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# FARM SYNDICATION AND RISK SHARING: A CASE STUDY*

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**The effectiveness of fully integrated group farming as a means of permitting farmers to achieve economies by working together and to share risk is investigated using two case-study farms from the mid-north region of S.A. Linear programming is used to explore the scope for economies achievable through group farming. The results show that, by joint use of resources, total net farm income can be increased and average costs per unit value of output can be reduced. The risk-sharing advantages of group farming are examined using quadratic risk programming. A group farm plan is found that generates a risky income which, when shared between the two risk-averse farmers, allows both to increase their expected utilities. The group plan also generates a higher aggregate expected net farm income than with sole ownership.**

## *Introduction*

Farm syndication (group farming) can be viewed as a means of rural adjustment and of adapting to a risky world. In this paper attention is focussed on the possible economies and possible risk reduction resulting from group farming. Particular attention is given to the economics of size of the multi-product agricultural firm. By amalgamating the resources of two or more mixed farms it may be possible to reap economies of size in individual enterprises while maintaining or increasing the level of enterprise diversification. Group farming may, therefore, have advantages for risk-averse farmers in providing opportunities for greater spreading of risk through diversification and in permitting a degree of insurance by sharing of risks among the partners.

## *What is Group Farming?*

Group farming is defined broadly as the working together of two or more farmers in farm production (Bartholomaeus and Powell 1979). A fully integrated group farm involves the pooling of all the production resources of several farms into one business organisation. Four resources can be defined: land, capital, labour and management. Ownership of land is retained by the individuals who lease their land to the new operating entity. Capital (machinery and livestock) is contributed by the individuals involved to form the basis of the new business unit. The people involved hire their labour and management skills to the group.

The gross farm income generated by the group is used to meet annual operating and overhead costs. The balance, or net farm income (NFI), is then distributed to provide a return on capital invested in land, working capital (machinery, livestock and purchased inputs), owner labour and management and profit (or loss), as illustrated in Figure 1.[1]

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[1] Profit (or loss) in this case is the residual following payment of rent, wages and interest from NFI. In most groups the residual is shared equally between the participants.

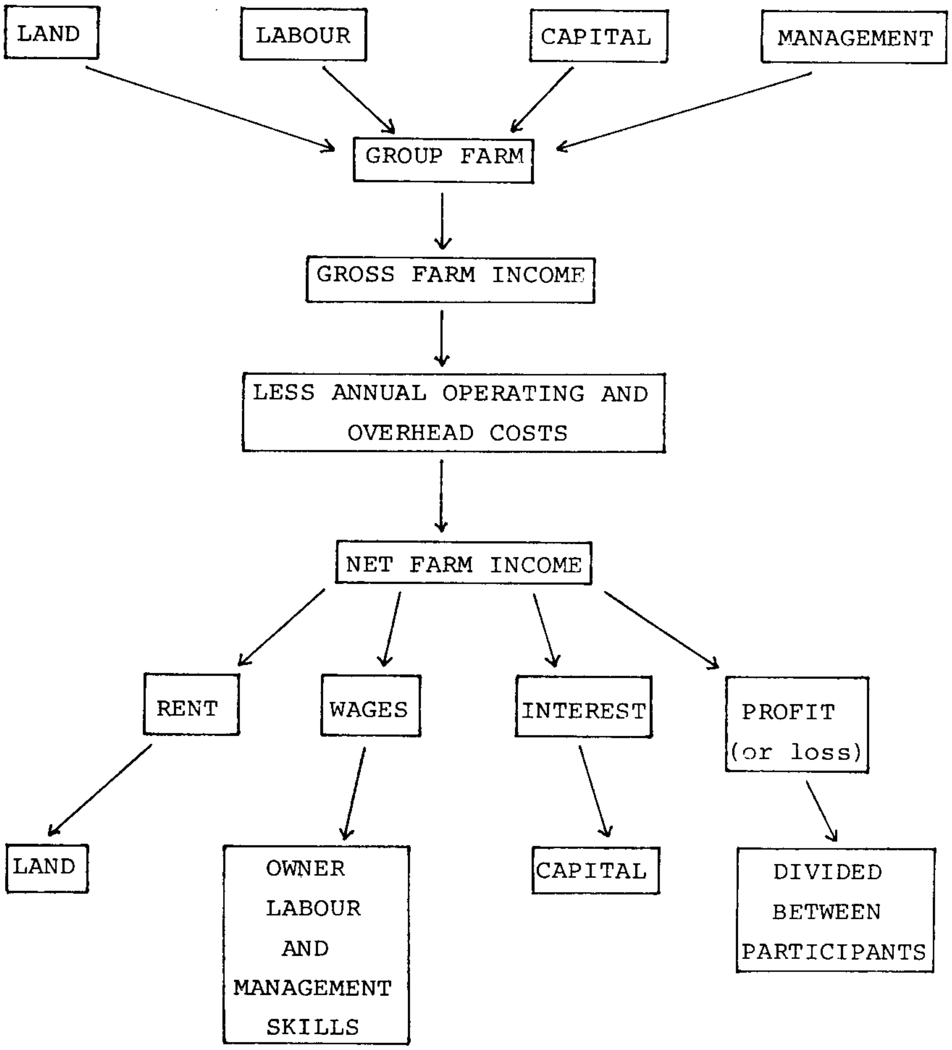


FIGURE 1—The structure of a group farm (adapted from Wynter (1975)).

