REVIEW OF MARKETING AND AGRICULTURAL ECONOMICS
VOL. 52, NO. 1 (*April*, 1984)

Productivity in the Meat Processing Industry in Queensland

R. H. Burke and J. C. Naughtin*

Estimates of total factor productivity in the meat processing industry in Queensland over the period 1968–69 to 1980–81 are provided. There was no overall improvement in productivity over this period, notwithstanding a decade of new investment during which the real value of the capital stock almost doubled.

Introduction

The productivity of the meat processing industry has been a major issue of concern to livestock producers and their organizations, and it has been the subject of some comment in recent discussions of issues such as industrial relations in the industry, award conditions for meat workers, the introduction of new technology, the distribution of the benefits from increased productivity, and structural change. Notwithstanding the importance of productivity in the meat industry to livestock producers, there has been relatively little research devoted to the measurement of productivity.

The concept of productivity is straightforward, but the measurement of productivity presents considerable difficulties. Recent discussions of productivity in the meat processing industry have been based on simple measures of productivity, particularly labour productivity or the average product of labour. Todd, Reeves and Robinson (1981) used as measures of productivity meat produced per employee or per establishment, employees per establishment, and the value of turnover per dollar spent on wages and salaries. The Cattle and Sheepmeat Councils of Australia (1982) used equivalent cattle units per employee and value added per employee. Apart from the potential for different measures to yield different results noted by the Cattle and Sheepmeat Councils (1982), there is a more fundamental problem associated with the use of simple measures of productivity.

---

* Department of Industry, Commerce and Technology, Victoria.

The authors have benefited from comment by the anonymous *Review* referees.

Labour productivity (or partial productivity measures) has the disadvantage as a measure of productivity that in general the calculated productivity is too high, because no allowance is made for continuing change in the utilization of capital and in technology. Solow (1957) has shown that the growth in labour productivity over-estimates the growth in actual productivity by an amount equal to the growth in the capital/labour ratio. While this disadvantage must be weighed against the two main advantages of labour productivity as a measure of productivity growth—the data required are simple and easy to obtain, and industries are ranked in essentially the same order for comparative studies (Stigler 1961)—labour productivity is a crude and potentially misleading measure of productivity.

An alternative measure of productivity is that of total factor productivity which is calculated in relation to the factors of labour and capital, and may be contrasted with partial productivity calculated in relation to a single factor (usually labour). All factors of production, both the tangible factors of labour and capital and the intangible factors such as technology, are incorporated into the final expression of productivity. Total factor productivity is frequently calculated through the use of a production function, often a Cobb-Douglas production function, as can be seen from the review of Kendrick and Vaccara (1980).

This approach was used by Kaspura and Ho-Trieu (1980) for a number of Australian manufacturing industries at the 3 digit classification level, including meat products, Australian Standard Industrial Classification (ASIC) 211. The objective of this paper is to measure the growth in productivity in the meat processing industry using the total factor productivity concept and a less aggregated definition of the meat processing industry. The economic performance of the meat processing industry in its use of labour and capital resources is then considered.

Theoretical Background

Productivity in an economic context defines the relationship between the output produced by an industry and the input of resources used by that industry, i.e., the factors of production. Productivity can be measured by accounting for the savings of real inputs used in a productive process relative to a given real output. Productivity is a measure of the efficiency with which factors of production are utilized in producing goods and services.

Empirical studies of productivity have often been based on a production function approach. The justification for any production function is that changes in output are the result of all inputs used plus other factors, and in taking into account labour and capital inputs some advance is made on the use of a simple ratio of output to one factor. Although a number of inputs can often be identified, labour and capital are generally regarded as the most important and basic inputs.

