth or at low ages or when they become weak and unproductive. The slaughter of these young male calves is a waste of productive national wealth (Ranjhan, 2004; Ali, 2006).

The annual growth in meat output has been greater than the growth in livestock and agricultural sector as a whole during the last two decades. The major opportunity

for growth of livestock sector lies in the increasing demand for animal food products. Per capita consumption of meat and meat products in India is extremely low. However, demand for meat is expected to grow faster with sustained economic growth, rising per capita income, strengthening urbanisation trends and increasing awareness of the nutritive value of meat and meat products (Bhalla and Hazell, 1998; Kumar, 1998 and Delgado *et al.,* 1999). It is not only the income factor which affects its consumption level in the country, but also the social and religious factors which play a crucial role in consumption of meat and meat products. Meat is not considered to be a regular food item in the diet of the majority of the population. Consumption of meat in India is seasonal in nature and is influenced by various socio-religious practices and varies across regions. In some cases, religious practices prohibit meat consumption for specified periods and in others, celebrations and festivals lead to increase in meat demand (Landes *et al*., 2004). These seasonal swings in demand contribute to fluctuation in monthly market prices of meat.

Export of meat and meat products showed an impressive performance over the last two decades. It experienced significant annual growth of 7.91 per cent over the period of 1980-81 to 2003-04. The export of meat products witnessed significant annual growth during the post-liberalised period and increased at the rate of 10.7 per cent during 1990-91 to 2004-05. However, species-wise growth in export varies over the period. The scope for export of sheep, goat and poultry meat is constrained by high domestic demand and prices (Ravishankar and Birthal, 1999).

IV

PRODUCTIVITY AND EFFICIENCY ANALYSIS

The technological change in production system is the key to overall productivity growth (Hossain and Bhuyan, 2000). The productivity and efficiency in Indian meat processing industry is measured using a non-parametric Data Envelopment Analysis (DEA). Malmquist TFP index is used for measuring productivity change in Indian meat processing industry. The TFP index interprets the change in output that is not accounted for by change in input, but is due to change in efficiency or technology or returns to scale or a combination of these three factors. Thus, changes in TFP can be decomposed into three components: (i) technological changes, (ii) changes in technical efficiency, and (iii) changes in scale efficiency. Input oriented variable returns to scale (VRS) model has been used for measuring technical and scale efficiencies in meat processing industry.

Characteristics of Meat Processing Industry

Table 2 shows the important characteristics of meat processing industry in India in terms number of units, number of persons employed per unit, gross value added, fixed capital, wages and salaries, cost of capital, raw material and energy use. These

indicators show that the meat industry is not operating at large scale on an average. The per unit fixed investment has significanlty increased after liberalisation period, whereas in case of per unit labour employment, it has come down. The growth in employment rate was negative during 1980s, which has become postive during 1990-91 to 2002-03. Though meat processing operations at different stages are largely handled by labour, per unit employment is not very large. This implies that over the time, meat industry is becoming capital intensive. The number of meat processing units significantly increased after liberalisation due to supportive government policy.

TABLE 2. IMPORTANT CHARACTERISTICS OF MEAT PROCESSING INDUSTRY

			Per unit value in Rs. lakhs at 1993-94 prices					
Period	Number of factories	Employment (No./ unit)	Gross value added	Fixed capital	Wages and salaries	Cost of capital	Raw material	Energy use
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1980-81	25	140	62	122	36	26	294	20
1990-91	32	109	123	186	40	45	405	28
2002-03	56	125	158	715	66	92	866	65
Annual Growth Rate (per cent)								
1980-81 to 1990-91	1.42	-2.66	3.51	-1.98	3.23	0.23	-0.31	1.83
1990-91 to 2002-03	4.94	1.90	4.89	16.08	6.62	8.18	8.82	8.98
1980-81 to 2002-03	3.42	0.08	9.14	11.96	4.13	8.56	8.02	6.99

Source: *Annual Survey of Industries*, Central Statistical Organisation, Government of India.

The cost of meat processing is influenced by the level of product processing and packaging. The production cost of meat processing industry is broadly categorised into four inputs, namely, labour, capital, raw material and energy use (Table 3). The share of various inputs show that raw material accounts for the major share of about 80 per cent (Figure 1) followed by capital (8.4 per cent), wages and salaries (6.1 per cent) and energy use (6.0 per cent). Within the raw material, raw meat constitutes the major share of cost.

TABLE 3. COST COMPOSITION OF MEAT PROCESSING INDUSTRY AT 1993-94 PRICES

(per cent)

Year	Wages and salaries	Cost of capital	Raw material	Energy use
(1)	(2)	(3)	(4)	(5)
1980-81	9.5	7.0	78.2	5.2
1990-91	8.0	8.5	77.9	5.6
2002-03	6.1	8.4	79.4	6.0

Source: Calculated from ASI data (various issues).