Unlike a farm where all resources are owned by one person, for a group farm it is important to distinguish between the various resources so that the members of the group can be rewarded equitably (O'Sullivan 1972; Wynter 1975). The fully integrated group farms in Australia are generally operated on the basis that the resources used are paid a realistic market return. Market rentals are paid to the owners of the land, wages paid to those members who work, and a market interest rate paid on all working capital contributed by members. The residual profit or loss remaining after these payments have been made from the group NFI is then allocated between the participants in some predetermined way.

## *The Economic Gains from Group Farming*

### *The hypotheses*

The question addressed in this study is whether group farming can aid

TABLE 1

*Comparison of Case Study Farms with Wheat Farms in the Mid-North Region and Australia*

| | Area | Total[b] capital | Capital/[b] hectare | Net farm[b] income | Return on capital |
|---|---|---|---|---|---|
| | ha | $ | $/ha | $ | % |
| MNR farms[a] | 641 | 187 355 | 324 | 19 874 | 6.01 |
| Australian farms[a] | 1 144 | 230 858 | 181 | 21 219 | 5.62 |
| Farm 1 | 380 | 287 103 | 756 | | |
| Farm 2 | 383 | 271 549 | 709 | | |

[a] Source: BAE (1973; 1979); averages from the two surveys.

[b] Adjusted by the Consumer Price Index.

adjustment of land, labour and capital resources of several farms and reduce the risk associated with annual NFI of the farmers involved.

A case study approach is adopted, using two farms from the mid-north region (MNR) of S.A. This region lies within the Wheat-Sheep Zone, due north of Adelaide. As shown in Table 1, farms in the region are small by Australian standards, in terms of both area and total capital investment. On the other hand, the total capital investment per hectare is high. The two case-study farms are no exception, being even smaller and more capital intensive than the averages for the MNR.

Although returns to capital and average NFI for farms in the MNR are close to, or above, the Australian average, farmers in the region, like others elsewhere, need to strive constantly to adjust to changing economic circumstances and opportunities if they are to continue to prosper. Many farmers try to adjust by increasing the scale of their operations, but capital rationing and competition for land often constrain the rate at which such expansion can occur.

Farming in the MNR is also risky. Variability in weather conditions and product prices make planning difficult in the medium term (4-5 years). Risk-averse farmers may be presumed to react to this by using their resources in a sub-optimal way in terms of maximising expected income (Anderson, Dillon and Hardaker 1977, Ch. 6).

In this study, it has been assumed that farmers maximise expected utility. Society, on the other hand, is assumed to be interested in the efficiency with which agricultural resources are used. Maximisation of expected farm profit is taken as a surrogate for society's objectives. On the basis of these assumptions, and to make explicit the research aims, the following hypotheses have been formulated:

1. group farming allows expansion in the scale of operation of enterprises, permitting size economies to be reaped;
2. the size economies of group farming, combined with opportunities for continued or increased diversification, can increase the expected utilities of the individuals involved; and
3. by forming a group, the farming operation can be moved closer to the expected profit maximising position without loss of expected utility to the individual farmers.

Hypotheses 1 and 2, taken together, imply that group farming can capture the benefits of both size and diversification. When a group farm is formed from a number of similar small farms, the size of each enterprise will increase in approximately the same proportion as the total resource base of the business. This may permit the group farm to remain diversified while reaping any economies of size associated with the expanded enterprises. In the absence of group farming, economies of size within an enterprise may be achievable only at the expense of the degree of diversification, and even then perhaps only to a limited extent.

Hypothesis 3 implies that the cost to society in sub-optimal resource use as a consequence of risk-averse behaviour by farmers is likely to be less under group farming.

### *Group farming and the long-run average cost curve*

In this study the group farming situation is simulated by amalgamating the resources of the two case-study farms and allowing these resources to be utilised by one business entity. If risk considerations are ignored, hypothesis 1 can be discussed in terms of the long-run average cost (LRAC) curve facing the case-study farmers. If a farmer is facing constraints preventing him from adjusting, he will not be operating at the profit maximising point on his LRAC curve. The question of whether group farming can help overcome these constraints is investigated in this study.

