An Investigation of the Relationship between Business and Financial Risk using Target - MOTAD: A Case Study in the Victorian Mallee

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1. Introduction

The relative contribution of financial risk and business risk to overall riskiness of a farm-firm has become a more significant issue in the Australian wheat industry recently. On the financial side, the reasons for this include financial deregulation, which has enabled farmers effectively to draw debt finance from a wider, more competitive market; and higher interest rates, which increase both the costs of debt finance and the likelihood of being unable to service the debt. On the business risk side there are the continuing inherent production and price risks of farming operations, and in addition particular current uncertainties concerning deregulation of wheat marketing.

It was in this environment that the issue of the impact of debt financing on our case-study farm was analysed. This farm was a typical cereals-mixed livestock enterprise in the Mallee in Victoria. The objective was to investigate the nature of the trade-off between financial risk and business risks in a total risk management approach to farm planning. The influence of fixed financial obligations on the production mix of farm enterprises was of particular interest.

The study is in line with Powell's (1987, p 6) thoughts that "Researchers can perform an independent and complementary role in the development and evaluation of finance products and plans, the development of suitable PC models for evaluating alternative finance plans and the relative cost of alternative ways of managing and sharing risk." Powell (1987, p 11) also notes that the discussion of future research issues should be directed "particularly for research in the area of the provision of rural finance and farm financial and risk management."

To achieve the above objectives the method applied was to:

(a) identify the efficient set of risk management strategies from alternative cropping and livestock activities,

(b) compare the effects of various levels of financial obligations on risk-efficient sets, and

(c) describe the distributions of returns associated with optimal high and low risk strategies.

Particular attention was given to the importance of downside risk. It is under a threat to farm survival that the issues addressed in this study are of most importance to farmers, the finance industry and to policy makers.

2. The Case-Study Farm

The case-study farm in the Mallee and the Mallee district in general are historically highly dependent on wheat. The overall short-term economic outlook for wheat farmers is good, with this season's higher expected prices attributed in part to low production and a depletion of stocks in the United States (U.S.D.A. 1989a) due to a serious drought. Despite the short-term outlook, considerable servicing of debt is still required and the long-term outlook is not as promising. A considerable threat to future returns from wheat is posed by the European Economic Community which is expected to export an additional eight and a half million tons in 1989 (U.S.D.A. 1989b), and the likelihood of the U.S. rejoining the competitive export market. Other threats to farm returns include the 4.4 per cent decline in Australian agriculture's terms of trade to the year ending March 1989. The substantial increases in interest rates, farm cost inflation at 8.4 per cent and a 15 per cent increase in fertilizer prices have created the sharpest price rises in the year to March 1989 (Cribb 1989). As a result many Mallee farmers are still faced with downside risk for their farm businesses.

At 1456 hectares, the case-study farm is close in area to the average Mallee farm of 1507 hectares (Hall 1988a, p.34). The twenty per cent clay-loam, sixty per cent loam, and twenty per cent sandy loam soils, combined with an average rainfall of three hundred and fifty millimetres, results in a typical district 'conservative' stocking rate of between two and two and a half dry sheep per hectare. The location of the farm is shown in Figure 1.

Water supply for stock is adequate with good dams servicing the three blocks making up the farm. The three blocks are separated by approximately five kilometres. Shedding and silos on the two larger blocks results in no shortage of shed or storage space, while sheep yards exist on each block. Facilities on one block such as the shearing shed 'lap of Victoria

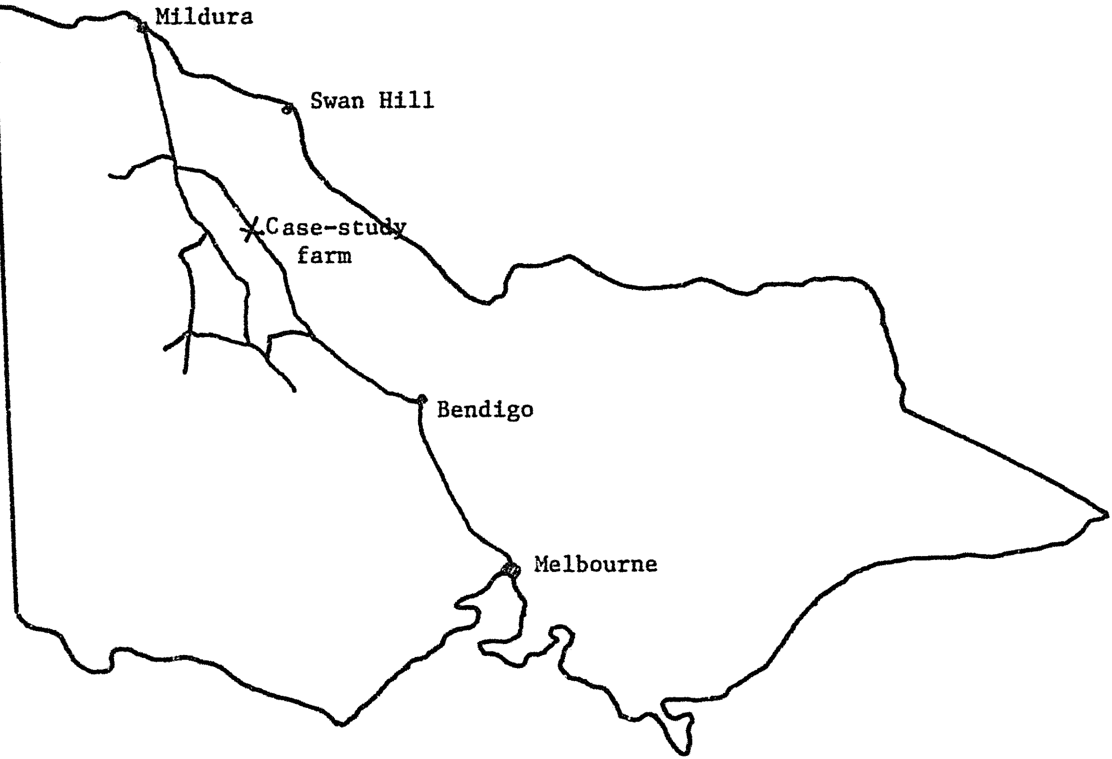

Figure 1 Location of case-study farm.

can service the whole farm. Established sheep handling facilities are typical of farms in the Mallee.

Attention was directed to the Mallee because our a priori expectation was that debt financing would be an issue there, particularly on cereals-mixed livestock farms. Tables 1 and 2 show the financial risk status of different types of farms, and reveal that cereals and cereals-and-livestock farms have incurred the largest amount of debt finance.

3. Theoretical Background

The method adopted was to assess the risk-return trade-off at various levels of threat to survival imposed by the obligation to meet debt repayments. In this context, financial risk is defined as the added variability of the net cash flows relative to owner's equity that results from the fixed financial obligation associated with debt financing (Weston and Brigham 1978). Financial risks expressing the cost and availability of credit are reflected partly in interest rates for loans and partly through non-price sources. Non-price sources include differing loan limits, security requirements, loan maturities, loan supervision and documentation (Barry 1983).

