RISK AND FARM SIZE IN THE PASTORAL ZONE

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Variable performance over time is an important feature of wool growing in the eastern pastoral zone of Australia. An analysis of time series data from the Australian Sheep Industry Survey indicates that standard deviation of net farm income is related more or less linearly to size of firm and increases with size at about the same rate as does average net income. A tentative conclusion is drawn that large farms have had a slight tendency to experience less variable rates of return than small farms. However, it is found that farms that have experienced relatively variable returns have tended to enjoy average rates of return above those of other farms of similar size.

Introduction

Agricultural production of nearly every description experiences risk from the physical and marketing environments. Risk is important in Australian agriculture because of the generally high climatic variability. Probably nowhere is it more important than in the semi-arid pastoral zones of Central Australia.

Attitudes to risk are essentially personal and are unique to individuals. However, it seems that most entrepreneurs are averse to risk [16] and so risk aversion may imply upper limits to the growth of firms quite apart from any diseconomies of size. One important hypothesis yet to be tested is that risk in farming varies with size of firm. Relative to pastoral sheep farming, this hypothesis is examined for various measures of risk.

Risk actually experienced by farmers is determined by a complex amalgam of the real environmental uncertainties, the perception of these by the farmer, his attitude to perceived risk and finally by the actions he takes as a result of his decision making. There is a dearth of information on these behavioural aspects of risk and their consequences and on how these are influenced by size of the farm firm. This paper goes a small way towards filling this gap by presenting results on experienced risk based on an empirical analysis of time-series data relating to wool growers in the pastoral zone of Australia. The empirical approach of

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using data already collected (at considerable cost) was adopted as the most economical way of making an initial study of this subject.

Data from the Australian Sheep Industry Survey

The only readily available and representative farm data from the eastern pastoral zone have been assembled by the Bureau of Agricultural Economics (B.A.E.) in the Australian Sheep Industry Survey (A.S.I.S.). Published reports (e.g. [3]) do not reveal details of individual properties in the survey but the Bureau made available unidentified data on selected items relating to 27 properties from the pastoral zone of N.S.W. and 10 properties from the pastoral zone of Queensland. These properties were continuous members of the A.S.I.S. sample from 1952 to 1966 whose holdings had not changed substantially in area during this period.

Since the size-stratified A.S.I.S. sample is drawn from a population defined to exclude studs and companies, the extent to which the non-random sub-sample of the Continuous Group is representative of wool producers in the zone is a matter for conjecture. Average wool production and average farm area of sub-sample properties were in fairly close agreement with averages for the complete sample at the beginning and end of the study period.[1] In addition, the distributions of flock sizes in the sub-sample and complete sample were examined through a Chi-square test which indicated that they did not differ significantly in the three years for which data were obtained and the test conducted (1954-55, 1959-60 and 1962-63). It is thus reasonable to regard the sub-sample as being generally representative of the sampled population. The stratification by flock size ensured a range of sizes of property in the Continuous Group adequate for the present purpose.

Size and Average Profitability

The first encountered difficulty in studying size relationships among cross-sectional data is to find a satisfactory measure of size. For the present purpose such a measure ideally should be independent of risk attitudes and climatic variability. Thus physical measures which directly reflect these, such as number of sheep carried or wool produced, are not ideal and an aggregative financial measure such as total market value seemed preferable. However, at the time data were provided the B.A.E. was not in a position to provide land values for the study properties at a common date. In addition, realistic land values must in some way reflect the variability of the different local environments. For these various reasons, and the fact that no single measure can measure size of firms perfectly [2], it was decided that total capital value excluding land would be a reasonable surrogate for size of firm.[2] For identical reasons,

[1] For example, consider the average areas of properties (in thousands of acres). For the continuous subsample these were approximately constant at 22·2 and 32·3 for the N.S.W. and Queensland segments respectively. These compare, respectively, with 22·5 and 29·7 in 1954-55 and 28·4 and 34·4 in 1964-65 for all the complete (but changing) A.S.I.S. sample.