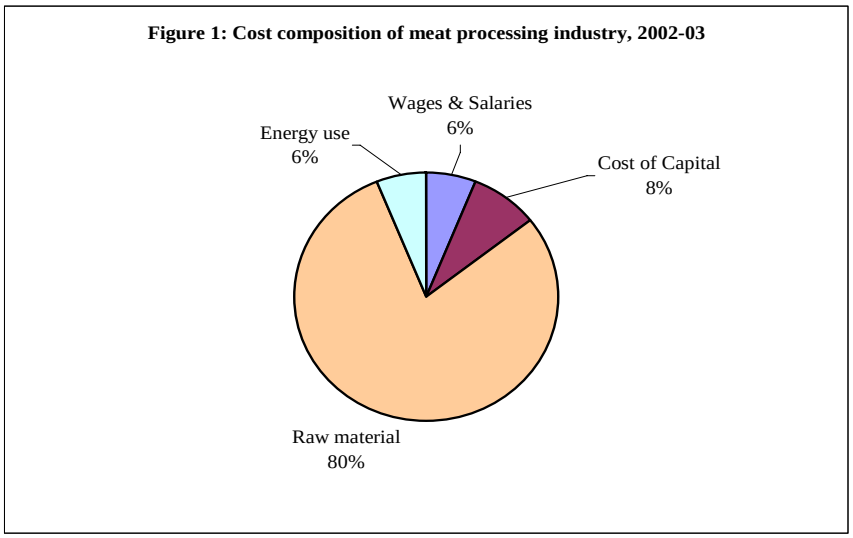

Figure 1: Cost Composition of Meat Processing Industry, 2002-03

Productivity and Efficiency Change

Malmquist TFP index measures productivity change over period *t* to period *t+1*. This output-based index explains the change in productivity level in the given level of inputs. Total factor productivity change in a firm occurs either due to technological progress, i.e., due to shift in the production function or due to efficiency improvements. A productivity value index larger than one indicates a productivity improvement and a value less than one indicates productivity decline. Total Factor Productivity (TFP) change over the years is given in Table 4. Meat processing in India shows mixed trends in TFP change (Figure 2). On an average, TFP grew at a rate of 1.03 per cent during 1980-81 to 2002-03. During the 1990s and onward, the change in TFP has slightly improved mainly because of technological improvement. The change pattern in TFP index from unity shows that in most of the years, there was positive change in TFP. But its magnitude seems to be very small.

The performance of meat processing industry is also measured in terms of technical and scale efficiency (Table 4). CCR model estimates efficiency relative to CRS technology. Since CRS technology is scale neutral, it is implicitly assumed that all Decision Making Untis (DMUs) are operating at optimum scale of operation. On the other hand, BCC model measures efficiency under VRS technology and allows the possibility that inefficiency may be due to DMUs deviating from the respective scale of operation as well as due to pure technical inefficiency. The values of efficiency indices equal to unity imply that the industry is on best-practice frontier while values below unity imply that the industry is below the frontier or technically inefficient.

TABLE 4. EFFICIENCY SCORE FOR INDIAN MEAT PROCESSING INDUSTRY

Year	CCR Model (TE)	BCC Model (Pure TE)	SE	TFPCH	Change Symbol
(1)	(2)	(3)	(4)	(5)	(6)
1980-81	0.55	1.00	0.55		
1981-82	0.48	0.98	0.49	1.12	+
1982-83	0.24	0.87	0.28	0.78	-
1983-84	0.37	0.76	0.49	0.95	-
1984-85	0.28	0.82	0.34	0.82	-
1985-86	0.34	1.00	0.34	1.07	+
1986-87	0.37	0.99	0.37	1.41	+
1987-88	0.46	1.00	0.46	1.00	+
1988-89	0.51	1.00	0.51	1.05	+
1989-90	0.56	0.98	0.57	1.05	+
1990-91	0.42	0.94	0.44	0.85	-
1991-92	0.52	1.00	0.52	1.46	+
1992-93	0.72	0.98	0.73	0.91	-
1993-94	0.41	1.00	0.41	1.05	+
1994-95	1.00	1.00	1.00	1.41	+
1995-96	0.97	1.00	0.97	0.96	-
1996-97	1.00	1.00	1.00	1.03	+
1997-98	0.93	0.97	0.96	1.09	+
1998-99	0.86	0.93	0.93	0.85	-
1999-2000	0.83	1.00	0.83	0.89	-
2000-01	0.51	1.00	0.51	1.16	+
2001-02	0.48	0.77	0.62	1.03	+
2002-03	0.35	0.74	0.47	0.97	-
Mean Score					
1980-81 to 1990-91	0.42	0.94	0.44	1.01	+
1990-91 to 2002-03	0.67	0.95	0.70	1.05	+
1980-81 to 2002-03	0.57	0.95	0.60	1.03	+

Source: Calculated from ASI data (various issues).
Note: TE=Technical Efficiency, SE= Scale Efficiency and TFPCH=Total Factor Productivity Change.