The Cobb-Douglas specification of the production function is one of the most commonly used in empirical estimation of production relationships. This specification of the production function assumes both constant returns to scale and that the elasticity of substitution of factor inputs is constant and equal to unity. Less restrictive specifications of the production function have been developed, notably the constant elasticity of substitution (CES) production function, which, although it assumes a constant elasticity of substitution between the two factors of production, is not restricted to assuming a unitary elasticity. The Cobb-Douglas function is a special case of the more general CES production function. However, since the empirical evidence to indicate whether the general form is superior to the special case has been inconclusive (Cramer 1969), the Cobb-Douglas specification is used in this paper.

Under the Cobb-Douglas formulation the level of productive efficiency (A_t) in year t is:

$$A_t = \frac{Y_t}{K_t^{\alpha} \; L_t^{1-\alpha}} \tag{1}$$

where

Y = output

K = capital input

L = labour input

α = the elasticity of output with respect to capital

$1 - \alpha$ = the elasticity of output with respect to labour

A = total productivity of the factors of production

The rate of change in A_t is the rate of technical change in the particular industry, activity, or economy in question. Two alternative formulations are considered next.

(i) The Kendrick Formulation

Kendrick (1973) has proposed an alternative specification, which defines the level of productive efficiency as:

$$A_t = \frac{Y_t}{\alpha^* \; K_t + (1 - \alpha^*) \; L_t} \tag{2}$$

where

α^* = estimated share of factor income accruing to capital

$(1 - \alpha^*)$ = estimated share of factor income accruing to labour

Hence the denominator, which measures total tangible factor input, is a weighted arithmetic average of labour and capital inputs. The weights (α^* and $(1 - \alpha^*)$) are derived from the estimated shares of factor income, and not estimated from a statistical production function. The weights are held constant within a time period (approximately a decade), but are allowed to vary between time periods.

Kendrick argues that this formulation has three major advantages over the Cobb-Douglas formulation:

(i) it avoids the assumption of unitary elasticity of substitution between the factors of production, so that Kendrick's formulation allows for changing factor shares of income over successive time periods;

(ii) the weights for the two inputs are the estimated factor shares derived from the national accounting estimates. These estimates are much more stable over successive time periods than are the weights estimated from statistical production functions;

(iii) the use of a weighted arithmetic mean rather than a geometric mean of factor inputs to derive an index of total factor inputs produces little difference in results, so that the advantages of this formulation are achieved at little cost.

The Kendrick formulation concentrates on the efficiency of production per unit of total factor inputs, rather than on the efficiency of labour or capital inputs separately, and thus provides a means of measurement of total factor productivity.

(ii) The Deakin-Seward Formulation

Deakin and Seward (1969) have proposed another formulation which is closely related to the Kendrick formulation. Deakin and Seward argue for a very detailed measurement of the increases in labour and capital inputs into the production process. They look at total factor productivity and at trends in individual factor productivity, and at the causes contributing to increases in what they term "applied technical and organizational knowledge and external factors". These last factors are the residual causes producing increased efficiency after allowance has been made for increases in the inputs of labour and capital, and this residual factor (*ATOKE*) represents a refinement of the term A_t in the Cobb-Douglas equation.

The Deakin-Seward formulation is based on the Cobb-Douglas formulation of the production function. By taking a logarithmic transform of the Cobb-Douglas equation and then differentiating this function with respect to time, the simple production function can be expressed in exponential rates of growth per annum:

$$Y = A \; K^{\alpha} L^{1-\alpha} \tag{3}$$

$$\ln A = \ln (Y/L) - \alpha \ln (K/L) \tag{4}$$

$$\frac{d \ln A}{dt} = \frac{d \ln (Y/L)}{dt} - \alpha \frac{d \ln (K/L)}{dt} \tag{5}$$

$$\triangle A = \triangle(Y/L) - \alpha \triangle(K/L) \tag{6}$$

In Deakin-Seward notation:

$$\triangle ATOKE_t = \triangle(Y/L)_t - \hat{\alpha}_t \quad \triangle(K/L)_t \qquad (7)$$

where

$\triangle$ = exponential rate of growth per annum

$\hat{\alpha}_t$ = the share of capital in total factor income, estimated annually