Business risk is the inherent uncertainty of the farm business resulting from production variability and input and product price uncertainty. Uninfluenced by the method(s) of finance, business risk is commonly defined by the coefficient of variation S_a/r_a, when the expected net operating income is r_a and the standard deviation is S_a.

Total risk (TR) faced by the farm firm is then the product of business risk (BR) and financial risk (FR) when risks are measured in terms of coefficients of variation.

(1) $TR = BR * FR.$

It has been hypothesised (Gabriel and Baker 1980) that farmers adjust the production mix and pricing methods in order to reduce business risk when they are faced with greater financial risk and vice versa. A change in the business or financial portfolios may arise as a compensatory action to cope with a forced change in the other portfolio in an attempt to keep total risk stable.

Table 1

Selected Farm Data for Different Australian Rural Industries (1985-86 dollars)

	Farm Capital	Farm Debt	Farm Liquid Assets	Farm Income
Wheat and other crops	675 620	126 590	411 240	-70
Mixed livestock and crops	669 620	79 270	28 420	11 520
Sheep	624 100	76 100	26 820	14 840
Beef	761 800	44 410	45 230	14 560
Sheep-Beef	737 120	73 530	27 650	22 140
Dairy	441 370	49 450	12 670	18 340
Horticulture	176 370	28 760	16 340	18 680
Total Agriculture	685 910	79 970	33 870	11 320

Source: Hooke 1988

Table 2

Financial Risk Status of Bank Funds Lent to Broadacre Farmers as Assessed by their Banks [a] (Proportion of Customers in each Broadacre Industry Late 1987)

	Financial Risk Category [b]					
	1	2	3	4	5	Total
	%	%	%	%	%	%
Wheat and other cereals and mixed livestock cereal grains.	8.9	5.8	14.5	56.3	14.6	54.2
Sheep and mixed sheep-meat cattle.	2.3	2.2	6.8	68.4	20.4	27.0
Meat Cattle	2.4	2.3	6.4	71.9	17.1	18.8
All Broadacre	5.9	4.2	10.9	62.5	16.6	100.0

Source:Powell 1987, p.63.

a Includes 7 banks (Australia and New Zealand Banking Group Ltd., Commonwealth Development Bank of Australia, Commonwealth Bank of Australia, National Australia Bank Ltd., Rural and Industries Bank of Western Australia, State Bank of Victoria & Westpac Banking Corporation).

b Category 1 Insolvent, no chance of recovery, classified as bad and doubtful debts.

" 2 Insolvent, but can be kept farming, loss of principal becoming apparent.

" 3 Problem accounts, no loss of principal or interest except in the short term (12 months).

" 4 Viable (borrower).

" 5 Debt free (depositor only).

Empirical evidence to support the hypothesis of Gabriel and Baker has been produced by Gabriel (1979) and Pederson and Bertelsen (1986). Gabriel looked at the financial responses to changes in business risk on Central Illinois grain farms. Results showed a substantial effect of financial risk upon modification of business risk. In addition the impacts were found to vary between the different groups of farmers categorised according to their level of risk aversion.

For a North Dakota farmer, Pederson and Bertelsen (1986) examined the 'trade off' between paying off the farm debt as quickly as possible to reduce financial risk (i.e., reducing the level of fixed financial obligations) and spreading business risks through diversification of enterprises (i.e., adoption of flexible strategies). They also considered the impact on the farm activities selected of a shift from share renting (low financial risk) to cash renting (higher financial risk). Again a relationship was found to exist between the portfolio of farm business enterprises chosen and the extent of fixed financial obligations.

Barry (1983), in his extended portfolio model, modified the above formula to produce equation 2.

(2) $$TR = (S_a / R_a) * \{R_a P_a / (R_a P_a - I_d P_d)\}$$

where S_a is standard deviation of return on risky assets,
R_a is expected return to the risky assets,
I_d is interest rate on debt,
P_a is proportion of risky assets in the portfolio, and
P_d is proportion of risk-free asset (debt) in the portfolio.
TR is total risk

According to Barry's model, percentage increases in business risks are expanded by percentage increases in financial risk through increased leverage. "Since variability of returns to assets (S_a) and the index of financial leverage (P_d) are both positively related to the level of total farm risk, a strategic trade-off could occur between financial management strategies which modify business risk exposure and scale adjustments in leverage" (Pederson and Bertelsen 1986, p. 68).

The final term of equation 2, which measures the coefficient of variation of financial risk, is the ratio of (a) total expected returns to the risky assets to (b) total expected returns to the risky assets less total cost of debt. Importantly, the size of the multiplicative risk effect caused by this term depends on the denominator, which measures the amount by which expected return on business assets exceeds the cost of borrowed funds.

In the case-study analysis, particular attention was paid to downside risk, and a Target-MOTAD model was developed to cope with the threat to farm survival from the uncertainty associated with achieving a minimum net operating income. This was considered to be the most appropriate analytical technique as it is under a farm survival threat that increased consideration would be given to the relationship between business and finance portfolios. It is also in this environment that the relationship will be of importance to policy makers, finance companies and farmers. The safety-first criterion (Pyle and Turnovsky 1970) included in the Target-MOTAD model is considered a suitable method of analysing risk responses of farmers concerned with farm liquidity and survival.

This model has its roots in the mean variance (E-V) analysis developed in the 1950s (Markowitz 1952, Tobin 1958), and many commentaries have been made about its suitability as a decision criterion (Tsiang 1972,1974). The optimal solution to an E-V problem can be obtained using quadratic programming. Mean-absolute deviation analysis or MOTAD is a linear technique designed to approximate this quadratic result (Hazell 1971). MOTAD is built on the assumption that risk is perceived as the absolute deviations from the mean. Unlike the quadratic programming technique of E-V analysis in which deviations are squared, larger deviations are not given extra weight with mean-absolute deviation analysis. Originally MOTAD was developed to accommodate the shortage and cost of computer power. As computational capacity has increased over time, however, so have the applications suitable to MOTAD and variations of MOTAD.

Adaptations of the above two efficiency criteria, which account for the safety-first approach include those by Porter (1974), Tauer (1983), and Watts, Held and Helmers (1984). Porter developed a target-semivariance (T-SV) analysis while the remaining authors were involved in the development of a target-negative deviation (T-ND) approach.

Target-semivariance analysis assumes that decision makers perceive risk as deviations below a critical, target level of income. The squaring of deviations below the target level results in quadratic programming being used, as in E-V analysis, so that larger deviations are given more weight (Bertelsen 1985). Larger deviations below the mean are therefore penalized more than smaller deviations implying that the assumption of decreasing absolute risk aversion is 'built in'. However, decreasing absolute risk aversion is unlikely to be an important influence in a time of economic hardship, and need not be used as a justification of target-semivariance analysis (T-SV). The use of quadratic programming requires a covariance-semivariance matrix to be specified. This involves a necessary level of data accumulation uncharacteristic at a farm level.