[2] In his analysis of economic performance of individual properties in the pastoral zone, Reid [17] has drawn attention to the fact that larger flocks are generally located in the climatically less favoured areas of the zone. This lack of independence between size and climatic variability to some extent must complicate study of risk and size using A.S.I.S. data.

rate of return to capital is computed by excluding land value from total capital; but since a zero rate of return is implicitly ascribed to land, comparisons with other studies should be made cautiously.

In contrast to the finding anticipated from Duloy's [7] production function analysis in the zone for the single year 1954-55, average profits (as measured by net farm income averaged over 15 years) increase at a diminishing rate with size. This is true for both physical and financial measures of size that were used, as is seen in the following regression equations for the 37 members of the Continuous Group:

$$NI = 4,460 + 5 \cdot 17\, SC - (1 \cdot 48)\ 10^{-4}\, SC^2, \quad \bar{R}^2 = 0 \cdot 72,$$
$$(5 \cdot 01) \qquad (2 \cdot 45)$$

$$NI = -10,580 + 0 \cdot 432\, CXL - (9 \cdot 64)\ 10^{-7}\, CXL^2, \quad \bar{R}^2 = 0 \cdot 62,$$
$$(4 \cdot 23) \qquad (2 \cdot 29)$$

where NI is average net farm income for each property over the 15-year period (range $2,000 to $64,000 per year, sample mean $15,600), SC is average no. of sheep equivalents carried on each property over the 15-year period (1,200 to 18,400 per year, sample mean 5,050), CXL is average capital value excluding land of each property over the 15-year period ($22,000 to $246,000, sample mean $80,000), and values of t are in parentheses below the respective coefficients in these and the following regression equations. In all cases the null hypothesis under test is that the respective population coefficients are zero.[3] By way of comparison with the ranges for the regression variables, average wool production (W) for individual properties ranged from 9,900 to 142,300 lb per year.

In some preliminary analyses, no such simple relationship as reported for net farm income was apparent between rate of return on total capital and any measure of size—a finding to be anticipated from B.A.E. reports (e.g. [3] p. 33) which indicate that rates of return on total capital are of similar magnitude across all strata except for a relatively low rate in the 500-999 sheep stratum which, along with the 200-499 stratum, is not represented in the population from which the Continuous Group was drawn. In an inter-zonal comparison, Gruen [10, pp. 52-54] has concluded that the relatively high profitability of sheep properties in the pastoral zone is largely a result of the higher proportion of larger properties in this zone. He used rate of return to total capital in his analysis. In this analysis, no simple satisfactory relationship was found between the rate of return on capital excluding land averaged for each property over the 15-year period ($RCXL$), and size of firm. Variables other than size must be important. The role of risk is explored in the following section, but a search for further explanatory variables was not very fruitful.

Davidson [5] has observed that high profitability tends to be associated with the least intensive methods of production in the pastoral industries generally. To attempt to capture any such effect, an index of intensity of improvement was defined as the ratio of average capital excluding land

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[3] The 5 and 1 per cent tabled values of Student's t for 34 d.f. are respectively 2·04 and 2·74. Since the zero-coefficient null hypothesis is tested throughout, t statistics are presented in the belief that most readers find these easier to assess than standard errors.

to average sheep numbers (*CPS*) and the best relationship found with these variables was

$$RCXL = 35 \cdot 2 - 1 \cdot 14 \, CPS + (4 \cdot 34) \, 10^{-5} \, CXL, \quad \overline{R}^2 = 0 \cdot 21.$$
$$(2 \cdot 38) \qquad (1 \cdot 10)$$

The observed negative effect of intensity appears to be in general agreement with Davidson's observations and the influence of size is not clear-cut.