$ATOKE$ = applied technical and organizational factors

The Kendrick approach does not involve the very detailed measurement of the factors as in the Deakin-Seward approach. Rather the effects of changes such as variation in man hours worked per person is allowed to show up in the calculated productivity ratios. However, the simplification of measurement is achieved at some cost since the Deakin-Seward measure of total factor inputs is a more clearly defined measure than that used by Kendrick, so that the residual factor (*ATOKE*) can be more confidently regarded as a measure of the increase in technical knowledge and organizational factors than in Kendrick's formulation. The approach of Deakin and Seward involves more detailed measurement of factors which contribute to changes to productive efficiency. Further, the method is less demanding on the accuracy of the absolute values of the factors, since the method is dependent on the measurement of changes rather than absolute amounts. It is for these reasons that the method has been adopted for the measurement of productivity in this paper.

Measurement of the Variables

Data

The meat processing industry is defined as that covered by the Australian Standard Industrial Classification 1978 edition as classes 2115 and 2117 comprising the establishments mainly engaged in slaughtering animals (except poultry), boning, freezing, preserving or packing meat (except poultry), canning meat, manufacturing sausage casings and gut materials, fertilizers or meal from abattoir by-products, bacon and ham, smallgoods and other meat products not otherwise included.

An examination of data collected by the Australian Bureau of Statistics (ABS) on the abattoir and meat processing industry for each State indicated that most States did not record the required information on capital stock for the period prior to the first integrated economic census of 1968–69. Queensland appeared to be the only State which collected and kept records of the information. Although estimates of productivity are made only for the years after 1968–69, it is necessary to obtain information for earlier years to value the capital stock. Consequently, productivity measurements have been made for Queensland only, although the results should be broadly representative of other States.

Output

A physical measure of output is preferable to a financial measure for the purpose of measuring productivity, because the difficulties associated with deflation procedures do not arise with a physical measure. The composition of the output of an industry frequently varies over time and the use of price indices, which are derived from a fixed basket of good and services, to calculate real output from the value of transactions does not allow for variation in the composition of output.

The nature of the output may also change over time, as may the regulatory environment in which the output is produced. These changes may be reflected in a financial measure of output, but they are not directly relevant to the measurement of productivity. Rather they must be taken into account in the interpretation of the growth in productivity of the industry, that is the growth in real output in relation to inputs.

The measure of output adopted is the total carcase weight of meat produced as recorded by ABS (1982*a*) for ASIC classes 2115 and 2117. The output of the abattoir and meat processing industry in tonnes carcase weight is shown in Table 1.

Table 1: The Output, Labour Usage, and Capital Stock of the Queensland Meat Processing Industry

Year ended 30th June	Output (tonnes carcase weight)	Labour (persons)	Machinery and equipment†	Land and buildings†	Total capital stock†	Capital share in factor income
			$'000	$'000	$'000	per cent
1969 . .	434 993	9 829	12,513	17,983	30,496	49.1
1970 . .	404 149 (-7.1)*	10 176 (3.5)	10,611	16,831	27,442 (-10.0)	43.4
1971 . .	389 789 (-3.6)	10 176 (0.0)	9,706	16,381	26,087 (-4.9)	43.5
1972 . .	444 861 (14.1)	11 543 (13.4)	11,130	16,919	28,049 (7.5)	43.5
1973 . .	474 418 (6.6)	11 928 (3.3)	12,648	17,679	30,327 (8.1)	50.8
1974 . .	415 676 (12.4)	11 392 (-4.5)	14,391	18,520	32,911 (8.5)	36.7
1975 . .	487 246 (17.2)	10 346 (-9.2)	15,987	18,528	34,517 (4.9)	44.6
1976 . .	556 961 (14.3)	11 833 (14.3)	18,705	18,781	37,486 (8.6)	48.2
1977 . .	597 487 (7.3)	12 585 (6.4)	18,933	18,958	37,891 (1.0)	43.9
1978 . .	662 907 (10.9)	12 981 (3.1)	21,130	19,661	40,791 (7.7)	45.2
1979 . .	731 709 (10.4)	12 995 (0.1)	25,249	21,027	46,276 (13.4)	39.4
1980 . .	589 851 (-19.4)	13 377 (2.9)	25,778	22,262	48,040 (3.8)	41.4
1981 . .	507 757 (-13.9)	10 184 (-23.9)	27,843	23,039	50,882 (5.9)	39.4

† All in 1968–69 dollar values.

