Australian Agricultural
and Resource Economics Society

AARES 52nd
ANNUAL CONFERENCE

5 - 8 February 2008

Conference Name: Australian Agricultural and Resource Economics Society 52nd Annual Conference in Canberra, ACT 5-8 February

Year: 2008

Paper title: Evidence of Scope Economies in Australian Agriculture

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Evidence of Scope Economies in Australian Agriculture

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Abstract

Scope economies can be used in studies of farming systems to provide a measure of synergies between different farm enterprises and between activities within farm enterprises. In this paper, they are reported for farms in two benchmarking groups in Australia by estimating stochastic input distance functions and calculating an 'economies of scope parameter'. Evidence of scope economies between sheep and crop enterprises, and between beef and crop enterprises, is presented and discussed. Similar evidence is reported between wool and lamb activities and wool and mature sheep trading activities within the sheep enterprise.

Keywords: *Australia; crops; livestock; scope economies; sheep*

The authors wish to acknowledge the funding assistance provided by the Australian Sheep Industry CRC and Meat and Livestock Australia (MLA), and the provision of data by benchmarkers participating in the CRC benchmarking project.

There are few Australian farms where complete specialization in a single enterprise occurs. The wisdom of diversifying across several enterprises, summed up in the phrase 'not keeping all one's eggs in one basket' reflects the use of diversification as a risk reduction strategy. Given the unpredictability of weather conditions and the exposure of Australian farmers to world market prices, diversification of production activity on farms is a sensible survival strategy. This leads to the question, which enterprises are the best ones to combine on a given property? The choice of enterprises can be seen as purely a function of the suitability of the farm's soil, topography and climate. However, we expect that the choice of enterprise mix on farms will also exploit scope economies that can be gained from diversification. At the very least, farmers would avoid choosing enterprise mixes that produce diseconomies of scope.

Nature of scope economies

Scope economies accentuate the economic advantages of integrating farm enterprises. Opportunities to exploit them in Australian agriculture exist in a number of different ways and vary according to the physical environment. This variation is evident across the three agroclimatic zones: Pastoral Zone; Wheat-Sheep Zone and High Rainfall Zone. Possibilities for exploitation are greater in the Wheat-Sheep Zone where the integration of crop and livestock enterprises offer synergies that farmers can build into their operations. Similar possibilities exist in the High Rainfall Zone although cropping activity, if possible, occurs on a smaller scale. Ability to exploit scope economies in farming systems featuring sheep production is probably least in the Pastoral Zone, which is dominated by specialist livestock enterprises featuring 'low input rangeland production systems' (Ewing and Flugge 2004, p. 2). But opportunities to exploit scope economies between pastoral enterprises such as sheep and beef do exist in this Zone. Within the sheep enterprise there is also the potential to adjust the emphasis of production between wool and lamb. Traditionally this has been most prevalent in the High Rainfall Zone. In the past decade the development of dual-purpose sheep enterprises has spread this choice of within-enterprise mix to the Wheat-Sheep Zone and the some parts of the Pastoral Zone. Another within-enterprise mix in sheep production is through the combination of wool production and mature live sheep export.

This paper focuses on the different opportunities to exploit scope economies in the Wheat-Sheep Zone and High Rainfall Zone using data on sheep, beef and crop production from two of the benchmarking groups detailed by Fleming et al. (2007). The extent of these scope economies depends on an ability to integrate the operations of farm enterprises. As Ewing and Flugge (2005, pp. 4-6) point out, integrating elements of a production system can occur at both the paddock and whole-farm level.

While discussion of scope economies often features observations made about the presence of complementary relationships between components of production systems (e.g. Ewing and Flugge 2004, p. 1), we prefer the term synergy as a more inclusive description and to avoid confusion with the standard definition in economics of complementarities between two outputs where the higher production of one output results in higher production of the other output. It is nevertheless valid and common to refer to scope economies as 'cost complementarities'. In most situations, a competitive relationship exists between activities within a farm enterprise (where a farm activity is defined as a specific method of production within a farm enterprise) or between farm enterprises. Synergy is defined and typified by Corning (2002, p. 22) as follows:

> Broadly defined, synergy refers to *the combined (cooperative) effects that are produced by two or more particles, elements, parts or organisms – effects that are not otherwise attainable*. … there are many different kinds of synergy … "functional complementarity" … "combination of labor" … "synergy of scale" … joint environmental conditioning, information-sharing and joint decision-making, animal-tool "symbioses", gestalt effects, cost- and risk-sharing, convergent effects, augmentation or facilitation (e.g., catalysts), and others …

Virtually all these different kinds of synergy can be found in Australian mixed-farming systems. Examples include, the allocation and use of labour and knowledge across farm activities and enterprises, efficient grazing strategies to make maximum use of pasture and fodder from crops, diversification strategies to manage downside risk, and combining activities or enterprises to share the costs of farm inputs and services, especially overheads.