Risk and Rates of Return

Fisher and Hall [8] have argued that industries operated by risk-averse utility-maximizing entrepreneurs will tend towards an equilibrium in which earnings are larger, on the average, for firms with greater variation in earnings than for firms characterized by relatively little variability. Fisher and Hall measured risk of return by both dispersion and skewness (negative skewness leading to greater risk exposure) of rates of return. Application of their model to time series data for a large sample of U.S.A. corporations indicated that average rates of return are importantly affected by 'risk exposure'. Firms with large standard deviations have higher mean profit rates, while firms with positively skewed distributions have lower profit rates. Differences existed, however, among rates of return and risk premiums for different industries.

The data for the Continuous Group provide an opportunity for further examination of the Fisher-Hall hypothesis and a test which is not complicated by industry differences. Fisher and Hall regressed average rate of return on standard deviation of rate of return about trend, and on skewness (based on the third moment) about trend, and found significant positive and negative coefficients, respectively, which supported their hypothesis. Fitting the same regression model to the rate of return data here indicated that skewness had no significant effect. This is not surprising since most of the profit distributions were fairly symmetric. The linear equation including only standard deviation[4] (*SDRR*) is

$$RCXL = -0 \cdot 023 + 1 \cdot 28 \, SDRR, \qquad \overline{R}^2 = 0 \cdot 17.$$
$$(2 \cdot 87)$$

Equations incorporating dummy variables showed that there was no difference between States in the relationship. As only about 17 per cent of variance is explained, clearly there must be factors other than risk which influence average rates of return but the only other combined factor found was the above-noted effect of size which is captured again in

$$RCXL = -5 \cdot 50 + 1 \cdot 22 \, SDRR + (7 \cdot 73) \, 10^{-5} \, CXL, \quad \overline{R}^2 = 0 \cdot 26.$$
$$(2 \cdot 90) \qquad (2 \cdot 28)$$

These similar relationships between standard deviation and rate of return suggest that in pastoral-zone wool production, as well as industrial corporations, part of the earnings differentials observed among various producers can be attributed to risk. It is not possible to argue from the

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[4] This is the square root of the residual variance about a linear trend (*RVRR*) discussed at the end of the penultimate section. The sample mean of *SDRR* is 21·2.

present evidence that producers attempt to maximize expected utility. However, it has been found that other pastoralists in the zone are generally averse to risk and that they do not seem to attempt to maximize expected profits [9].

Risk and Size of Firm

Defining a measure of risk is controversial and difficult [18]. Pertinent studies in agriculture have variously used variance [6], standard deviation [14, 15] and coefficient of variation [1]. Other measures of risk have been reviewed by Markowitz [13, pp. 287-297]. As each measure has both good and bad features, the procedure adopted in this cross-sectional analysis is to choose those measures which result in the simplest possible yet adequate numerical descriptions.

The coefficient of variation is intuitively the most appealing measure for comparisons of variability across a wide range of size of firm. However, these coefficients present difficulties in estimation when used as dependent variables which are functions of size, because observations tend to be scattered about a horizontal plane and R^2 values are consequently very low. Consider, for example, the regression of coefficient of variation of wool produced (CVW) on size,

$$CVW = 0{\cdot}278 - (1{\cdot}73)\ 10^{-7}\ CXL, \qquad R^2 = 0{\cdot}01.$$
$$(7{\cdot}35) \qquad (0{\cdot}43)$$

This indication that standardized variability of physical performance is not significantly related to size results from the fact that both the mean and standard deviation of wool production are similarly related to size.

Standard deviation of wool production is closely related to average wool production (W) as expressed by the equation

$$SDW = 2{,}430 + 0{\cdot}205\ W, \qquad \overline{R}^2 = 0{\cdot}71.$$
$$(9{\cdot}49)$$

This has an indirect relevance for regression analysis where output is used as an independent variable such as in statistical cost analysis. For example, in estimating a simple cost function, $TC = b_0 + b_1 W + u$, knowledge of such a relationship would lead to suspicion that the standard deviation of the disturbance term might also be proportional to W (a particular case of heteroscedasticity [11, p. 209]). In this instance, it would then be most appropriate to apply the usual significance tests to a transformed estimating equation such as $TC/W = b_0/W + b_1 + u/W$.