* Percentage change on previous year in brackets.

Labour

The labour usage within the meat processing sector has been measured using information on the average number of persons employed over a year collected by the ABS (1982*b*). The average number of persons employed for all establishments, whether they employ four or more persons or less than four persons, is shown in Table 1. The ABS did not undertake a manufacturing census in 1970–71, and an estimate has been made of the employment for that year by assuming that the employment was similar to 1969–70. This assumption was based on the fact that there was similar output for the two years.[1]

Capital Stock

The capital stock of the meat industry is taken to be the total amount of physical capital in the form of land, buildings, machinery and equipment, measured at particular points in time.

The capital stock has been measured using published and unpublished data from the annual factory census in Queensland (ABS 1982*b*). This census has been undertaken since 1903 and although some unpublished information on additions and replacements is now not available, information on the value of assets is available annually up to 1967–68, and the annual value of additions and replacements is available for subsequent years.

The capital stock in the current year has been measured as the value of assets in the immediately preceding year, less the depreciation on assets which have not yet been depreciated to zero, plus the value of additions and replacements in the current year. Since records of both the value of assets and the value of additions and replacements were not available for the same year, it was necessary to assume depreciation rates in order to calculate the value of additions and replacements in the years up to 1967–68 and the value of assets in subsequent years.

The calculations were undertaken using the assumptions of a straight line depreciation of annual capital expenditure deflated to 1968–69 prices with lives of fifty years for buildings and structures and twenty years for machinery and equipment. The depreciation factor was assumed to be 1.4 per cent for buildings and 7 per cent for machinery and equipment, following Haig (1980). Given these assumptions, and a requirement to measure productivity from 1968–69 onwards, it was necessary to obtain data from 1919–20 onwards to estimate the capital stock of buildings and 1949–50 onwards for machinery and equipment. Prior to 1924–25 information was collected on a calendar year basis. This information was converted to a financial year basis by averaging successive years.

[1] This assumption involved a degree of approximation since, as discussed subsequently, the adjustment in the size of the labour force appears to be more related to expectations developed from the trend of output in recent years than to output in the current year. There was a moderate downward trend in output in the preceding two years.

Other adjustments were necessary in calculating the capital stock of land and buildings because of discontinuities in the statistical series. Establishments employing less than four persons were not included in the annual manufacturing censuses from 1975–76 onwards for the relevant categories, but the output of these establishments was recorded separately in the transition year 1974–75 as 1.36 per cent of total output. In calculating the capital stock for the years 1975–76 onwards, an amount of 1.36 per cent has been added to the outlays in land and buildings to adjust for the non-inclusion of small establishments in these years.[2]

Retail butchers with slaughtering facilities were included in the integrated census of 1968–69 for the first time, so that the number of establishments increased from around 45 in the years immediately prior to 1968–69 to around 135 in the years immediately after that year. Consequently, the capital stock in the years prior to 1968–69 has been underestimated due to the non-inclusion of these establishments. The magnitude of this effect is not known, but it is believed to be relatively small.[3]

The indices used to deflate the current value of annual expenditures were those calculated by Haig (1980) for the years up to and including 1976–77. The indices for subsequent years were calculated using the implicit price deflator for construction, since this was the basis for the calculations of Haig.

The sources of information and procedures used in calculating the capital stock of machinery and equipment follow broadly that used for land and buildings. The calculated capital stock for land and buildings, and machinery and equipment for the period 1968–69 to 1980–81 is shown in Table 1.

