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## Productivity and returns to resources in the beef enterprise on Victorian farms in the South-West Farm Monitor Project

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**Abstract.** Productivity change and real returns to resources are measured for a sample of farms in south-west Victoria that produce beef. A stochastic frontier production model is estimated from which annual production frontiers and individual farm technical inefficiencies are calculated during the survey period from 1995-96 to 2004-05. Results suggest that best-practice beef producers in this region (those operating on the production frontier) modestly improved their productivity during the period. Technically inefficient farms seem to be achieving productivity increases lower than their top-performing counterparts and are on average falling behind the productivity levels of the latter. A single factorial terms of trade index is also estimated for each farm as a measure of the real returns to resources used in the beef enterprise. The mean annual index increased substantially after declining during the first year of the survey period. This measure showed much greater volatility than the productivity measure, principally because of fluctuations in beef prices.

**Keywords:** Beef production, productivity, best practice, Australia.

### Introduction

Beef cattle production is the most common enterprise on Australian farms and can be found in all parts of Australia. The industry exists in many and varied forms across the country, from extensive holdings in the north to predominantly smaller, more intensive operations in the south. Production conditions vary according to region, scale of production, breeding strategy and enterprise diversity.

We confine our case study to farms in a benchmarking group in south-west Victoria that have a beef enterprise, and study changes in productivity and real returns to resources on these farms during the decade, 1995-96 to 2004-05. These farms also commonly operate sheep and cropping enterprises as part of a mixed farming system and have relatively small-scale beef operations.

The performance of Australian beef properties during the decade under review appears on the surface to have been strong. Mullen and Crean (2007) cited an estimate by the Australian Bureau of Agricultural and Resource Economics (ABARE) of total factor productivity (TFP) growth rate of 2.5 percent per annum between 1989 and 2004. This estimate proved to be too optimistic, and the most recent estimate for the period from 1997-78 to 2005-06 by ABARE (2008a) is 1.4 percent per annum. Both of these estimates are for the Australian beef industry as a whole and provide only a general picture of performance, which has varied markedly

among sub-sectors. ABARE (2004) reported that the better-performing farms are characterised by larger areas, higher branding rates and higher costs that, at least in most years prior to 2004, were more than offset by higher receipts. Larger-scale beef farms have been achieving higher rates of productivity growth than smaller-scale farms. ABARE (2004) also highlighted the main factors bringing about recent productivity improvements, such as genetic advances, increased use of *Bos indicus* blood, improved pasture, and herd and disease management that were particularly evident in northern Australia. Productivity growth was also observable in southern Australia, but was less impressive and more difficult to ascribe to specific factors.

Survey statistics compiled by ABARE (2007) also show a great disparity between the top and bottom performers in financial terms, with the former enjoying higher rates of return than the latter for specialist beef producers with more than 300 cattle. ABARE (2007) used average rate of return excluding capital appreciation to rank producers according to their farm financial performance. Because the main farm asset, land, is omitted, it allows for differences in the productive capability of land reflected in land value (ABARE 2007) and enables a comparison of performance between farms that have quite different soils, rainfall, resource quality and stage of development. ABARE (2007) reported that rates of return of

the top 25 percent of beef producers oscillated between 3 percent and 5 percent from 1995-96 to 1999-2000, increased to about 9 percent in 2000-01, and then varied from about 3 percent to 4 percent for the remainder of the study period. Rates of return for average producers were much lower, being negative for most years in the decade.

Increased rates of return may reflect either increased productivity or rising beef prices relative to input prices, usually in the context of strong export demand. Our primary concern is to decompose changes in returns to resources into changes in TFP and changes in farmers' terms of trade, measured by an index of output and input prices. TFP change in turn is decomposed into technical change, represented by a shift of the production frontier, and change in technical efficiency, representing shifts in the distance of the individual beef producer from the production frontier in each year.