In contrast, target-negative deviation (T-ND) analysis can be solved using linear programming. The analytical technique is given the name 'Target-MOTAD'. The risk constraint is the probability weighted sum of deviations below the target income level (Bertelsen 1985).

The target-negative deviation approach seems the most suitable, time-and-cost efficient method of deriving the efficient set of farm plans under the target income level restriction. The deviations from the mean are not squared, so that the Target-MOTAD approach does not require a covariance-semivariance matrix and the detailed information to create it; the lower amount of specific farm level data is more readily obtained given that this constraint does not exist. "No numerical index of risk preference is required in T-ND analysis. The level of constraint on negative deviations from target is inversely related to the degree of risk aversion. The risk-efficient set of actions is derived by maximizing expected income at varying levels of risk constraint. A trade-off occurs between expected income and deviations below the target income level" (Bertelsen 1985, p. 15).

Fishburn (1977) demonstrates that target-negative deviation analysis produces an efficient set which is a subset of the second degree stochastic efficient set. Stochastic dominance (Anderson, Dillon and Hardaker 1980) is a preferred efficiency criterion of many purists of decision analysis. Empirical studies (Porter and Gaumitz 1972, Anderson and Lionardi 1982) and the analysis of Porter (1974) also suggest that other moment based methods are suitable low cost instruments for obtaining efficient sets. Results from the moment based target-negative deviation analysis are therefore considered reliable estimates from which inferences can be drawn.

4. The Model

The Target-MOTAD model used in this analysis examining trade-offs between business and financial risks is represented by the following system.

(3) Maximize $E(R)\,X = R\,X$ (3.1)

Subject to: $A\,X < B$ (3.2)

$R^*X + d^- > T$ (3.3)

$Pd^- < D$ (3.4)

$X,\ d > 0$ (3.5)

R = 1 x n vector of expected returns for each activity;
X = n x 1 vector of activity levels;
E = expectation
A = k x n matrix of resource requirements;
B = k x 1 vector of resource constraints;
R* = series of 1 x n vectors of expected net returns;
T = m x 1 vector with each element equal to the target;
d- = m x 1 vector of negative deviations from target;
P = 1 x m vector of probabilities for each observation (i), $P_i=1/m$;
D = a scalar parameterised from zero to a large number;
n = number of activities;
m = number of observations, (simulated years); and
k = number of constraints.

Equation 3.1 is the specification of the objective function used. Revenue maximization, while not the only measure of a farmer's success, is of particular importance in the context of a threat to farm survival, which is the context assumed for this examination and on which the model is constructed.

Resource constraints are specified by equation 3.2. Land, labour, and feed availability are the limited resources to be considered.

In equation 3.3, the deviation from the target level of income is defined as 'd-'. The sum of the simulated net revenues (R*X) and the permitted number of deviations (d-) must exceed the target income level (T). The permitted number of deviations in equation 3.3 is defined according to equation 3.4 in which the probability weighted sum of deviations (Pd-) must be less that the defined acceptable deviation from the target (D). Parameterisation of D provides the risk-efficient frontier.

Table 3 is a schematic matrix of the linear programming model used. Linear resource constraints which are binding on the farm operations are represented mathematically in the first set of rows of the matrix (RO_1 to RO_k in Table 3). The entries $R_{1,1}$ to $R_{50,10}$ are 50 simulations of net revenue for each of the production activities. Then each of the constraints OBS_1 to OBS_{50} has an associated target income (T) shown in the right hand side. If the difference between the sum of the revenues of the enterprises in the basis and the target income is negative, then deviation activities enter the solution (DEV_1 to DEV_{50}). Finally, the row labelled SUMDEV accumulates the negative deviations and weights them by their probabilities (P_1 to P_{50}), equal to 0.02. By parameterising the right hand side of this matrix for a given level of target income, different basic solutions to the target-MOTAD problem are obtained, each varying according to the probability of achieving a given target income. The series of solutions from such a parameterisation is the risk-efficient frontier.

5. Data

The data set for this model can be categorised into the three areas of production constraints, the target income, and simulated net revenues and objective function.

5.1 Production constraints

The land and capital constraints were treated together. The property size is 1,456 hectares. Ten hectares are assumed to be used for roads, houses, sheds, wind breaks and fence lines. To cope with the farm decision maker's preferences, limits were placed on the number of hectares which can be allocated to the production of wheat, barley and peas. Such limitations help cope with barley's timeliness-of-harvest requirement; barley will damage more readily than wheat and has a shorter optimal time before it lies flat, sprouts or drops to the ground. The area allocated to peas is limited to cope with the specific disease problems which could build up if the area of peas in a crop rotation is enlarged. Similarly,

Table 3

Schematic Tableau of Target MOTAD Model

Row	Production Activities			....	Other Activities	Dev1	....			Dev50	RHS	INC
OBJ	ER1	ER2	ER3	......ER10							max	
RO1	_	_	_	......_	_............_						B1	
RO1	_	_	_	......_	_............_						B2	
.....											.....	
ROk	_	_	_	......_	_............_						Bk	
OBS1	$R_{1,1}$	$R_{1,2}$	$R_{1,3}$	......$R_{1,10}$		1					T	
...	....	....	....	....			...				...	
...	....	....	....	....				...			...	
...	....	....	....	....					...		...	
OBS50	$R_{50,1}$	$R_{50,2}$	$R_{50,3}$	.....$R_{50,10}$						1	T	
SUMDEV						P1	P2...........			P50	D	-10

OBJ is the objective function to be maximised.

RHS is the right hand side for the resource restriction (B) or target (T).

INC is the increment by which the right hand side is parameterised.

B, R and m are as defined in equation 3.1

P is 0.02 (1/m) times the value of any negative deviation from the target income.

D is a parameterised value.

wheat 's maximum area helps stop the build up of diseases such as Cereal Cyst Nematode and Takeall. Medic pastures also break life cycles of grass-born diseases so it is assumed that the area not cropped is given to medic pastures. Wheat, barley, and peas are limited to eight hundred, four hundred, and two hundred hectares respectively.

Turning to labour, in order to allow for the hours spent on general farm activities, repairs, maintenance and other miscellaneous work, a total labour constraint was imposed. The constraint is in the form of seasonal labour restrictions and allows for the fact that the farm operator's wife is active in assisting with various activities. A 'hire labour' activity was included in the Target-MOTAD matrix to give flexibility with respect to labour in selection of optimal management programs, and account for the availability of casual labour and the farm operator's willingness to use casual labour. Labour requirements specific to the different activities defined for the farm were obtained from Department of Agriculture farm management surveys of the region adjusted in consultation with the operator. They are listed in Table A.1 in the appendix.