Scope economies, then, are a measure of synergies between different farm enterprises and between farming activities within enterprises. They exist between two farm enterprises or activities when, for a given level of resource use, more can be produced by combining the production of the enterprises than by operating the enterprises as separate systems. Another way of looking at scope economies is that the same level of output from two enterprises could be produced at lower cost by a farm operating the enterprises together than by two farms producing the same aggregate level of output but with one farm producing one of the outputs and the second farm producing the other output.

Scope economies can arise in several ways. Within a farming system they are commonly derived from jointness in outputs, jointness in inputs, jointness between production functions and production flexibility.

Jointness in inputs occurs where one farm input can be used in the production of more than one farm output. Land, labour and management resources are commonly spread across a number of farm enterprises or activities within a given period to make them more fully utilised. A typical example is the use of family labour in sheep and crop production enterprises. Machinery tends to be more specialised according to farm enterprise or activity, but the same machinery items are frequently used in wool and lamb production (for example, shearing equipment).

Jointness in outputs occurs when more than one output is produced from the same (or approximately the same) set of inputs, thus differing from jointness in inputs by the degree of commonality in input use and an inability to produce outputs separately. An obvious example of this sort of diversification economy is the use of genetics and cross-breeding in the sheep production enterprise to produce both wool and lamb.

Interactions between independent production processes constitute another source of diversification economies. They occur when the production processes generate independent outputs but are linked where outputs from one process are inputs into the second process. An example is the winter grazing of sheep on stubble left over from a cereal crop.

Finally, flexibility in production, or ‘the ease with which the farming business can adjust to changed circumstances’ (Hardaker et al. 2005, p. 274), can be an important way to manage risk in farming. A more diversified farming system is likely to have greater flexibility to respond to sudden changes in circumstances at relatively little cost, thereby generating scope economies.

Scope economies between livestock and crop production enterprises

For our purposes, mixed-enterprise farms of particular interest are properties running sheep and beef, those with cropping and sheep enterprises, and those with sheep, beef and cropping enterprises commonly found in the wheat-sheep zone. As van Keulen and Schiere (2004) observed, the synergies between crops and livestock enterprises have been long recognised over many cultures and exploited through history. The waste products from one enterprise behave been used as inputs to another. Obvious examples are the use of manure to increase crop production and the use of crop residues and by-products to feed animals. Sophisticated rotation patterns evolved over time as patterns of crops, pasture and fallow were developed to exploit physical synergies between enterprises, maintain fertility of the land and allow labour coordination over the farm year. Increased specialisation in agriculture became a viable option with the development of mechanical technologies, inorganic fertilisers, and chemicals for disease and weed control. These developments, coupled with genetic improvements of crop varieties and animals, reduced the dependence of farmers (particularly in western countries) on rotational methods during the latter half of the 20th century. Van Keulen and Schiere (2004) highlighted the renewed interest in crop-livestock systems to mitigate the negative environmental impacts of specialised agricultural systems. Ewing and Flugge (2004) observed that although the more diverse production systems developed in Australia in the past decade reflect the flexibility of the farming system to respond to innovation and economic signals, the mixed-farming systems also need to deal with sustainability issues such as salinity, acidity increase and weed management. This implies a return to the idea that the choice of cropping and pasture sequence has an immediate within-year effect but also has flow-on effects to subsequent production.

Scope economies within the sheep production enterprise

Many of the types of synergy outlined above can be identified in agricultural production systems involving sheep. Within the sheep enterprise, there are obviously many different ways in which wool and meat are produced. The type of sheep enterprise can range along the spectrum from specialist Merino wool production to specialist prime lamb production. In between there exists a variety of dual-purpose sheep enterprises. The definition of dual-purpose sheep enterprises used here is those in which at least 25 per cent of income is derived from wool and at least 25 per cent of income is derived from meat. The fine- and medium-wool dual-purpose sheep activities possess production advantages over both prime lamb and Merino wool activities because they produce higher wool output and higher wool value. Pure Merino wether activities produce slightly more wool but much less meat than ewes (Warn et al. 2005).