### Method of analysis

Stochastic frontier analysis was employed assuming an underlying translog production function that allows flexibility in the relations between outputs and inputs in production technology. Productivity was measured as Malmquist TFP indices computed from the technical efficiency and technical change estimates in the stochastic frontier production model.

Data on beef production were obtained from the South-West Farm Monitor Project database. This project, which has a long history of benchmarking production on farms, is located in south-west Victoria. There were 227 observations, consisting of farm physical and financial data for the 10 years from 1995-96 to 2004-05 (Department of Primary Industries 2005). The years beyond 2004-05 were excluded because of the effects on the data set of the severe drought in south-eastern Australia beginning in late 2005, and its distorting effects on herd structure (ABARE 2007) that make it difficult to measure the relations between inputs and outputs accurately.

The beef output variable was measured in kilograms liveweight of beef produced per hectare. Eight input variables were included in the model: livestock capital (measured in dry sheep equivalents (DSEs) of beef cattle per hectare at the beginning of each year commencing 1 July), animal health costs, supplementary feed and agistment costs, pasture costs, labour costs, freight and selling costs, sundry costs and overheads. All cost data were calculated on a per hectare basis in 1999-2000 dollars, deflated using the

index of prices paid (including capital items) published by ABARE (2008b). This procedure enables us to represent these costs as implicit inputs.

The analytical method we employed was to estimate a stochastic frontier production function, which is one of the standard procedures for estimating productivity. Our study goes further than the other studies following this approach in that we use farm-level productivity estimates to estimate a single factorial terms of trade (SFTOT) index for each beef producer in each year.

Following Coelli et al. (2005), the stochastic frontier production function is defined as:

$$\ln Y_{it} = \alpha_i + \sum_{j=1}^8 \beta_j \ln X_{jit} + \sum_{j=1}^8 \sum_{k=1}^8 \beta_{jk} \ln X_{jit} \ln X_{kit} + v_{it} - u_{it}$$

(1)

where  $Y_{it}$  is the beef output of the  $i$ -th producer in the  $t$ -th year,  $X_{jit}$  is the  $j$ -th input of the  $i$ -th producer in the  $t$ -th year for eight input categories, the  $v$ s are assumed to be independently and identically distributed with mean zero and variance  $\sigma_v^2$ ; and the  $u$ s are technical efficiency effects that are assumed to be truncated normal and independently distributed such that  $u$  is defined by the truncation at  $\mu$  of the normal distribution with known variance,  $\sigma_u^2$  and mean  $\mu$ .

Estimates of the model parameters were obtained using the maximum likelihood procedures in the FRONTIER 4.1 program (Coelli 1996). A technical inefficiency effects model was estimated, with farm-specific inefficiency dummy variables and interaction variables between the farm dummy variables and a year variable added to obtain individual farm technical efficiency estimates. The technical change and technical efficiency estimates calculated within the program were used to construct TFP indices for each farm in each year. Prior to estimation, the means of the natural logs of input and output variables were adjusted to zero so that the coefficients of the first-order terms may be interpreted as elasticities, evaluated at the sample means.

Following Fleming (2007), SFTOT was calculated for the beef enterprise in the farm business as:

$$TOT_{SF} = (P_Y/P_I) \cdot O_F \quad (2)$$

where  $P_Y$  is the price index of beef output,  $P_I$  is the price index of inputs used in beef production, and  $O_F$  is the TFP in beef production. The farmers' terms of trade index was calculated as  $P_Y/P_I$ .  $P_Y$  was measured as the mean beef price received by surveyed farmers.  $P_I$  was measured as the index of prices paid by farmers throughout Australia, published by ABARE (2008b). Both of these components of the farmers' terms of trade index are typically outside beef producers'

control. It was initially hoped that individual terms of trade indices could be calculated for each farm, but the unbalanced nature of the data set and lack of reliable price data on some input categories meant that this more-relevant, farm-level price series could not be calculated.