In calculating feed availabilities, crop rotations had to be considered to cope with diseases such as Cereal Cist Nematode and Takeall as well as to maintain adequate soil nutrients. An assumption was therefore made that at least twenty per cent of medic pastures will be in their first year. Another assumption with respect to feed availability is that there is autonomous feed production at a level of 0.05 Live Stock Months (LSM) (Rickards and Passmore 1971) per hectare in Summer and Winter and that figure is doubled in the Autumn and Spring. The autonomous feed production is designed to account for natural grass germination and growth. Feed produced by various types of pasture and crops and feed required by livestock were derived from White and Bowman (1981) and Oram (1985). Appendix Table A.2 shows the actual levels of feed and feed requirements.

No limits were placed on the number of sheep and cattle possible in the production mix apart from those restrictions imposed through other constraints such as feed. It is assumed that a reasonable spread of the work load associated with lambing will occur because of the natural spread of lambing due to failures to conceive and the normal lack of synchronization of the oestrous cycles. Parasite control measures are assumed adequate to cope with a large flock.

The preference of the farm operator is that there will be only one sheep breeding activity in the production mix. No additional computations are needed to cope with this preference as only one sheep activity enters any production mix in the results obtained.

5.2 Target income

The target income level (T in Table 3) is the amount required to meet the demands for family consumption, fixed farm costs and fixed financial obligations. The target income for the typical 1500 hectare Mallee wheat/sheep farm with a debt problem can be formulated according to the method in Table 4.

A broadacre farm, such as the case-study farm, under a threat to survival because of its financial position would typically have equity levels of 60 to 70 per cent (Burgess and Carne 1989). Given this range of typical equity levels and with the knowledge that commercial interest rates have fluctuated significantly since the deregulation of the money market, Table 5 was constructed. It outlines possible debt servicing obligations of a farm under a threat to survival. The case-study property is believed to have a value of $625 per hectare or a total of close to $1 million (Simpson 1989). A 10-year loan is assumed for the debt outstanding with a one per cent margin placed on the interest rates between 17.75 and 21.75 per cent (Burgess and Carne 1989).

The three target incomes to be examined in this study, to express different financial risks through different fixed financial obligations were therefore $107 000, $125 000 and $145 000. These target incomes cover a likely range of interest rates and farm leverage situation.

5.3 Simulated net revenues and objective function

The objective function entry for each activity is the mean of the simulated net revenues $\sum_i R_{ij}/50$. Hence by describing the estimation of simulated net revenues, the objective function is automatically considered. Each element (R_{ij}) has a value equal to revenue (p_{ij} y_{ij}) minus variable costs (VC_j), where p_{ij} is defined as the real effective returns to growers per unit and y_{ij} the yield.

Table 4

Formulation of Target Income

	$	$
Family Living Expenses [a]		20 000
Fixed Farm Costs [b]		
-administration	6036	
-rates	5622	
-insurances	3385	
-rent	1575	
-wages and contracts(autonomous)	3640 [c]	20 258
Fixed Financial Obligations [d]		
-commercial interest plus margin	68 268	
-principal required on twenty-year loan	16 450	84 718
		124976

a Arbitrary figure approaching that necessary to support one household on the case-study farm.

b Derived from Hall (1988b)

c Casual labour assumed autonomous.

d Derivation given in detail in Table 5

Table 5

Likely Debt Servicing Obligations

Equity %	Commercial Interest plus 1.0 % margin		
(debt)	18.75 %	20.75 %	22.75 %
70 ($300 000)	67200		
65 ($350 000)		84700	
60 ($400 000)			104800

(3) $R_{ij} = p_{ij} y_{ij} - VC_{ij}$

R	=	simulated net revenue
p	=	price.
y	=	yield.
VC	=	variable costs.
i	=	1 to 50 simulated observations.
j	=	1 to 10 production activities.

In general, subjective data were used for levels of yields and prices while objective data were used for variable costs and for estimating correlations in yields and prices. Incorporation of subjective beliefs of likely price and yield distributions is considered vital for the analysis to accurately define the decision context of the farm operator. The information elicited from the farm operator was obtained in the form with which he was most familiar; in the case of yields, bags per acre were recorded and subsequently converted to tonnes per hectare. The approach of eliciting data in this way is consistent with dealing with some of the problems highlighted by Anderson, Dillon and Hardaker (1980) regarding the elicitation of distributions. In an appeal to parsimony, triangular probability density functions of yields and prices were elicited from which cumulative distributions were created and from which random samples were taken using a variation of Monte Carlo random sampling. The above approach may go against the grain for purists of Decision Analysis, preferring a less definite ending to the cumulative distribution functions derived, but alternative methods of establishing cumulative distribution functions such as the judgmental fractile method (Anderson, Dillon and Hardaker 1980, p. 24) would have been too time consuming and were considered too testing of the farm operator's patience. The resulting distributions are shown in Table 6.

A complicating feature of the simulated net revenues is that there are correlations between the various activities in their yields and prices. Yield correlation is clearly existent as the Mallee is highly susceptible to climatic variations which affect all crops. To account for this, historical yield information generated by various trials conducted in the Mallee was used (see Cumming 1989 for details).

Table 6

Triangular Distributions of Production Activities.

Activity	Price			Yield		
	Maximum	Most Likely	Minimum	Maximum	Most Likely	Minimum
Wheat	168.7	153.4	153.4	3.27	1.84	0.51
Malt Barley	200.0	180.0	170.0	1.93	1.23	0.35
Feed Barley	150.0	140.0	130.0	3.34	1.76	0.88
Field Peas	250.0	180.0	150.0	1.84	0.82	0.41
		Price of wool per head			Price per head put off	
Wool/weth's	32.0	30.0	26.0			
1X Lamb A	28.0	25.0	12.0	38.0	30.0	20.0
1X Lamb S	28.0	25.0	12.0	38.0	30.0	20.0
2X Lamb A	18.0	15.0	13.0	41.0	29.0	20.0
2X Lamb S	18.0	15.0	13.0	38.0	27.0	20.0
wf Weaners				350.0	300.0	230.0

1X = first cross, 2X = second cross.

A = Autumn drop lambs, S = Spring drop lambs.

wf = winter fatten.

Yield in $ per hectare, Price in $ per tonne or $ per head.

Price correlation is believed to exist because of local and international substitutability of grains, especially as stock feed. The historical price information for crops is contained in Appendix Table A.3. Because there are insufficient records, with the current market structure, of the price of peas over time, peas are left out of the data used to generate the correlatioı matrix and a correlation with wheat of 0.25 is assumed for the modelling exercise reported in this study. A correlation of 0.25 reflects the comparatively low substitutability of wheat and field peas due to their different protein contents and different uses.

Correlations between wool prices and the prices paid for lambs should be recognised. A correlation between first-cross lambs and the price of wool was assumed to be 0.3 and the correlation between second-cross lambs and the price of wool was assumed to be 0.2. These figures reflect the influence wool prices have on the willingness of producers to pay for stock.