The potential economic advantages from group farming can arise in a number of ways. If existing farm resources are aggregated and rationalised with the formation of a fully integrated group farm, some economies might be achieved. The rationalisation of resources might involve the sale of duplicated equipment and rostering of labour for shift work to enable the remaining machinery to be used more fully. Further possible economies may be achieved by moving from the use of several small machines to fewer, larger ones. Labour economies and other operating economies may be associated with the more advanced technology often found in larger machines. Similarly, machines now more fully utilised may justifiably be replaced more frequently, permitting the more rapid adoption of any improved technology embodied in new models. Further (probably minor) productivity gains may be made from labour specialisation and from the sale of larger, more even lines of produce. There may also be pecuniary economies associated with bulk buying of inputs (Tuck 1970). Finally, if group farming allows capital savings to be achieved (for example, through rationalising machinery), the group may be able to invest that capital to increase the total size of the farm operation enabling a further movement out along the LRAC curve.

## *Research Approach*

Linear programming (LP) and quadratic risk programming (QRP) were used to test the hypotheses. The basic structure of the matrices is given in Appendix I. Further details can be found in Bartholomaeus (1981*a*).

TABLE 2

*Farm Plans Obtained from Maximising Expected Net Farm Incomes*

| | | Farm 1 | Farm 2 | Aggregate ($F_1 + F_2$) | Group farm |
|---|---|---|---|---|---|
| Barley 1 (stubble)[a] | ha | 58.8 | 3.3 | 62.1 | 17.8 |
| Barley 2 (stubble) | ha | 0 | 73.7 | 73.7 | 126.0 |
| Barley 3 (pasture) | ha | 26.5 | 77.0 | 103.5 | 143.8 |
| Barley 4 (pasture) | ha | 32.3 | 0 | 32.3 | 0 |
| Lucerne seed | ha | 22.0 | 0 | 22.0 | 22.0 |
| Merino wethers | no | 1 084 | 755 | 1 839 | 1 932 |
| Lucerne grazing | ha | 23.0 | 0 | 23.0 | 23.0 |
| Contract harvest | h | 107 | 93 | 200 | 193 |
| Total pasture | ha | 217.6 | 229.0 | 446.6 | 462.6 |
| Feed transfers winter | 1sm | 0 | 24 | 24 | 0 |
| spring | 1sm | 7 280 | 4 850 | 12 130 | 12 190 |
| summer | 1sm | 2 930 | 2 250 | 5 180 | 5 080 |
| autumn | 1sm | 344 | 0 | 344 | 90 |
| Employed labour | | | | | |
| January | h | 86 | 26 | 112 | 114 |
| April | h | 0 | 49 | 49 | 0 |
| May | h | 0 | 14 | 14 | 0 |
| June | h | 3 | 99 | 102 | 35 |
| August | h | 0 | 0 | 0 | 8 |
| September | h | 0 | 20 | 20 | 0 |
| October | h | 0 | 0 | 0 | 17 |
| December | h | 27 | 144 | 171 | 87 |
| Buy land | ha | 0 | 0 | 0 | 32 |
| Total gross margin | $ | 32 702 | 30 780 | 63 482 | 70 024 |
| Total overhead costs | $ | 11 050 | 12 110 | 23 160 | 21 010 |
| Net farm income | $ | 21 652 | 18 670 | 40 322 | 49 014 |
| Variance | $\$10^6$ | 118.20 | 267.70 | n.a. | 907.17 |
| Total cost per $1000 value of output | $ | 643 | 628 | 636 | 556 |

[a] The different barley activities relate to time of sowing. Barley 1 and Barley 3 being early, and Barley 2 and Barley 4 being late.

### *Linear programming and size economies in group farming*

Linear programming solutions were obtained for both case study farms as they exist currently. These were added to give an aggregate measure of the maximum expected NFI obtainable without group farming.

For comparison, an LP solution was obtained with group farming. In amalgamating the resources of the two farms to simulate the group farming situation, only the existing livestock, labour and machinery resources were rationalised. No machinery was sold off and replaced by larger, more modern equipment. Only duplicated machinery was sold off where excess capacity was generated in the group farming situation. As only the larger machinery from the two farms was retained for the group farm, some labour economies would also be included in the LP solution for the group farm. There was an allowance made for reinvesting the capital generated from the sale of duplicated machinery in more land.