Linear associations were found between variability in net income, total revenue, wool production and sheep carried and size. For instance, the linear relationship for net income variability and size is

$$SDNI = 1{,}300 + 0{\cdot}145\ CXL, \qquad \overline{R}^2 = 0{\cdot}69,$$
$$(9{\cdot}01)$$

where $SDNI$ is the standard deviation of net farm income ($). Since family sustenance (or operator's allowance) and debt repayments as well as an implicit reward for invested capital must be met from net farm income, the magnitudes of fluctuations in net income are relevant in considering survival and potential for growth of pastoral firms. In assessing such fluctuations it is necessary that the measure of deviation be appropriate. For instance, in the present case the ratio of wool price

to cost of production has fallen substantially over the study period. Thus the estimates of *SDNI* must to some extent be confounded by general price changes and ideally a measure of variation is required which is free of such market effects.[5]

Two methods of removing these general trends were employed. An indexing approach was of most intuitive appeal but did not work as well as anticipated. Before computing net income, total returns were deflated by the B.A.E. index of prices received for wool, and total costs were deflated by the B.A.E. index of prices paid by farmers.[6] Standard deviations of net income streams based on these deflated items are denoted by *DSDNI*. The linear association of this measure with size of firm is

$$DSDNI = 1,930 + 0.129\ CXL, \qquad \overline{R}^2 = 0.67,$$
$$(8.56)$$

which is similar to the undeflated relationship.

The second approach used was to fit a linear time trend to net income from each property, and to record the residual variance about this trend. The square root of this variance is denoted by *RSDNI*. Since the trends in income are generally somewhat non-linear, the use of linear trends involves the possibility of introducing spurious elements into the residual variance. However, either such elements were apparently unimportant or the deflating series were inappropriate, since for most farms the deflated exceeded the residual standard deviation. An overview of these results is gained by comparing the sample means of *SDNI*, *DSDNI* and *RSDNI* which are 12,890, 12,250 and 11,230 respectively. On this basis the residual estimate, *RSDNI*, was judged as being most germane to the present discussion. Its linear association with size is indicated by

$$RSDNI = 1,660 + 0.119\ CXL, \qquad \overline{R}^2 = 0.62.$$
$$(7.86)$$

A linear relationship was definitely most appropriate for *RSDNI*, whereas scatter diagrams for the other two measures showed a slight tendency for the trends to be concave from below.

The last equation can readily be combined with the equation relating average net income to size to give a diagrammatic representation of relative and absolute variations experienced in net farm income. In Figure 1, expected net income predicted for different sizes of firm is compared with predicted net income at plus and minus one and two standard deviations computed from the last equation. Assuming income is normally distributed (and inspection of individual sets of data indicates that this is not an unreasonable approximation), net income received in any one year would fall within the inner band of Figure 1

[5] A further complicating effect may be the tendency for large firms denied the averaging provisions of the Income Tax Act to allocate capital expenditures in such a way as to make taxable income (and net farm income) less variable. For the first fourteen years of the study period, incomes could be averaged for taxation purposes providing the five-year moving average income did not exceed $8,000. In the last year of the study period this limit was extended to $16,000 [4].