The localised weather patterns need not have any substantial effect on the local, world dominated competition for grains, therefore at the farm level being considered in this study, no price-yield correlations are incorporated.

Net revenues for crops were obtained after subtracting expenses from the gross revenues calculated by multiplying the 'price generated' with the 'yield generated'. Expenses were subtracted from the sum of the generated prices of wool and lamb sales, and from the price received for cattle. A statistical description of the net revenues associated with each enterprise, given the correlations discussed above and given the farm operator's subjective distributions, is presented in Table 7.

6. Study Results

6.1 Risk-efficient solutions

Assuming that the farm business and financial situation is adequately represented by the set of resource constraints imposed in the Target-MOTAD matrix, risk-efficient plans derived as solutions to the model are described as in Table 8. Each change of basis in the risk-efficient set is associated with an expected return and a mean negative-deviation from the target return at that expected return. Riskier production mixes have higher expected

Table 7

Statistical Description of Simulated Net Revenues of Production Activities

($ per ha, or $ per grown sheep)

Name	Mean	St. Dev	Variance	Minimum	Maximum
Wheat	146	70	4932	7.8	287
Malt Barley	104	43	1814	18.9	183
Feed Barley	144	44	1976	50.8	213
Field Peas	98	47	2249	4.4	218
1st Cross S	37	5.2	27	25	46
1st Cross A	37	4.5	20	25	45
2nd Cross S	28	3.7	14	22	38
2nd Cross A	25	3.6	13	18	34
Merino Wool	20	1.4	2.0	18	23
wf Weaners	40	23	532	3	89

wf = winter fatten, A = Autumn lambing, S = Spring lambing

Table 8

Target MOTAD Efficient Sets

Expected	Mean Negative	Activity Levels							
Returns	Deviation	Wheat	Fbarley	Peas	XS	Pasture1	Pasture2	Labour	Others
		Target income level = $107 000							
195868	3073	800.0	400.0	200.0	179	9.2	36.8	550.2	_
193855	2929	768.8	400.0	200.0	243	15.4	61.7	529.3	_
159853	929	239.5	400.0	200.0	1339	121.3	485.2	173.6	_
152702	620	128.1	400.0	200.0	1570	143.6	574.3	98.8	_
150923	558	105.8	400.0	200.0	1616	148.0	592.2	122.2	_
142489	345	_	400.0	200.0	1835	169.2	676.8	233.1	_
		Target income level . 125 000							
195858	6065	800.0	400.0	200.0	179	9.2	36.8	550.2	_
187489	5347	669	400.0	200.0	448	35.3	141.0	462.7	_
166392	3654	341.3	400.0	200.0	1128	100.9	403.8	242.0	_
153894	2815	146.7	400.0	200.0	1531	139.9	559.4	111.3	_
152702	2763	128.1	400.0	200.0	1570	143.6	574.3	98.8	_
150269	2678	97.59	400.0	200.0	1633	149.7	598.7	130.8	_
150211	2677	96.87	400.0	200.0	1634	149.8	599.3	131.6	_
		Target income level = 145 000							
195858	8927	800.0	400.0	200.0	178	9.2	36.8	550.2	_
175313	7310	480.1	400.0	200.0	841	73.2	292.7	335.3	_
170744	7025	409.0	400.0	200.0	988	87.4	349.6	287.5	_
167271	6891	354.9	400.0	200.0	1100	98.2	392.8	251.2	_
162952	6809	287.7	400.0	200.0	1239	111.7	446.6	206.1	_

returns, the number of deviations below the target return also increase to express the increase in risk. Given the probability-weighted sum of deviations used in this analysis, an expression of risk is the mean negative-deviation below the target. As listed in Table 8, it is the average negative-deviation below target with a one-in-fifty chance of occurring.

By graphing the results of Table 8, Figure 2 is obtained. It shows that allowing a greater mean negative-deviation below target than 6 065, will not increase revenue above $195 858, when the target revenue is $125 000. Similarly, increases in the acceptable target negative-deviations of 3 073, and 8 927 for the other two target revenues will not result in revenue increases. Resource constraints and constraints describing production preferences would have to be broken for net revenue to increase further. On the other hand, as the level of acceptable deviation below-target is reduced, constraints are effectively being placed on the optimal production mix. Risk is defined as the mean negative-deviation, and therefore as the level of acceptable deviation is reduced, plans

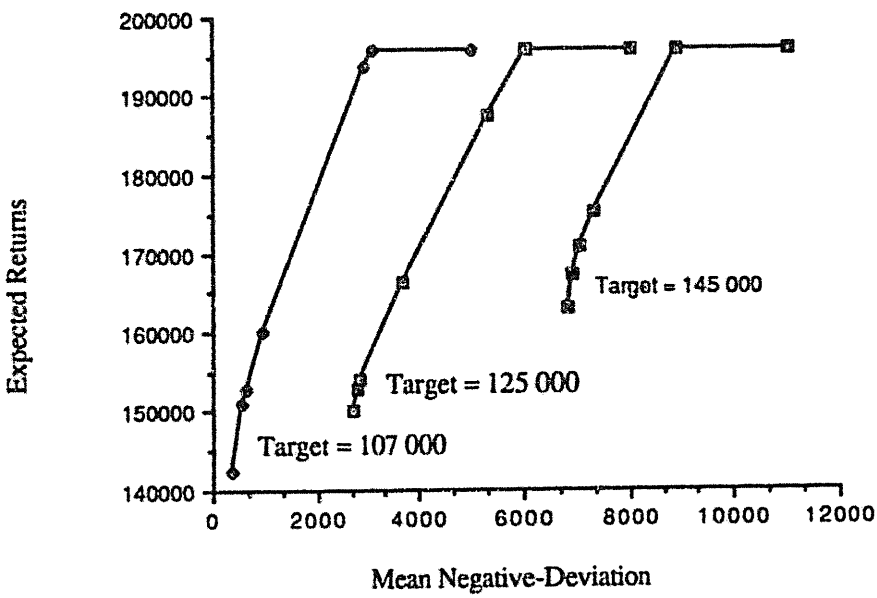

Figure 2 Risk-Efficient Production Frontiers

become less risky and the optimal expected revenue is reduced. The minimum mean negative-deviation below target for which any solution can satisfy all constraints is indicated by the last entry for each target level in Table 8. Overall, the results show that, as expected, the farm is forced into a riskier production set as the level of target income is increased.

As the expected revenue and acceptable risk is decreased, wheat's place in the production mix is taken predominantly by first-cross spring lambs. A characteristic decline in labour, with increases in area of medic pastures is also noticed as a general rule. As a larger number of first-cross spring-drop lambs is forced into the optimal production mix, to decrease the mean negative-deviation, a requirement for extra labour results in a jump in the hire labour activity. For ease of recognition, the changes in activity levels are drawn across their critical domains of mean negative-deviation for the three target revenue levels in Figures 3, 4, and 5.