Share of Capital in Factor Income

The share of capital in factor income has been estimated from the annual factory census of ABS (1982*b*) by calculating the value added less wages and salaries as a percentage of value added, and the results are shown in Table 1.

The Results

The calculations of total factor productivity in the meat processing industry in Queensland, together with the output/labour and capital/labour ratios are shown in Table 2.

---

[2] This adjustment may involve some degree of overestimation of the contribution of small establishments to the capital stock in more recent years if, as seems likely, small establisments were more affected by more stringent State Government registration requirements than larger establishments.

[3] The employment in the abattoir and meat processing industry recorded in the 1967–68 factory census was 8 611, whereas the employment recorded in 1968–69 manufacturing census was 9 827—a 14 per cent increase. However, most of this increase in employment appears to be due to an increase in meat production in 1968–69 of 10 per cent for beef and veal, 10 per cent for sheep meat, and 7 per cent for pig meat. Furthermore, these establishments may be less capital intensive per unit of output or employment than larger firms.

Table 2: The Productivity of the Meat Processing Industry in Queensland, 1968–69 *to* 1980–81, 1968–69 = 100

Year ended 30th June	Output/Labour ratio (Y/L)	Capital/Labour ratio (K/L)	Total factor productivity, Deakin-Seward Method
1969	100.0	100.0	100.0
1970	89.7	86.9	93.0
1971	86.4	77.4	91.7
1972	87.1	78.3	92.0
1973	89.9	81.9	92.8
1974	82.4	93.1	81.2
1975	106.4	107.5	98.3
1976	106.4	102.1	100.8
1977	107.3	97.0	103.9
1978	115.4	101.3	109.6
1979	127.2	114.8	115.1
1980	99.6	115.7	89.8
1981	112.7	161.0	89.2

The output/labour ratio (labour productivity) fell below the 1968–69 level in the years up to 1973–74, in line with the low levels of meat production in those years. The output/labour ratio was above the 1968–69 levels in the years of higher and rising output up to 1978–79 to peak at 27 per cent above the 1968–69 level. The output/labour ratio then fell back to the 1968–69 level in 1979–80 with the substantial decline in meat output of that year, but the ratio improved by 13 per cent in 1980–81 despite a further substantial fall in output, because of a major contraction in the labour force.

A feature of the relationship between output and labour is the lag in the adjustment of the size of the labour force to significant changes in the level of output. The percentage change in the labour force shown in Table 1 is generally less than the percentage change in output. Furthermore, in the years 1969–70, 1974–75, and 1979–80 the changes in output and the labour force were in the opposite direction. The adjustment in the size of the labour force appears to be more related to expectations developed from the trend of output in recent years rather than output in the current year.

The capital/labour ratio showed a declining trend in the early 1970's which arose from a declining real value of the capital stock and an increase in the labour force. However, from 1971–72 onwards there has been substantial and continuous net investment in the industry so that by 1980–81 the real value of the capital stock has almost doubled. The capital/labour ratio increased from its 1970–71 low to be 16 per cent above the 1968–69 level by 1979–80. The capital/labour ratio increased sharply in 1980–81 in response to a further increase in the capital stock and to the substantial decline in the labour force in this year.

The productivity of the meat processing industry as measured by the Deakin-Seward method shows a broadly similar trend to the movements in labour productivity. Total productivity fell from the 1968–69 level in the years to 1973–74, then increased progressively in the years to 1978–79, and then declined sharply in 1979–80 and remained at that level in 1980–81. The total factor productivity in 1980–81 was 11 per cent below that of 1968–69. The variability of the measured productivity from year to year is not surprising in view of the fluctuation in output in this industry, and the measured values for individual years need to be considered in this context. However, the absence of any discernible increase in total productivity over a thirteen year period since 1968–69 indicates a relatively poor performance in the utilization of resources in the industry. Notwithstanding a decade of new investment during which the real value of the capital stock almost doubled, there has been no discernible improvement in the total productivity of the Queensland meat processing industry. There is little reason to expect that the meat processing industry in other States would have performed any better than Queensland in this respect.