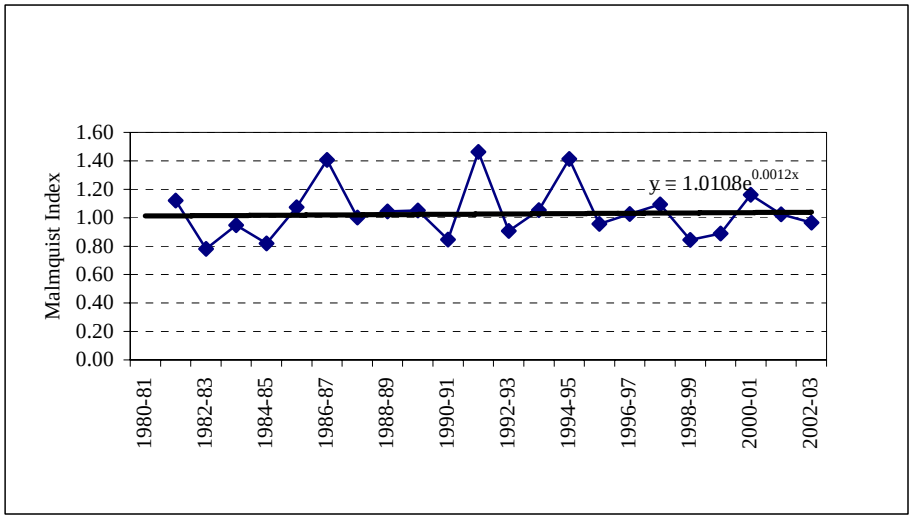

Figure 2. TFP Change in Indian Meat Processing Industry, 1980-81 to 2002-03.

The average technical efficiency score is estimated to be 0.57 under CRS model and 0.95 under VRS model. The average scale efficiency for the entire period is 0.60. During 1980-81 and 1990-91, the average efficiency under the CRS and VRS technologies was 0.42 and 0.94 respectively. During 1990-91 to 2002-03, efficiency under CRS model improved to 0.67, whereas in case of VRS model the efficiency slightly declined to 0.95. The scale efficiency also improved from 0.44 to 0.70 during this period. Scale efficiency scores suggest sizeable deviation from optimal scale of operation but it has approached unity over time. The performance scores based on CRS model are equal to one for the years 1994-95 and 1996-97. For all the other years, the recorded efficiency scores were less than one indicating inefficient use of resources under constant returns to scale. However, the efficiency score based on VRS model indicate that the performance scores were equal to one during more number of years than the CRS model. Similarly, meat processing industry was scale inefficient during most of the years except 1994-95 and 1996-97. Figure 3 clearly shows that upto 1995-96, TE and SE were increasing over time and experienced declining trends afterwards. This is mainly because of increased investment in meat processing sector to capture the export potential with emergence of WTO and liberal foreign trade policy of the government.