The LP solutions were used to test hypothesis 1 relating to economies of size with group farming. The null and alternate hypotheses to test hypothesis 1 were:

TABLE 3

*Unused Levels of Labour and Tractor Hours (LP Solution)*

| Resource | Farm 1 | Farm 2 | Aggregate ($F_1 + F_2$) | Group farm | Change |
|---|---|---|---|---|---|
| | h | h | h | h | h |
| Labour | | | | | |
| January | 0 | 0 | 0 | 0 | 0 |
| February | 76 | 160 | 236 | 236 | 0 |
| March | 63 | 50 | 113 | 62 | −51 |
| April | 93 | 0 | 93 | 103 | +10 |
| May | 56 | 0 | 56 | 71 | +15 |
| June | 0 | 0 | 0 | 0 | 0 |
| July | 99 | 10 | 109 | 97 | −12 |
| August | 25 | 50 | 75 | 0 | −75 |
| September | 128 | 0 | 128 | 178 | +50 |
| October | 20 | 50 | 70 | 0 | −70 |
| November | 128 | 50 | 178 | 178 | 0 |
| December | 0 | 0 | 0 | 0 | 0 |
| Tractor hours | | | | | |
| April | 25 | 45 | 70 | 35 | −35 |
| May | 96 | 78 | 174 | 189 | +15 |
| June | 61 | 134 | 195 | 159 | −36 |
| July | 116 | 95 | 211 | 215 | +4 |

$$H_0 : \text{Group } E(NFI) > [\text{Farm 1 } E(NFI) + \text{Farm 2 } E(NFI)];$$
$$H_1 : \text{Group } E(NFI) \leq [\text{Farm 1 } E(NFI) + \text{Farm 2 } E(NFI)].$$

The results obtained are summarised in Table 2. The lowering of total overhead costs for the group farm is in response to smaller total investment in plant and machinery (lower machinery depreciation and insurance costs). The changes in labour and tractor use are given in Table 3. The two important points to note are that, with group farming, total NFI can be increased by $8692 and the average total cost reduced by $80 per $1000 value of output.

From Tables 2 and 3 it is apparent that the group farm can make better use of the available labour, needing to employ less outside labour. Although the levels of unused tractor hours with the group farm are reduced, there is still unused capacity in all critical months. This is despite the fact that the group farm uses only one tractor where two tractors of the same size were needed previously. This can be achieved on the group farm by allowing labour to be rostered on a day and night shift basis when needed for tractor driving. On the individual farms, tractor hours were limited to 12 per day unless additional labour was employed for night driving.

On the basis of the LP results hypothesis 1 can be accepted, indicating that, from society's point of view, group farming can be used to aid adjustment, that is, facilitate movements around the LRAC curve.

### *Risk sharing in group farming*

Even if hypothesis 1 had been rejected, group farming may still allow the individuals involved to reduce the risks involved in farming. Most Australian farmers are risk averse (Officer and Halter 1968; Francisco and Anderson 1972; Bond and Wonder 1980). If the assumption of certainty is dropped, the analysis must be cast in terms of expected short-run average cost (SRAC) curves and expected LRAC curves.

To reduce the risk they face, risk-averse farmers may over-capitalise in machinery and labour resources, diversify their farm activities between products and spatially, and adopt a conservative approach to planning, all with the effect that marginal costs are no longer equated to marginal revenues as required for profit maximisation under the traditional theory of the firm. In consequence, many farmers may be operating on expected SRAC curves that are not on the expected LRAC curve, and perhaps well away from the expected profit maximising point.

Hypothesis 2 is designed to test whether the economies and enterprise diversification elements of group farming can reduce the total level of risk, enabling risk-averse farmers to achieve a higher level of expected utility.

QRP was used to find the farm plans which maximise expected utility for the individual farmers. Negative exponential utility functions of the form:

$$(1) \qquad U = 1 - e^{-\alpha w},$$

were derived for each farmer,

where $\alpha$ = the Arrow-Pratt coefficient of risk aversion given by $-U''(w)/U'(w)$; and
$w$ = annual income.

Following the technique used by Freund (1956), the following model was used:

$$(2) \qquad \begin{aligned} &\text{Maximise } z = c'x - 0.5\,\alpha x'Qx, \\ &\text{s.t.} \quad Ax \lesseqgtr b, \text{ and} \\ &\qquad x \geq 0, \end{aligned}$$

where $x$ = an $n \times 1$ vector of activities;
$c$ = an $n \times 1$ vector of expected gross margins;
$Q$ = an $n \times n$ variance-covariance matrix of the gross margins;
$\alpha$ = the Arrow-Pratt coefficient of risk aversion;
$b$ = an $m \times 1$ vector of resource availabilities; and
$A$ = an $m \times m$ matrix of input-output coefficients.