Discussion

The measurements of the productivity of the meat processing industry presented in this paper using total factor productivity techniques indicate a relatively poor performance in relation to other sectors of manufacturing industry. The meat processing industry is by no means unique in its productivity performance over this time period, as the results of Kaspura and Ho-Trieu (1980) and Burke (1982) indicate, but its performance is poor in relation to manufacturing industry as a whole. As expected the results indicate a somewhat poorer level of performance than that reported by Todd, Reeves and Robinson (1981) and the Cattle and Sheepmeat Councils of Australia (1982), using simple productivity measures such as labour productivity. The results are of significance in view of the concern within the livestock industries over the economic performance of the meat processing industry and its impact on livestock producer returns and international competitiveness.

The substantial investment in the Queensland meat processing industry over the last decade can be related to requirements to upgrade quality standards, the updating of equipment, increasing works and freezer capacity and to environmental regulations. However, the instability of output makes the return on new investment in the industry uncertain, and the apparent increases in productivity in the period 1975–76 to 1978–79 were negated as output fell in the succeeding years. The instability of output has probably been the most important factor in the failure of the substantial investment in the capital stock to produce an improvement in productivity.

Other factors affecting productivity which have been widely discussed elsewhere include industrial relations problems and the tally system as a basis for award determination. The meat processing industry is currently undergoing a period of major structural adjustment as slaughter capacity is rationalized in line with the likely requirements over the next 5–10 years. It seems unlikely that there will be much improvement in productivity in the industry until this process has been substantially completed.

References

AUSTRALIAN BUREAU OF STATISTICS (1982*a*), Cat. No. 7206.0, *Meat Australia,* 1980–81 (and previous editions.

AUSTRALIAN BUREAU OF STATISTICS (1982*b*), *Census of Manufacturing Establishments, Details of Operations by Industry,* Cat. No. 8203.3, Yearly Editions, 1968–69 to 1980–81.

AUSTRALIAN BUREAU OF STATISTICS (1978), *Australian Standard Industrial Classification, Vol.* 1, AGPS, Canberra.

COMMONWEALTH BUREAU OF STATISTICS (1969), *Statistics of the State of Queensland,* Yearly Editions, 1918 to 1967–68. (Earlier editions published by the Registrar General for Queensland.)

BURKE, R. H. (1982), *Manufacturing Productivity 1950–1977,* Research Paper R1/82, Ministry for Economic Development, Victoria.

CATTLE AND SHEEPMEATS COUNCILS OF AUSTRALIA (1982), *Cost Disadvantages in the Abattoir and Meat Processing Industry arising from Industrial Practices and Awards,* Canberra.

CRAMER, J. (1969), *Empirical Econometrics,* North Holland, Amsterdam.

DEAKIN, B. M. and SEWARD, T. (1969), *Productivity in Transport,* Cambridge.

HAIG, B. D. (1980), *Capital Stock in Australian Manufacturing 1920–1977,* Australian National University, Canberra.

KASPURA, A. and HO-TRIEU, L. (1980), *Productivity and Technological Change in Australian 3-Digit Manufacturing Industries, 1968-69 to 1977–78,* Working Paper No. 10, Department of Productivity, Canberra.

KENDRICK, J. W. (1973), *Postwar Productivity Trends in the United States 1948–69,* National Bureau of Economic Research, New York.

KENDRICK, J. W. and VACCARA, B. N. (1980), *New Developments in Productivity Measurement and Analysis,* National Bureau of Economic Research, University of Chicago Press.

SOLOW, R. M. (1957), "Technical change and the aggregate production function," *Review of Economics and Statistics* 3, 312–320.

STIGLER, G. J. (1961), *Economic Problems in Measuring Changes in Productivity, Studies in Income and Wealth,* V. 25, 47–63, Princeton University Press.

TODD, M., REEVES, G. and ROBINSON, C. (1981), "Structural changes in the livestock slaughtering industry", *Quarterly Review of the Rural Economy* 3 (4), 320–329.