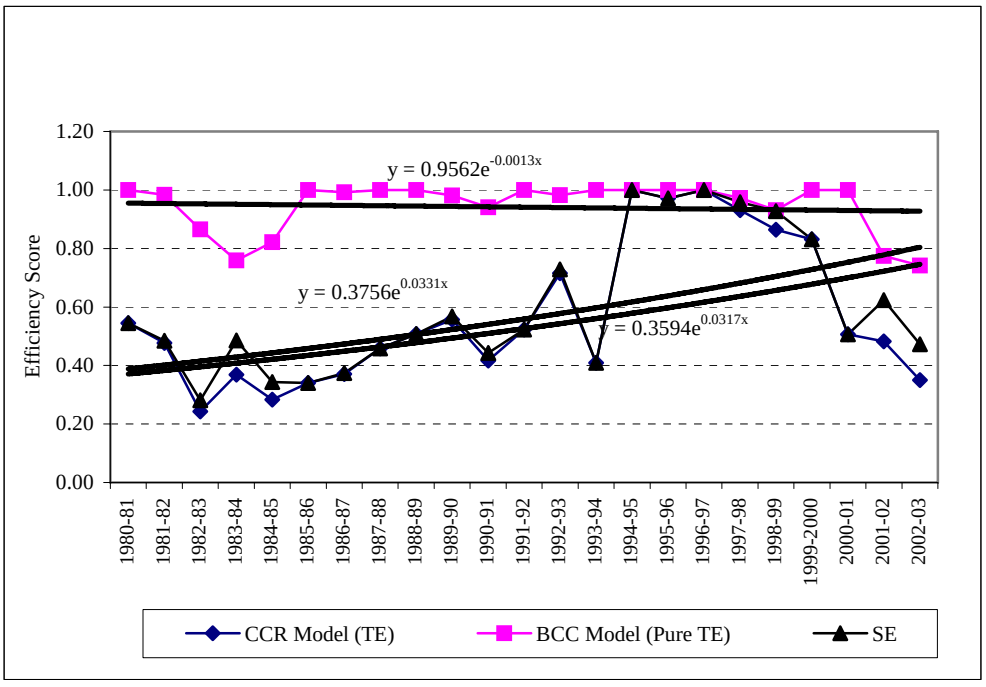

Figure 3. Trends in Efficiency Score of Meat Processing Industry, 1980-81 to 2002-03.

Table 5 provides results on target inputs and the estimated slack inputs in Indian meat processing industry. Target inputs refer to what a particular *DMU* ought to have consumed if it was on the efficient frontier. The slack inputs are excess inputs. The slack is calculated as the difference between actual inputs consumed minus the target input a *DMU* ought to have consumed. An efficient *DMU* will have zero input-output slacks. In absolute terms, major slack input per unit was recorded in case of raw material use (Rs. 43.4 lakhs) followed by energy (Rs. 3.1 lakhs) and capital (Rs. 2.6 lakhs) during 1980-81 to 2002-03. The analysis of per unit individual inputs excessively being used in meat processing industry show that about 9.1 per cent of total material cost is being used inefficiently on an average causing inefficiency in the production process followed by energy use (9 per cent) and cost of capital (5.2 per cent).

TABLE 5. TARGET INPUTS AND ESTIMATED SLACK INPUTS IN MEAT PROCESSING INDUSTRY (AT 1993-94 PRICES)

Period	Labour and employees (Nos.)	Cost of capital (Rs. in lakhs)	Raw material (Rs. in lakhs)	Energy use (Rs. in lakhs)
(1)	(2)	(3)	(4)	(5)
Average target input				
1980-81 to 1990-91	118.2	22.0	226.4	20.5
1990-91 to 2002-03	121.3	71.7	675.5	46.0
1980-81 to 2002-03	120.5	49.9	478.2	34.8
Average input slacks				
1980-81 to 1990-91	0.0	1.5	22.6	0.7
1990-91 to 2002-03	0.0	3.4	57.6	4.9
1980-81 to 2002-03	0.0	2.6	43.4	3.1
Input slacks (per cent)				
1980-81 to 1990-91	0.0	7.0	10.0	3.5
1990-91 to 2002-03	0.0	4.8	8.5	10.7
1980-81 to 2002-03	0.0	5.2	9.1	9.0

Source: Calculated from ASI data (various issues).

V

CONCLUSIONS AND POLICY IMPLICATIONS

Meat industry in India experienced significant growth during the last two decades. The processing of meat for value addition is meager and most of the production takes place in unorganised slaughterhouses. The empirical analysis of productivity and efficiency in meat processing units indicates that there are ample possibilities of enhancing the performance of these units. Total Factor Productivity (TFP) change is negligible and the increase in output of meat processing industry is basically due to increase in input use and capital investment.

The average technical efficiency score is estimated to be 0.57 under CRS model and 0.95 under VRS model. This indicates that the average technical inefficiency could be reduced by 43 per cent under constant returns to scale and 5 per cent under

variable returns to scale. The average scale efficiency for the entire period is 0.60 which shows that the potential of increasing scale efficiency in meat processing units to the extent of 40 per cent.

The reasons for inefficiency and low TFP change have been empirically analysed in terms of input slacks at optimal level of production process. The analysis of input slacks in meat processing industry suggests that the industry is labour intensive and the effects of expansion of meat industry on labour employment and productivity appear to be favourable. The analysis shows that meat processing industry has been scale inefficient mainly due to slack in raw material, capital and energy use. This implies that these inputs were excessively used in meat processing untis.

In order to improve the industry's productivity and efficiency, these results are useful for policy makers and meat processors to work out the optimal level of input mix, to rationalise the process of acquiring and usage of these inputs and to design a proper policy framework to address the identified problems in the meat processing sector. The results indicate that the industry needs to modernise its production system to improve the capacity utilisation of factor inputs mainly of raw material, capital and energy. As the raw material constitutes about 80 per cent of the production cost which primarily constitutes live animals, proper methods of sourcing quality animals for meat production should be adopted to shorten the supply chain of meat processing industry.

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