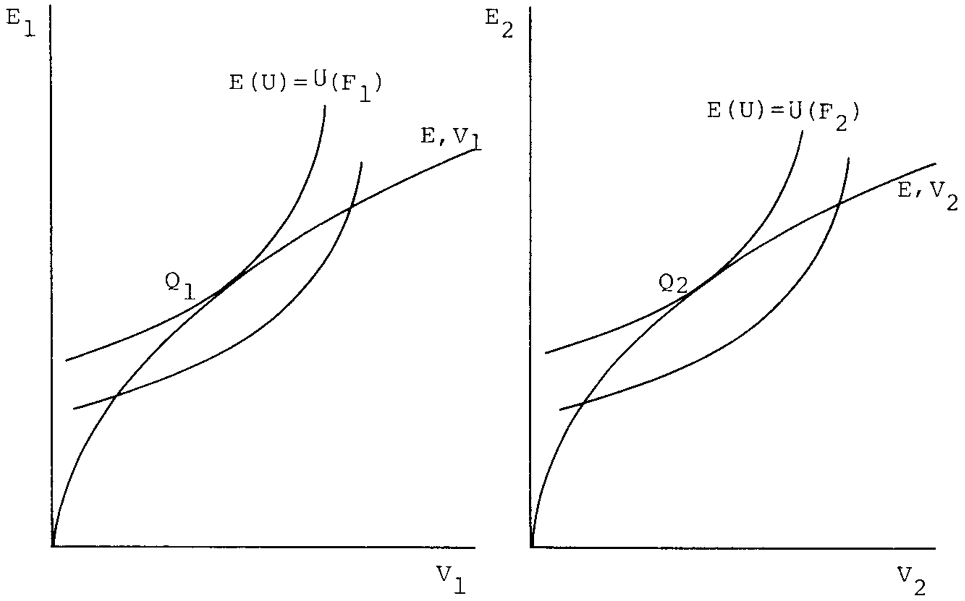
In equation (2) the decision maker's certainty equivalent is maximised, which is equivalent to maximising his expected utility.

To test hypothesis 2 it is necessary to calculate expected utility levels with and without group farming so that the following null and alternate hypotheses can be tested:

$$H_0: U(F_1)^* \geq U(F_1) \text{ and } U(F_2)^* \geq U(F_2);$$

$$H_1: U(F_1)^* < U(F_1) \text{ or } U(F_2)^* < U(F_2),$$

where $U(F_i)^*$ represents the expected utility level of Farmer $i$ with group farming. Considering the situation without group farming, farm plans



Farm 1 Farm 2

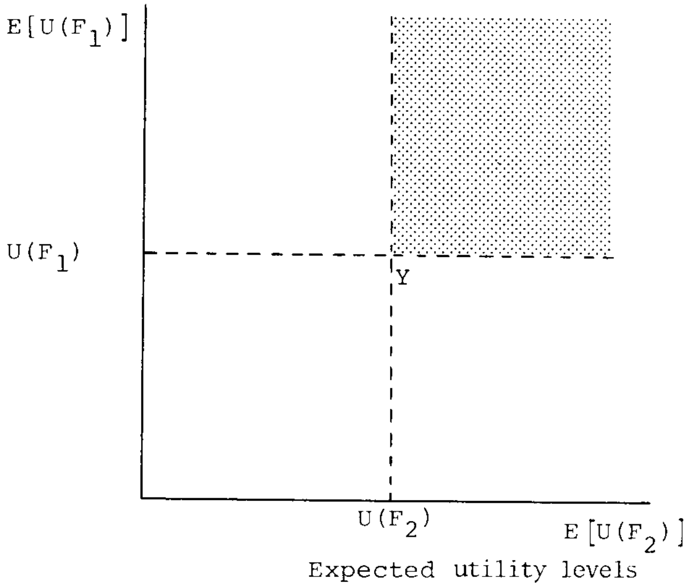


FIGURE 2—Maximising expected utility without group farming.

which maximise expected utility can be defined for the individual farmers. The associated utility levels can be plotted in utility space as shown in Figure 2. With group farming, if the null hypothesis of hypothesis 2 holds, a new point must be defined in utility space within the shaded area.

Difficulties arise in trying to determine expected utility levels for the individuals with group farming. The net farm income generated by the group farm will be a random variable with a known expected value and variance calculated for each point on the group E-V frontier using QRP. If the utility functions of the individual decision makers could be combined into a social welfare function, a point on the group E-V frontier could be defined which maximises social welfare for the group farmers. This would still leave the problem of partitioning a risky prospect (the group NFI) between the individual decision makers. An optimal sharing rule can only be defined if individual utility functions can be compared.

If a point on the group E-V frontier is chosen, then the set of joint utility evaluations arising from all possible partitions of the group NFI can be plotted in the utility space. The boundary of this set can be called the utility possibility frontier. A different point on the group E-V frontier will yield a new utility possibility frontier. Hypothesis 2 can only be accepted if a utility possibility frontier passing through the shaded area of Figure 2 is found.