There are three main outputs in the sheep enterprise: wool, sheepmeat and live sheep for export. The composition of the sheep flock is a key determinant of the output emphasis. A heavy dominance of ewes in the flock reflects in part the increased importance of prime lamb production for meat, particularly cross-bred lambs If the flock is mainly made up of Merinos, then the production emphasis could be wool, or both wool and lamb. If the Merinos are on marginal land or in environments not capable of turning off lambs or hoggets for meat, then wool will be the main output. If the environment is more favourable, then the merino ewes will be crossed with terminal meat sires. In this situation, the dual outputs of wool and prime lamb are important. If the flock consists of highly productive crossbred ewes, then these ewes can be crossed with specialist terminal meat sires for prime lamb production.

As well as the above dual-purpose systems another dual-purpose option has developed. Here dual-purpose Merinos have been developed with good meat qualities (growth rate and muscling) to accompany premium wool production. The original dual-purpose system relies on good meat genetics from the sire and good wool genetics from the dam, while the second dual-purpose approach strives for genetic improvement in both wool and meat traits in the Merino dams.

A degree of flexibility is present in all dual-purpose sheep systems. By varying the choice of terminal sires, different proportions of the Merino ewe flock may be used to obtain different proportion of outputs: more wool, more prime lamb, more store lambs or more replacements for the nucleus flock. The choice of sire can be made according to seasonal conditions and market conditions. Producers are also able to reduce their flock to core breeding stock in response to adverse seasons.

Estimation of scope economies

Estimated scope economies are derived from models based on stochastic input distance functions for the farms in two benchmarking groups: JRL Hall and Co. in Darkan, south-west Western Australia, and Holmes Sackett and Associates (HSA), based in Wagga Wagga but with benchmarked farms across four states (see Fleming et al. 2007 for details). The dual-purpose sheep farms were identified by the benchmarker. Information on the unbalanced panel data sets used for this study is outlined in Table 1.

Table 1 Data sets

Data Set	Years	Cross-sections	Observations
HSA – Dual-Purpose Sheep	8	125	294
Darkan	12	86	587
HSA – Whole-Farm	8	347	984

Scope economies are estimated at two levels. First, they are estimated within the sheep production enterprise, between wool and lamb using the dual-purpose sheep enterprise data in the HSA data set and between wool and live sheep trading in the Darkan benchmarking group. Second, at the whole-farm level, scope economies are estimated between sheep, crop and beef production enterprises using the data set for New South Wales farms in the HSA benchmarking group.

Method

The data sets used are from farms that are paying the benchmarking firms for practical and financial advice as well as for their benchmarking performance indicators. Therefore, we estimate economies of scope measures obtained from the production frontiers of some of the best-practice farmers in the relevant regions. The question arises about the relevance of such results to the average farm. Economies of scope should be measured using frontier rather than non-frontier methods of analysis. Grosskopf, Hayes and Yaisawarng (1992, p. 458) justified this approach because 'nonfrontier methods' may confuse measurement of scope economies with inefficiency measurement.

Estimation procedures are based on stochastic distance function analysis (SDFA), which provides estimates of technological change, technical efficiency change and TFP change when applied to a panel data set. An input orientation was chosen to estimate the multi-input multi-output stochastic input distance function rather than the more realistic output orientation because this choice allows us to test for the presence of synergies in sheep production. Results provide a technical efficiency index for each sampled enterprise or farm, and mean technical efficiency across all enterprises or farms for each year of the study period, using the time-varying option in FRONTIER 4.1c (Coelli 1996). These results have been previously reported. See Fleming et al. (2007).

Coelli and Fleming (2004) estimated a translog output distance function to investigate the existence of economies of scope. The measure outlined below is not equivalent to the traditional scope economies measure derived from a cost function. Coelli and Fleming used the term ‘economies of diversification’ for this measure, to emphasise the distinction. While recognising this distinction, we continue to use the terms (dis)economies of scope in this paper to distinguish the method from another approach (see, Grosskopf et al. (1992)) where the term ‘economies of diversification’ is used.

To test for the presence of synergies in sheep production, we estimated the economies of scope parameter developed by Coelli and Fleming (2004). Economies of scope (implying cost complementarities) exist between outputs *i* and *j* if:

$$\partial^2 C / \partial y_n \partial y_{n'} < 0 , \qquad n \neq n', \; n, n' = 1, \dots, N \qquad (1)$$

where C is the cost of N outputs and y_n is the n-th output variable (Deller, Chicoine and Walzer, 1988). The addition of an extra unit output n reduces the marginal cost of producing an extra unit of output n'.