[6] The indexing series were obtained from indices published in various issues of the *Quarterly Review of Agricultural Economics*. Since they relate to the whole of the Australian wool industry and all Australian farmers, respectively, they are not ideal for the use made of them here but were the best series readily available.
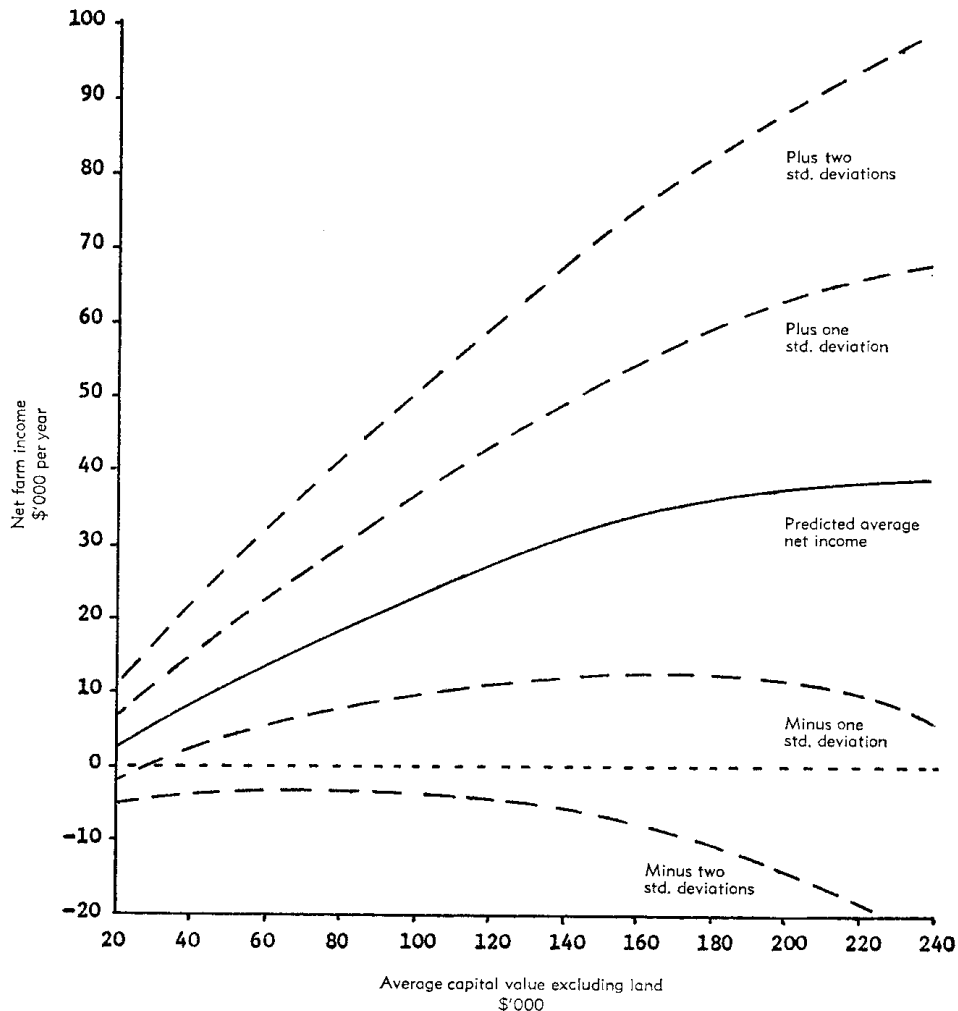
Figure 1. Size of firm and net farm income predicted on average and at plus and minus one and two standard deviations.

about 70 per cent of the time and within the outer band about 95 per cent of the time.

Interpolation between the two lower bounds suggests that, on the basis of performance over the study period, firms of any size tend to have had negative net incomes in at least 10 per cent of years. Firms of the smallest size considered have had negative incomes in about 25 per cent of years and thus will tend to be the first to suffer hardship as wool prices fall. In terms of Figure 1, a price decline is roughly equivalent to the zero-income axis being shifted upwards. Firms in the middle size range tend to be relatively the most stable under such a change. The largest firms appear to have fairly high probabilities of achieving negative incomes of considerable magnitudes but this situation is, of course, balanced to some extent by their history of occasional high levels of income. Overall the picture which emerges is remarkably similar to that sketched by Moore [14, pp. 113-114] in his synthetic analysis of variability of crop growing in California.