In the absence of a social welfare function it is not possible to find the optimal utility possibility frontier, or the optimal partitioning of the risky prospect (that is, the optimal point on the utility possibility frontier). However, in the special case of the negative exponential utility function a general sharing rule can be defined. Based on this rule it is also possible to make a selection between several lotteries (that is, points on the group E-V frontier) when more than one decision maker is involved (Raiffa 1968, Ch. 8).

Given equation (1) and given two decision makers, Raiffa proves that all Pareto-efficient partitions of a lottery take the form of an initial side payment from one individual to another, followed by proportional shares of the lottery in the ratio $\alpha_1^{-1}$ to $\alpha_2^{-1}$. In this study, Farmer 1's proportional share of the group NFI would be:

$$\varrho_1 = \alpha_1^{-1}/(\alpha_1^{-1} + \alpha_2^{-1}), \tag{3}$$

with the side payment determining the position of the partition on the Pareto-efficient boundary (i.e. the utility possibility frontier). Raiffa also shows that Farmer 1 would have to make a side payment given by:

$$b = [\alpha_1^{-1}\,\alpha_2^{-1}/(\alpha_1^{-1} + \alpha_2^{-1})] \log [\lambda_2\,\alpha_1^{-1}/\lambda_1\,\alpha_2^{-1}]. \tag{4}$$

The side payment will be positive if $\lambda_2\,\alpha_1^{-1} > \lambda_1\,\alpha_2^{-1}$, zero if $\lambda_2\,\alpha_1^{-1} = \lambda_1\,\alpha_2^{-1}$ and negative if $\lambda_2\,\alpha_1^{-1} < \lambda_1\,\alpha_2^{-1}$. The value $\lambda$ is a weight applied to the individual utility functions such that $\lambda_1 + \lambda_2 = 1$.

This sharing rule is linear and can be summarised for all states of nature as:

$$w_{k1} = \varrho w_k - b; \text{ and} \tag{5}$$

$$w_{k2} = (1 - \varrho)w_k + b, \tag{6}$$

where $w_k$ = the aggregate net income for state $k$; and
$w_{ki}$ = the net income received by farmer $i$ given state $k$.

If it were possible to place relative weights on the utility functions of individuals, equations (4) and (5) would be sufficient to define the optimal point on a utility possibility frontier.

Given the linear sharing rule associated with negative exponential utility functions and risk sharing, it is possible for a group to make an optimal choice between several possible lotteries. Raiffa (1968) shows that the optimal lottery will be the one which maximises:

$$(7) \qquad CME_1(\varrho_1 \,.\, L) + CME_2(\varrho_2 \,.\, L) = CME^*(L),$$

where $CME_i$ is individual $i$'s certainty equivalent for $(\varrho_i \,.\, L)$ which is his proportional share of a lottery, $L$. The value $CME^*$ $(L)$ is the certainty equivalent of the lottery $L$, determined from the utility function:

$$(8) \qquad U = 1 - e^{-\alpha^* w},$$

where $\alpha^* = (\alpha_1^{-1} + \alpha_2^{-1})^{-1}$.

In the special case where the risky prospect has an unknown payoff that is normally distributed with mean $\mu$ and variance $\sigma^2$, the certainty equivalent of $(\varrho \,.\, L)$ for an exponential utility function is:

$$(9) \qquad CME(\varrho \,.\, L) = \varrho\mu - 0.5\alpha(\varrho\sigma)^2.$$

Hence,

$$(10) \qquad CME_1(\varrho_1 \,.\, L) + CME_2(\varrho_2 \,.\, L) = \mu - 0.5\alpha^*\sigma^2.$$

Maximising (10) is the same as maximising (2) where the risk coefficient is a group coefficient ($\alpha^*$) made up from the risk coefficients of the individual decision makers.

The risk coefficients derived for the individual farmers and the group were:

| | |
|---|---|
| Farmer 1 | $\alpha_1 = 7.538 \times 10^{-5}$; |
| Farmer 2 | $\alpha_2 = 1.5305 \times 10^{-5}$; and |
| Group | $\alpha^* = 1.272 \times 10^{-5}$. |

Using these in equation (2) the results presented in Table 4 were obtained. The farm plans presented in Table 4 can be compared with those in Table 2 to give an indication of the effects of risk averse behaviour. There has been some change in the enterprise mix in each case, resulting in small decreases in the expected NFIs and large decreases in the associated variances of NFI. This indicates that the E-V frontiers are relatively flat at the upper income levels. This is consistent with E-V frontiers estimated by Lin, Dean and Moore (1974).

