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Evidence of Scope Economies in the Australian Wheat-Sheep Zone

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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 a benchmarking group in the Wheat-Sheep Zone in New South Wales, Australia, by estimating a stochastic input distance function and calculating an 'economies of scope parameter'. Evidence is presented of scope economies between sheep and beef enterprises, sheep and crop enterprises, and beef and crop enterprises.

Keywords: Australia; crops; livestock; scope economies.

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There are few Australian farms where complete specialisation 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 management 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 a function of the suitability of the farm's soil, topography and climate. But 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, other things being equal.

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 offers 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 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 at the enterprise level in the Wheat-Sheep Zone using data on sheep, beef and crop production from a benchmarking group described 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 or between farm enterprises but synergies can reduce the extent of this competition. 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 and are represented graphically in the two-output case as a convex production possibilities frontier. 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.

As indicated in the quote from Corning (2002) above, 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, production flexibility and scale economies. In addition, the standard assumption in microeconomic analysis of diminishing returns to inputs implies a convex production possibilities frontier.

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.

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.

Finally, Chavas and Kim (2007) demonstrate how scale economies are an integral component of scope economies. They provide a theoretical exposition on how 'increasing (decreasing) returns to scale contribute to the presence of economies (diseconomies) of scope' (Chavas and Kim 2007, p. 422).

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 have 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 production 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. We attempt to measure such synergies by evaluating scope economies in production systems featuring a combination of livestock and crop enterprises.

Estimation of scope economies

Estimated scope economies are derived from models based on stochastic input distance functions for the farms in the benchmarking group, Holmes Sackett and Associates, based in Wagga Wagga but with benchmarked mixed-enterprise farms across four states (see Fleming et al. 2007 for details). The farms selected for this study are based in the state of New South Wales and comprise an unbalanced panel data set of 347 farms across eight years, 1997/98 to 2004/05, and totalling 984 observations. Scope economies are estimated at the whole-farm level between sheep production, cereal cropping, ‘other’ cropping and beef production enterprises. The enterprise named ‘other’ cropping refers to all non-cereal cropping activities such as oilseed and legume production.

Method

The data set used is from farms that are paying the benchmarking firm 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. While the question might be asked 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 on the grounds that 'nonfrontier methods' may confuse measurement of scope economies with inefficiency measurement.

Estimation procedures are based on stochastic distance function analysis, 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 an output orientation because this choice allows us to test for the presence of synergies in production systems. The model was estimated adopting the estimation procedure used by Coelli and Fleming (2004). Results provide a technical efficiency index for each sampled farm, and mean technical efficiency across all farms for each year of the study period, using the inefficiency effects option in FRONTIER 4.1c (Coelli 1996).

These results also enable a measure of scope economies to be estimated that is not equivalent to the traditional scope economies measure derived from a cost function. Coelli and Fleming (2004) used the term 'economies of diversification' for this measure, to emphasise the distinction. While recognising this distinction, we continue to use the terms, economies of scope and diseconomies of scope, for their estimates to distinguish their method from another approach (see Grosskopf et al. (1992)) where the term 'economies of diversification' is used. Coelli and Fleming (2004) contended that economies of scope (implying cost complementarities) exist between outputs *i* and *j* if:

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

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:

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

Conversely, a negative second cross partial derivative signifies diseconomies of scope. Standard errors were calculated as Taylor series expansions to test the hypothesis that there are no scope economies or diseconomies. Underlying this approach is the assumption of an input-homothetic production function (Coelli and Fleming, 2004).

Four enterprises are considered in the study – sheep, beef, cereal cropping and other cropping – and separate outputs are included in the stochastic input distance model for each enterprise. Seven input variables were included: labour; capital; materials; sheep, beef and crop enterprise costs; and livestock capital, measured in dry sheep equivalents. A trend variable was also included, and interacted with input and output variables to account for biased technical change over the study period. Four dummy variables were included for regions in New South Wales (Southwest region as base) and five dummy variables were included for the main seasonal break (excellent season as base). Seven year dummy variables (1997-98 as base) were included in the estimated efficiency model.

Evidence of scope economies

Results reveal that the coefficients on all input and output variables were of expected sign and magnitude, and highly significant. A likelihood ratio test statistic of the one-sided error term for 11 restrictions (187.07) indicates strongly that technical inefficiency is present. The mean technical efficiency for the whole period was 0.79 but varied significantly across the period, generally declining as the average producer fell further behind a frontier expanding at 3.13 per cent per year.

Six pairs of outputs are of interest to evaluate scope economies between farm enterprises. The estimates used to evaluate the existence of scope economies, using the model defined by equation (2), are reported in Table 1.

Table 1 Estimated parameters of economies of scope between farm enterprises

Output combination	Parameter estimate	Standard error	t-value
Sheep and Cereal Crops	0.0560	0.0099	5.65
Sheep and Other Crops	0.0260	0.0101	2.53
Beef and Cereal Crops	0.0190	0.0088	2.18
Beef and Other Crops	0.0041	0.0087	0.47
Beef and Sheep	0.0450	0.0100	4.50
Cereal Crops and Other Crops	-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 production 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 the synergies between the sheep and other cropping enterprises, although significantly different from zero, are not as strongly significant as the cereal–sheep synergies.

Highly significant scope economies were found to exist between the sheep and beef enterprises on 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 evidence of synergies (or dyssynergies) was found between the beef enterprise and other crops or between cereal and other crops. The lack of synergies in the latter case is 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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