6.2 Optimal Production Mixes

To maximise expected revenue subject to risk, the production activity mix should be on the risk-efficient production frontier of the target income under inspection. However, even if he remains on the frontier, the case-study farmer has a choice of production activity mixes. Thus, there will be a specific point on the frontier which will define the optimal production mix. To discover this point one could either elicit a utility function and find the point of tangency between such a function and the risk-efficient frontier, or one could elicit the optimal production mix directly from the case-study farmer.

To keep the farm level decision context and to maintain the close involvement of the case-study farmer, a directly elicited optimal production mix was preferred over one determined by a utility function. It was important to give the case-study farmer as good an indication as possible of the distributions of expected revenue from which he could choose. To provide the farmer with the required understanding of the distributions involved, the mean-negative deviation is probably not sufficient. From an inspection of the output file for a given target income, the critical information of the number of years in which revenue fell below target was recorded, and the range and average of those shortfalls in revenue could be obtained.

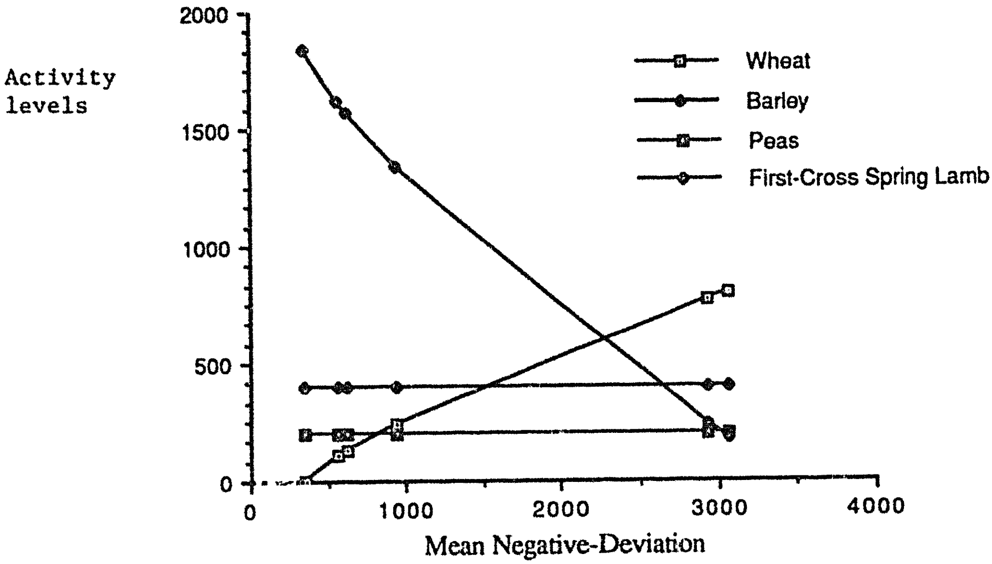

Figure 3.1 Production Activities

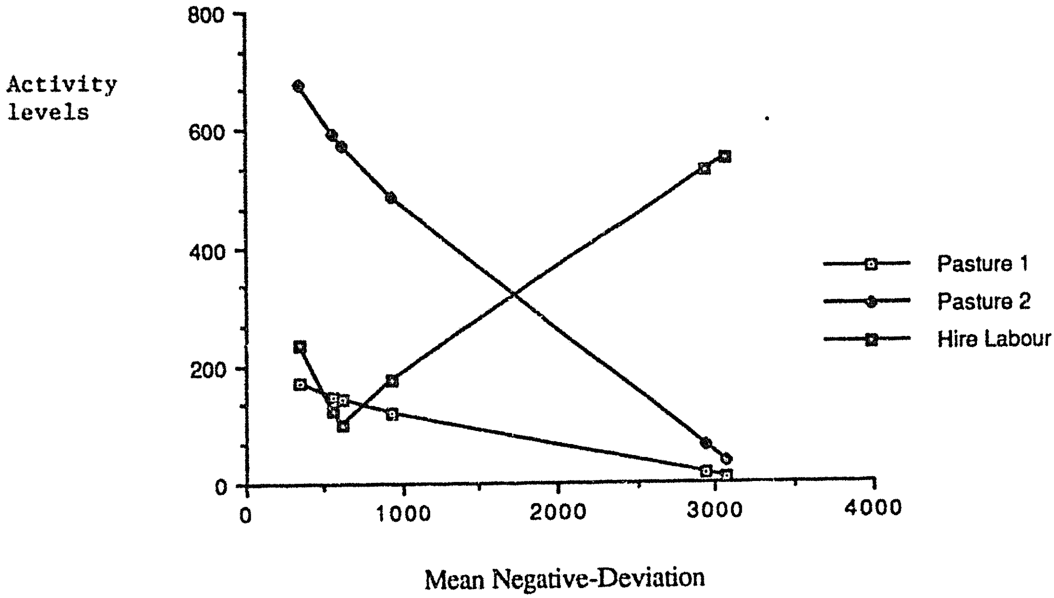

Figure 3.2 Other Activities

Figure 3 Activity Changes with a Target of $107 000

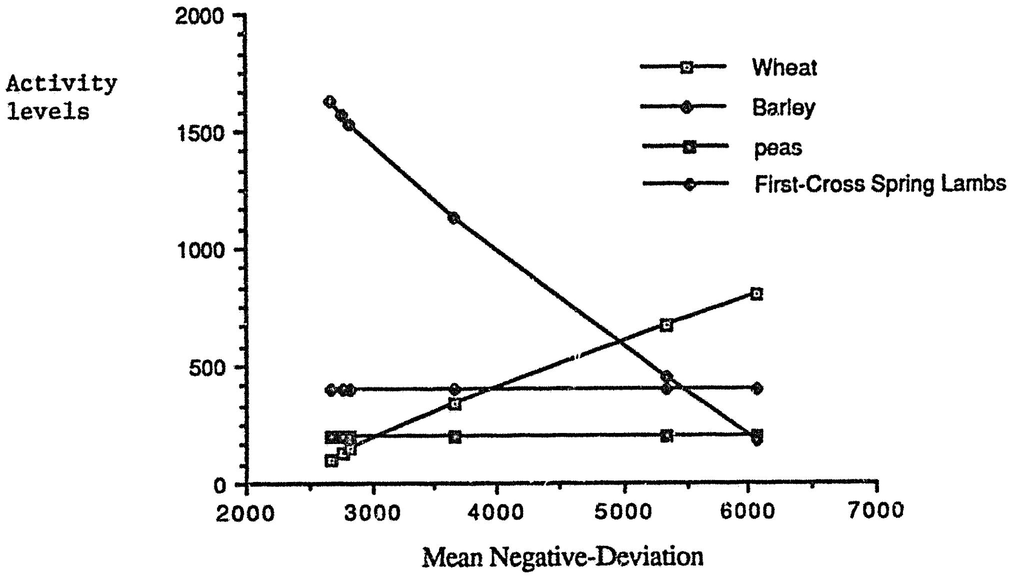

Figure 4.1 Production Activities

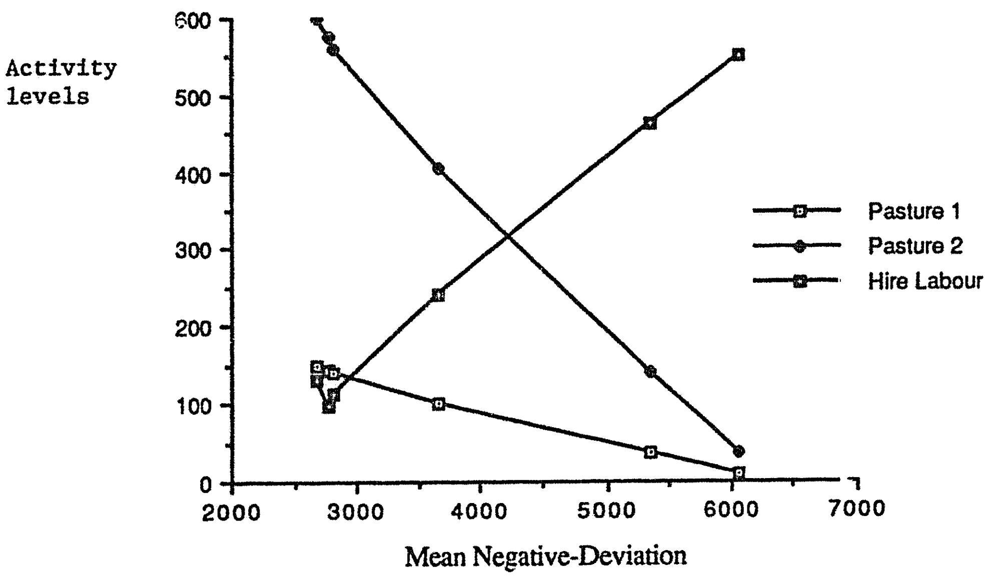

Figure 4.2 Other Activities

Figure 4 Activity Changes with a Target of $125 000

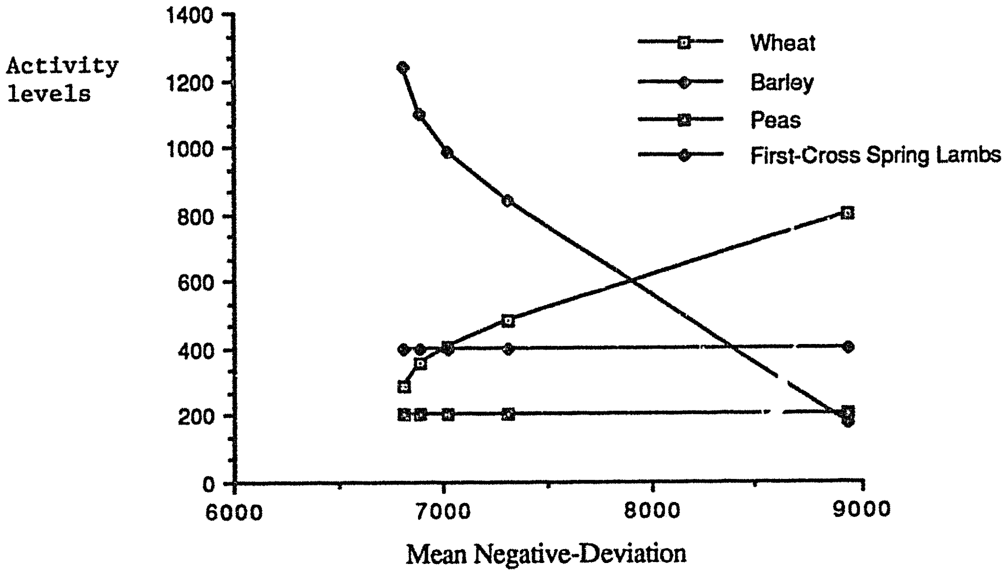

Figure 5.1 Production Activities

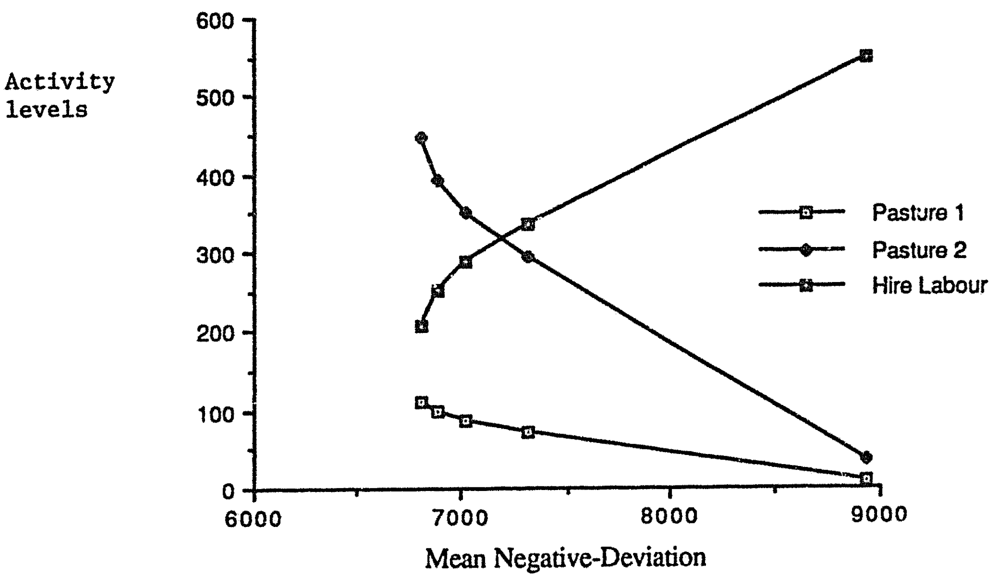

Figure 5.2 Other Activities

Figure 5 Activity Changes with a Target of $145 000

Table 9 summarises the information presented to the farmer in an interview. The information from the output file is for each of the changes of basis which occur along the risk-efficient frontiers. As well as expected revenue and mean negative-deviation, the number of observations below target and their maximum, minimum and average values below target are shown.