## Results and discussion

### *Model estimates*

Maximum-likelihood estimates of the coefficients for inputs in the frontier production model, defined in equation (1), are presented in Table 1. For parsimony, only the first-order terms are shown. Their coefficients can be interpreted as output elasticities. As expected, livestock capital is the dominant influence on output. A one percent increase in livestock capital results in an increase in meat output of 0.75 percent. The only other inputs with a significant and substantial elasticity estimate are pasture and overhead inputs. A gamma value of 0.805 indicates that slightly more than 80 percent of the disturbance term is explained by inefficiency effects and slightly less than 20 percent is due to random effects. Health, labour, selling and freight, and sundry inputs have no significant impacts on beef output at the margin according to the estimates.

### *Estimates of productivity change*

Figure 1 contains mean annual TFP, SFTOT and TE measures for the study period. It shows that little change took place in mean TFP during the study period. The annual rate of technical progress averaged 0.715 percent, around one-half the latest TFP estimate for the Australian beef industry. But it was offset to a limited extent by an increased mean distance of the average beef producer from the frontier, as indicated by the slight decline in mean TE evident in Figure 1. By the end of 2002-2003, mean TFP had risen to 1.14 from a base of 1.00 in 1995-1996. However, a decline occurred in mean TE during the final two years of the study period and the mean TFP index stood at 0.99 by 2004-2005.

The average situation masks considerable temporal change in the distribution of TE and hence TFP indices across the sample. Inter-year movements in TFP distributions are demonstrated in the left-hand column of Figure 2. One of the most notable features is the wide spread of TFP estimates. They were particularly widely spread in 1996-97 and the latter two years of the study period. This spread probably reflects to some extent the importance attached to beef production by farmers. Those farmers for whom beef

production is the main enterprise perform better than those for whom it is a minor part of the farming system.

The most likely explanation for the decline in mean technical efficiency is that less efficient producers have struggled to keep up with improvements made by best-practice producers. This divergence in trend in TFP between best-practice producers and less efficient producers was also observed for producers in the Australian wool industry (Fleming et al. 2007). Another possible explanation for the decline, especially in the latter two years of the study period, was thought to be the switch by many farmers from wool to lamb production, where less efficient producers were unable to maintain their performance in beef production as well as best-practice producers in the wake of the extra demands placed on them by having to manage a new enterprise. But the proportion of beef producers producing lamb scarcely changed during the final few years of the study period. A further alternative possible explanation could be that some farmers experienced less favourable climatic conditions than others during later years of the study period, a situation we have not been able to detect because of a lack of data on spatial variations in rainfall, in particular, within the study region.

### *Estimated changes in returns to resources*

Estimates of changes in the mean SFTOT are presented in Figure 1. They show an increase in mean SFTOT, and hence an improvement in real returns to resources, during the study period. Because of the relatively minor impact on the SFTOT estimates of TFP changes, these returns were mainly influenced by changes in the beef farmers' terms of trade, which in turn varied primarily because of the oscillations in beef prices received by farmers in the sample over the study period. Farm input prices increased gradually and were 28 percent higher by the end of the period than they were in the first year. This increase was considerably less than the 75 percent increase in beef prices during the same period. Annual distributions of farm-level SFTOT are shown in the right-hand column of Figure 2. As might be expected, given the use of common input and output prices across farms, the spread of these distributions in each year reflects the distributions of TFP.

As a measure of real returns to resources, the SFTOT index would be expected to be quite highly and positively correlated with the rate of return excluding capital appreciation published by ABARE (2007) for specialist beef

producers. Some discrepancies are likely because the rate reported by ABARE is for a broader set of beef producers (Victoria for the years from 1995-96 to 2001-02, Australia in 2002-03 and southern Australia in 2003-04 and 2004-05). Also, the ABARE rate of return is based on a different data collection system and includes returns and costs of other enterprises on the farms. Despite these sources of difference, the Pearson correlation coefficient is reasonably high at +0.61.