The group NFI was then partitioned between the two farmers. In line with other group farming ventures in Australia, fixed annual payments were allocated to the individuals for the use of the land, labour and capital they each contributed to the group venture.[2] These payments were based on current market rentals, wages and interest rates in 1978 (see Table 5). The expected residual NFI which embodies all the risk associated with the group farming operation was then distributed in the proportions suggested in equation (3). No side payments were allowed for because of the difficulty associated with weighting the utility functions of the two farmers on a relative basis.[3]

On the basis of the results presented in Table 6, hypothesis 2 can be accepted. Both farmers can increase their certainty equivalents with group

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[2] In this analysis the returns to labour also include returns to management.

[3] This implies that $b = [\alpha_1^{-1}\,\alpha_2^{-1}/(\alpha_1^{-1} + \alpha_2^{-1})] \log [\lambda_2\,\alpha_1^{-1}/\lambda_1\,\alpha_2^{-1}] = 0$, so that $\lambda_1 = 0.8312$ and $\lambda_2 = 0.1688$.

TABLE 4

*Farm Plans Obtained from Maximising the Certainty Equivalents*

| | | Farm 1 | Farm 2 | Aggregate ($F_1+F_2$) | Group farm |
|---|---|---|---|---|---|
| Wheat 1 (pasture) | ha | 54.6 | 67.2 | 121.8 | 99.4 |
| Barley 1 (stubble) | ha | 58.8 | 77.0 | 135.8 | 135.8 |
| Barley 3 (pasture) | ha | 4.1 | 9.8 | 13.9 | 36.3 |
| Lucerne seed | ha | 22.0 | 0 | 22.0 | 22.0 |
| Merino wethers | no. | 1 009 | 755 | 1 764 | 1 864 |
| Beef cattle | cows | 0 | 0 | 0 | 6 |
| Lucerne hay | ha | 46.0 | 0 | 46.0 | 23.0 |
| Contract harvest | h | 111 | 97 | 208 | 205 |
| Total pasture | ha | 217.6 | 229.0 | 446.6 | 446.6 |
| Feed transfers | | | | | |
| winter | lsm | 0 | 24 | 24 | 0 |
| spring | lsm | 5 339 | 4 850 | 10 189 | 11 840 |
| summer | lsm | 2 035 | 2 250 | 4 285 | 4 910 |
| autumn | lsm | 31 | 0 | 31 | 110 |
| Employed labour | | | | | |
| January | h | 84 | 26 | 110 | 112 |
| April | h | 0 | 49 | 49 | 0 |
| May | h | 0 | 51 | 51 | 0 |
| June | h | 0 | 107 | 107 | 35 |
| September | h | 0 | 20 | 20 | 0 |
| October | h | 0 | 0 | 0 | 9 |
| December | h | 27 | 144 | 171 | 87 |
| Buy land | $ | 0 | 0 | 0 | 21 800 |
| Expected NFI | $ | 21 090 | 18 020 | 39 110 | 48 080 |
| Variance | $\$10^6$ | 64.56 | 150.9 | n.a. | 515.1 |
| Coefficient of variation | % | 38 | 68 | n.a. | 47 |
| Certainty equivalent | $ | 18 660 | 16 865 | 35 525 | 44 805 |

farming, implying increases in their levels of expected utility. The increases in expected utility can be attributed directly to the specialisation and enterprise diversification benefits of group farming.

Accepting hypothesis 2 does not imply that the increases in expected utility levels have been accompanied by an increase in expected total NFI with group farming. It is conceivable that large reductions in risk with

TABLE 5

*Resource Contributions and Fixed Annual Payments to the Farmers*

| Resource | Annual unit value (1978) | Farm 1 | | Farm 2 | |
|---|---|---|---|---|---|
| | | Resource level | Annual value | Resource level | Annual value |
| | $/unit | | $ | | $ |
| Arable land (ha) | 34.00 | 280 | 9 520 | 308 | 10 470 |
| Improved pasture (ha) | 18.50 | 61 | 1 130 | 30 | 550 |
| Unimproved pasture (ha) | 12.35 | 39 | 480 | 45 | 560 |
| Labour (h) | 4.00 | 1 536 | 6 140 | 910 | 3 640 |
| Capital ($) | 10% | 64 500 | 6 450 | 62 070 | 6 210 |
| Total payments ($) | | | 23 720 | | 21 430 |

## TABLE 6

*Expected Utility Levels with and without Group Farming*

| | Farmer 1 | | Farmer 2 | |
|---|---|---|---|---|
| | Without GF | With GF | Without GF | With GF |
| Guaranteed annual payments ($) | n.a. | 23 720 | n.a. | 21 430 |
| Share of residual ($) | n.a. | 495 | n.a. | 2 435 |
| Expected NFI ($) | 21 090 | 24 215 | 18 020 | 23 865 |
| Variance (\$$10^6$) | 64.56 | 14.68 | 150.9 | 355.9 |
| Coefficient of variation (%) | 38 | 16 | 68 | 79 |
| Certainty equivalent ($) | 18 660 | 23 660 | 16 865 | 21 140 |
| Expected utility (utiles) | 7.5 | 8.3 | 2.3 | 2.7 |

group farming may outweigh reductions in total NFI when the benefits of group farming are analysed in an expected utility maximising framework. Hypothesis 3 is designed to test whether simultaneous increases in total NFI and in the individuals' expected utilities are possible.