Table 9

Summary of Below Target Revenues

No	Expected Revenue	Mean Negative Deviation	Number below target	Min Deviation	Max Deviation	Average Deviation
	Target = $107 000, 30% debt totalling $300 000, interest at 18.75%					
1	195 868	3 073	6	1 313	55 634	25 610
2	193 855	2 929	5	16 910	53 708	29 291
3	159 853	929	4	5 120	20 337	11 611
4	152 701	620	4	855	13 319	7 744
5	150 923	558	3	5 880	11 912	9 292
6	142 489	345	3	2 992	8 992	5 742
	Target = $125 000, 35% debt totalling $350 000, interest at 20.75%					
7	195 858	6 065	9	2 316	73 674	33 696
8	187 489	5 347	8	13 134	65 461	33 420
9	166 392	3 654	7	12 942	44 755	26 100
10	153 894	2 815	7	7 179	32 490	20 105
11	152 702	2 763	8	1 416	31 319	17 268
12	150 269	2 678	8	3 743	29 394	16 736
13	150 211	2 677	9	38	29 349	14 870
	Target = $145 000, 40% debt totalling $400 000, interest at 22.75%					
14	195 858	8 927	9	9 627	93 674	49 596
15	175 313	7 310	9	7 447	73 510	40 612
16	170 744	7 025	10	3 719	52 1[illegible]	35 126
17	167 271	6 891	11	4 122	65 618	31 322
18	162 952	6 809	12	4 254	61 379	28 370

With the $107 000 target income, the case-study farmer opted for production plan No.1 which would maximise his expected revenue. Under the $125 000 target income, production plan No.9 was considered optimal. Production plan No.15 was chosen as optimal under the $145 000 target income, with a "boom-or-bust" philosophy. Hence, for the two lower levels of debt financing the farmer's selection is in accord with the safety-first criterion of the model. This is evidenced by activities that have lower business risk entering the solution as financial risk is increased. However, at higher levels of debt (and financial risk), a reversal is observed, and a riskier overall solution is selected which contravenes the safety-first criterion. Indeed, later in the interview it become clear that some other components of the model, including crop rotation constraints, would be ignored by the farmer if debt obligations reached these extreme levels.

7. Summary and Conclusions

Efficient sets of risk management strategies from alternative cropping and livestock activities have been generated as the first objective of this study. While these strategies are efficient, they incorporate the safety-first decision criterion inherent in the target-negative deviation analysis via the Target-MOTAD technique. This technique allows both financial and business risks to be considered. Financial risks are introduced through the fixed financial obligations and the consequent generation of a target income. The study was motivated by the stress on cash flow management from the current business environment, particularly the pressure imposed by the high and volatile interest rates on past 'over-borrowing'.

Varying the target has enabled consideration of the second objective of comparing the effects of various levels of financial obligations on risk-efficient sets of production activities. It is evident by the change in optimal production mix of the case-study farmer between each of the risk-efficient frontiers, that fixed financial obligations do affect the optimal production mix of farm enterprises.

As the target income is changed from $107 000 to $125 000, business risks are lowered, to compensate for the increase in financial risk, by the choice of a more stable optimal production point, with respect to expected revenue, on the risk-efficient frontier.

However, as the target income is increased from $125 000 to $145 000, there is an increase in business risk as financial risk increases.

8. Study Implications

This study has demonstrated the usefulness of target-negative deviation analysis in the modelling of decision making in a risky environment. An aspect of the study which is considered valuable is the on-farm decision context which was interwoven with the analysis. The use of generated price and yield information in a cheap, easy-to adjust fashion will allow easy adoption of this process to other farms. The generated price and yield observations can be based on the decision maker's most recent experiences and beliefs, while cost of production estimates based on accounting records further reflected the farming practices and financial system of the case-study farm.

While concepts of risk aversion and utility theory are important considerations in economic models it is more likely that farmers will be able to relate better to a target return level which they set, and with their own tolerance of returns below the target level when deciding on a management system.

Biological simulation of farm production systems is currently evolving (White and Weber 1987; White, Weber, Bowman and McLeod 1989) along with an increasing number of, and competence in the use of computers. A dynamic, user friendly, personal computer program which will consider both the financial and business risks, with weightings between predictions of biologically-derived mathematical relationships and the decision maker's own beliefs, taking into account the history of the property, could be developed with risk-efficient options expressed in an easily understandable form. All information used in this study is readily accessible to a farm operator with reasonably accurate records; historical correlations would evolve over time along with the biological yield predictions.

The potential roles of new enterprises in a farm plan could be easily tested by inclusions of generated prices and yields in the simulated years and by including establishment costs in the fixed financial obligations. Importantly to farm survival, the Target-MOTAD technique offers a way of modelling the effects of fixed financial obligations in a volatile business environment.

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Appendix

Table A.1

Seasonal Labour Requirements per unit (hours)

Activity	Summer	Autumn	Winter	Spring
Wheat	1.14	_	0.47	0.07
Mbarley	0.65	_	0.33	0.07
Fbarley	0.65	_	0.33	0.07
Peas	0.70	_	0.47	0.07
XS	0.20	0.18	0.25	0.54
XA	0.20	0.48	0.25	0.24
XXS	0.20	0.23	0.25	0.49
XXA	0.20	0.49	0.25	0.19
Woolpdn	0.14	0.13	0.19	0.13
Cattle	_	0.10	0.15	0.15
Pasture1	0.27	0.47	_	_
Pasture2				

Sources: Oram (1985).
Hall, N. (1988a).
O'Sullivan (1987).

Table A.2

Feed Production (LSM) and Use (DSE)

	Season			
Activity	Summer	Autumn	Winter	Spring
Wheat	(2.08)			
Mbarley	(2.08)			
Fbarley	(2.08)			
Peas	(8.32)			
XS	1.54	0.90	0.90	1.60
XA	0.90	1.60	1.54	0.90
XXS	2.50	1.30	1.30	2.30
XXA	1.30	2.30	2.50	1.30
Woolpdn	1.00	1.00	1.00	1.00
Cattle	–	8.30	27.70	10.70
Pasture 1	(1.00)	–	(1.00)	(4.16)
Pasture 2	(2.08)	(4.16)	(2.08)	(8.32)

Brackets indicate supply in LSM

Sources: White and Bowman (1981).
Oram (1985).

Table A.3

Prices Returned per tonne

Year	Wheat [a]	Malting Barley [b]	Feed Barley [c]	Peas [d]
1977-78	77.57	78.75	71.75	
1978-79	107.35	74.50	67.50	
1979-80	132.72	109.45	101.45	
1980-81	124.68	140.42	132.42	
1981-82	122.19	132.83	127.83	
1982-83	151.38	184.67	184.67	
1983-84*	129.72	142.60	125.60**	
1984-85*	132.27	123.33	115.30**	
1985-86*	127.46	114.85	109.85**	
1986-87*	106.75	122.34	97.34**	190.00
1987-88*	124.99	121.45	96.45**	210.00

Sources: a ABARE (1988).

b Classified as No 1-Australian Barley Board Annual Report 1988. Returns as listed minus costs of the Grain Elevator's Board as supplied by Australian Barley Board, Adelaide

c As for 2, except Galleon, a recently introduced variety with Cereal Cist Nematode tolerance taken to have equivalent quality to 'No 3' classified barley-Annual Report 1988.

d Prices supplied by V.O.P. Mercantile/Personal consultation.

* Assume participant of Australian Barley Board's 'pool payment scheme'.

** Classification changes to 'No 4' for Galleon.