### Conclusions

A stochastic frontier production model was estimated to derive measures of technical efficiency and production frontiers for a sample of farms in south-west Victoria that produced beef during the decade from 1995-96 to 2004-05. Results were used to compute changes in productivity, measured as TFP, and real returns to resources, measured as SFTOT. Results suggest that best-practice beef producers in this region modestly improved their productivity during the study period. Technically inefficient farms seem not to be sharing these productivity increases and in fact their TFP growth rate is stagnant. The estimated SFTOT index increased substantially during the decade after declining in the first year. This measure experienced much greater volatility than the productivity measure, principally because of fluctuations in beef prices.

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Table 1. First-Order Maximum-Likelihood Estimates of the Stochastic Frontier Production Function for the South-West Farm Monitor Project Benchmarking Group, Beef Producers: 1995-96 to 2004-05

<b>Input variable</b>	<b>Coefficient</b>	<b>Standard error</b>	<b>t-value</b>
Livestock capital	0.754	0.101	7.488
Health	-0.025	0.034	-0.723
Feed and agistment	0.029	0.023	1.263
Pasture	0.063	0.028	2.246
Labour	0.011	0.246	0.459
Selling and freight	0.010	0.023	0.455
Sundry	-0.063	0.071	-0.090
Overheads	0.198	0.050	3.978

Figure 1. Mean annual TFP, TE and SFTOT indices, 1995-96 to 2004-05

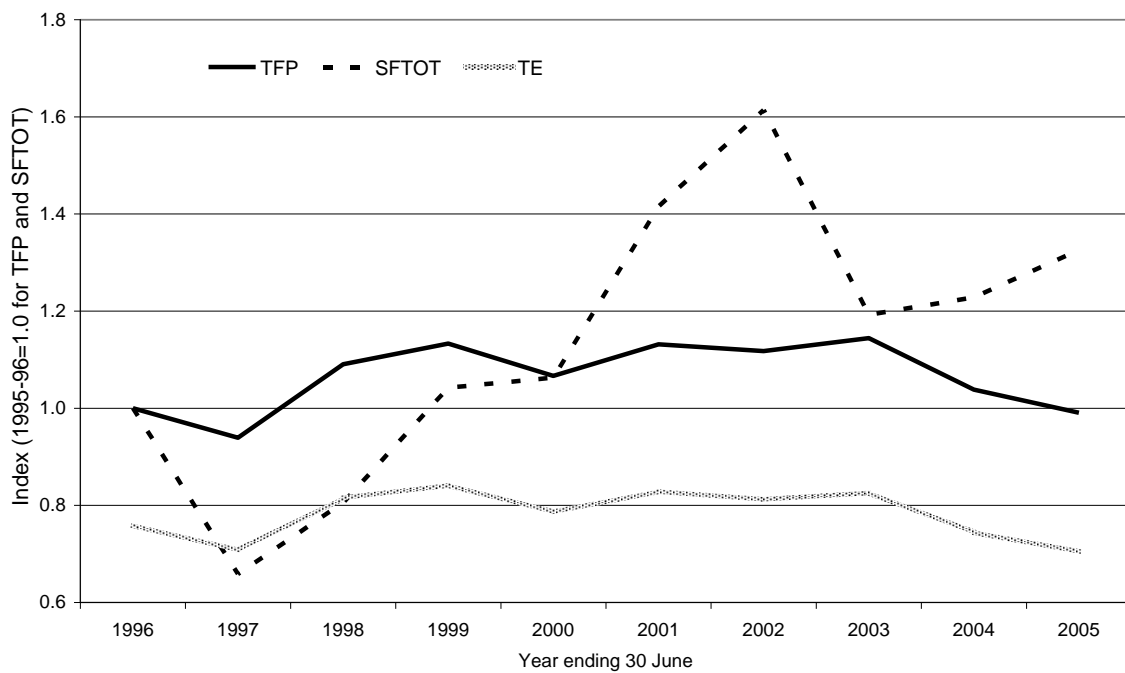


Figure 2. Annual distributions of TFP and SFTOT indices