The null and alternative hypotheses to test hypothesis 3 were:

$H_0$: $U(F_1)^* \geq U(F_1)$ and
$U(F_2)^* \geq U(F_1)$ and
Group $E(NFI)^* \geq$ (Farm 1 $E(NFI)^*$ + Farm 2 $E(NFI)^*$);
$H_1$: $U(F_1)^* < U(F_1)$ or
$U(F_2)^* < U(F_2)$ or
Group $E(NFI)^* <$ (Farm 1 $E(NFI)^*$ + Farm 2 $E(NFI)^*$),

where $U(F)^*$ = the expected utility level achieved with group farming;
$U(F)$ = the expected utility level achieved without group farming; and
$E(NFI)^*$ = the expected net farm income earned when the certain equivalent is maximised.

The results of this study, presented in Table 6, indicate that both the expected NFI levels and the expected utilities of both farmers can be increased simultaneously. On this basis hypothesis 3 can be accepted.

### *Concluding Comments*

The results of the study confirm that the resources of the two case-study farms could be used more efficiently with group farming, in the sense that, by working together, both farmers could increase their expected net incomes. Taking risk into account, both individuals could increase their levels of expected utility, as well as their expected net farm incomes, with group farming. Operating as individuals the farmers could only increase the efficiency with which they use their respective fixed sets of resources by moving away from their expected utility maximising positions.

An additional benefit from operating in a group farming situation is that the risks can be shared between the participants. As shown by Raiffa (1968), a group will be less risk averse than any of the individual members of that group. This is because there is scope to partition the risky prospect between the participants on the basis of their respective attitudes to risk, as measured by their risk coefficients. In the special case where negative exponential utility functions are assumed, the risky prospect can be partitioned in the ratio of the individual's risk coefficients.

Group farming is only one option of several ways of organising production that can affect farm income and the associated level of risk. Share-farming arrangements, making use of agricultural contractors and seeking some off-farm employment, are other alternatives being used by some farmers to improve their annual incomes and reduce income fluctuations. While the results presented in this paper refer to one case study, it can be seen that group farming is at least a viable alternative for some farmers wishing to improve the efficiency of their farming operations.

More literature about group farming systems is becoming available (for example, Kennedy 1977; Webb 1977; Davies 1979, 1980; Bartholomaeus 1981*a*, *b*), describing how the groups can be organised and reporting actual case studies. Little work has been done, however, to substantiate the claims of the economic benefits beyond the individual case-study level. While the results presented in this paper relate to a case-study approach, it is hoped that some insight into the economic benefits has been gained through the type of analysis performed. This is essential if the work is to be extended to investigate the desirability and impact of group farming as a means of rural adjustment.

## APPENDIX I

The basic structure of the input-output matrices for the LP and QRP models is given in Table A.1. The matrix for Farm 2 differed slightly in that there were no lucerne activities. For the group farm there was no link between hiring labour and available tractor hours.

The matrix structure was dictated by the requirements for QRP. Risk could only be expressed through the activity gross margins. For example, risk in the pasture and lucerne grazing acitivities (fluctuating yields) was taken account of in the livestock gross margins, where a constant stocking rate from year-to-year was assumed with production, and therefore the gross margins, fluctuating in response to pasture yields. The variance-covariance matrices were calculated for the stochastic activities for each farm. Specific details regarding the LP and QRP models can be found in Bartholomaeus (1981*a*).

## TABLE A.1

*Basic Structure of the Input-Output Matrices*

| | STOCHASTIC ACTIVITIES | | | | | | | NON-STOCHASTIC ACTIVITIES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cereal crops | Lucerne seed crops | Merino sheep | | Beef cattle | | Pasture hay | Lucerne for grazing | Pasture grazing | Contract harvesting | Hire labour (monthly) |
| | | | Hay | No hay | Hay | No hay | | | | | |
| Land con-straints | □ | □ | | | | | | □ | □ | | |
| Labour con-straints (monthly) | □ | □ | □ | □ | □ | □ | □ | | | □ | □ |
| Tractor hours (monthly) | □ | □ | | | | | □ | | | | □ |
| Harvesting hours (monthly) | □ | | | | | | | | | □ | |
| Feed pool (seasonal) | □ | □ | □ | □ | □ | □ | □ | □ | □ | | |
| Hay pool | | □ | □ | | □ | | □ | | □ | | |

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