The first partial derivative of the input distance with respect to the n-th output is negative. The sign indicates that the addition of an extra unit of output, holding all other variables constant, reduces the amount needed to put the observation onto the efficient frontier by deflating the input vector (Coelli and Fleming, 2004). A positive second cross partial derivative is evidence of economies of scope:

$$\partial^2 D / \partial y_n \partial y_{n'} > 0 , \qquad n \neq n', \; n, n' = 1, \dots, N \qquad (2)$$

Conversely, a negative second cross partial derivative signifies diseconomies of scope (Coelli and Fleming, 2004).

The coefficient estimates of scope economies for each pair of outputs in the production system, as defined by equation (2), are listed in Table 2 and Table 3. Standard errors were obtained in order to test the hypothesis that there are no scope economies. These standard errors were calculated as Taylor series expansions. A significantly positive sign on the parameter indicates the presence of scope economies in production whereas a significantly negative sign indicates scope diseconomies.

Evidence of scope economies

The estimates used to evaluate the existence of scope economies within the sheep enterprise are reported in Table 2.

Table 2 Estimated parameters of economies of scope within the sheep enterprise

Benchmarking Group	Output combination	Parameter estimate	Standard error	t-value
HSA Dual-Purpose Enterprise	Prime Lamb and Wool	0.3183	0.0318	10.01
Darkin WA	Wool and Sheep Trading	0.0264	0.0354	0.75

We estimate the production relations for all farmers who produce both wool and lamb outputs on HSA benchmarked farms. Strong synergies exist between wool and lamb production with the estimate for the second cross partial derivative highly significant. This result confirms the earlier discussion about the increase in management options available in dual–purpose sheep systems, which have been particularly enhanced by genetic improvements.

Data on farms in the Darkan benchmarking group were used to evaluate the presence of scope economies between wool production and trading in mature sheep, mainly for live sheep export. The estimate for the second cross partial derivative is not significant different from zero. Although the result implies no positive synergies between the two outputs, it is interesting to note that the absence of a significant negative value also implies that no diseconomies of scale (dyssynergies) exist between the alternative outputs.

The estimates used to evaluate the existence of scope economies between farm enterprises obtained from the HSA whole-farm data are reported in Table 3. Four enterprises are considered; sheep, beef, cereal cropping and ‘other’ cropping. The enterprise named ‘other’ refers to all other non-cereal cropping activities such as oilseed and legume cropping.

Table 3 Estimated parameters of economies of scope between farm enterprises - HSA Data

Output combination	Parameter estimate	Standard error	t-value
Sheep and Cereal Crops	0.0560	0.0099	5.65
Sheep and Other	0.0260	0.0101	2.53
Beef and Cereal Crops	0.0190	0.0088	2.18
Beef and Other	0.0041	0.0087	0.47
Beef and Sheep	0.0450	0.0100	4.50
Cereal Crops and Other	0.0083	0.0089	0.93

There is evidence of significant synergies between livestock enterprises and cereal crop enterprises, with these synergies being more significant for the sheep enterprise than the beef enterprise. This result confirms the synergies between cereals and sheep enterprises in the traditional Wheat-Sheep Zone. The developments of cereal varieties more suitable for grazing and research resulting in supplementary feeding recommendations for animals grazing on stubble are examples of innovations that contribute to these synergies. It is interesting to note that that the synergies between sheep and ‘other’ cropping enterprises, although significantly different from zero, are not as strongly significant as the cereal–sheep synergies. No evidence of synergies was found between the beef enterprise and ‘other’ crops.

Highly significant evidence of scope economies was found to exist between the sheep and beef enterprises on HSA benchmarked farms. This estimate indicates that synergies are being generated by efficient grazing strategies that balance the need for pasture and fodder from crops between the two animal enterprises. No (dys)synergies were found to exist between cereal and other crops. This is somewhat surprising given the high level of equipment, labour skills and management skills the two enterprises would share.

While analysts often allude to synergies in agricultural production, and the factors bringing them about, evidence to support these comments is fragmentary at best. According to Sackett and Francis (2006, p. 205), ’Optimum integration of enterprises to capture the synergies between enterprises is a substantial challenge for which there is limited good-quality quality research or support data.' In spite of this lack of quality scientific results on which farmers can base their enterprise (activity) mix decisions, it appears from our results that farmers are mixing their enterprises in ways that bring about synergies. Whether the choice of enterprise mix is optimal is a subject on which we are unable to comment.

Finally, we found no evidence of dyssynergies. The absence of diseconomies of scope in any of our results indicates that producers would not benefit from more specialised production processes in the areas considered in this study.

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