Figure 1 indicates that the coefficient of variation of net income initially declines and then increases as size of firm increases. However, for the previously mentioned reasons, direct statistical estimation of such a relationship is not very satisfactory. These implications apparent for small and large firms are further reinforced by some B.A.E. work [12, pp. 185-186]. In a classification of farms by net income over the three-year period which encompassed the severe drought of 1965, Malikides and Cumming [12] found that properties in the least successful group tended to be considerably smaller than those in the most successful group.

Recent industrial studies of variability of financial performance, and size of firm have concentrated attention on rate of return on capital as the profit measure whose variability is investigated. This measure is generally readily available compared with, say, internal rate of return and is an appropriate measure when a cross-section of firms of widely differing size in involved. In this section, rate of return on capital excluding land is used for analogous comparisons of variability.

In the U.S.A., Steckler [20] found an inverted U-shaped relationship between size of firm and time-variability of profit rates to hold for industrial firms. Samuels and Smyth [19], who found an inverse relationship between size of firm and variability of profit rates for U.K. firms, noted that their findings were not necessarily in conflict with Steckler's because he had probably induced a downward bias in his estimates of variance for small firms by eliminating unprofitable firms from his sample.

The data for the Continuous Group revealed no simple and consistent relationship between variability of rate of return and size of firm. Variability was measured variously by standard deviations and variances of original and deflated series and of residuals about time trends. The finding that size did not influence this variability in any simple and unambiguous manner suggests that if variability of rate of return is influenced by size, the effect is probably slight and in this instance was masked through the operation of other influences.

The most interesting empirical relationship found is analogous to that reported earlier for rate of return and size and intensity of capital per sheep (CPS). Following Samuels and Smyth [19], variability was measured by the residual variance of rate of return ($RVRR$) about a linear time trend. The sample mean of this variance was 223. Comparisons with other measures, including those based on deflated series, indicated that this measure is satisfactory for this purpose. The independent influence of size is observed to be somewhat ambiguous in the equation

$$RVRR = 569 - 17\cdot1\,CPS - (5\cdot18)\,10^{-4}\,CXL, \quad \bar{R}^2 = 0\cdot23.$$
$$(3\cdot51) \qquad (1\cdot30)$$

Since only one-quarter of the variance in $RVRR$ is 'explained' here, factors other than capital measures must be operative although none was identified. The t test for the CXL variable can be interpreted as indicating that if size really had no effect on variability, a regression coefficient of this magnitude could be recorded in about 20 per cent of such estimations. As such, a conclusion that large properties have less variable rates of return than small must be rather tentative. On the

other hand, decline in variability with increasing intensity of capital improvements seems to be well defined but to some extent this decline may be confounded by the negative correlation between capital intensity and size (simple correlation coefficient -0.43) and the tendency for smaller properties to be in less risky areas (see footnote 2).

Summary

The primary purpose has been to provide empirical evidence on the risk experienced by pastoralists in the arid sheep zone of eastern Australia, as previously there has been no collection of data on this important question. Cross-sectional regression analyses have indicated the extreme variability experienced over a recent period of 15 years. There is, however, much scope for refinement and future farm management research should be addressed to determining how time-variability is influenced by such factors as stocking rates, drought strategies, credit and taxation arrangements, corporate ownership, etc.

A conclusion concerning the initial hypothesis that risk in pastoral sheep farming varies with size of firm depends upon how risk is measured. For a variety of reasons probably connected with risk and credit management, it appears that net income increases at a diminishing rate with increasing size of firm while standard deviation of net income increases at a constant rate. When correction is made for the level of property improvement, and profitability is measured as a rate of return on invested capital, the evidence suggests that the tendency is for larger firms to be more profitable and possibly less risky than smaller firms. Tentative support is given to two general hypotheses emerging from studies in secondary industry, namely (a) that large firms tend to have less variable rates of return than small firms and (b) that firms which face relatively large risks tend to enjoy relatively high average rates of return.

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