# Variable animal performance and farm diversification

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## ABSTRACT

Distributions of gross margins of breeding ewe, breeding cattle and plantation forestry enterprises were used in a linear programming model of a 651 ha Taranaki hill country pastoral farm to determine the mix of enterprises that maximised expected net farm revenue for given levels of downside risk. Risk was specified as the mean negative deviation of farm revenue from an assumed target income of $180,000.

Animal performance variables used in estimating gross margins included (mean, minimum, maximum) (a) lambing percentage (92, 87, 99), (b) wool weight-kg per stock unit (5.4, 5.1, 5.8), (c) calving percentage (85, 83, 88) and (d) bull beef carcass weight-kg (229, 208, 247).

The enterprise mix of 250 ha forestry and 3,791 stock units of bull beef yielded an optimum expected net farm revenue of $497,591 with little or no downside risk. Breeding ewe and breeding cow enterprises did not contribute to the optimum enterprise mix.

Using a sheep/cattle ratio of 70/30 stock units, the expected net farm revenue reduced to $348,884. The optimum enterprise mix, with this ratio, was 310 ha forestry and 3,310 stock units of bull beef and sheep. The model predicted that it would be possible to increase the expected net farm revenue to a maximum of $362,923 by increasing the acceptable downside risk and the area allocated to forestry.

**Keywords:** Pastoral farm diversification; downside risk; forestry.

## INTRODUCTION

A number of livestock enterprises, stocking policies, improved pasture species and afforestation have been proposed as options for the sustainable management of land resources (Keoghan and Cossens, 1990; Korte, 1990; MAF, Landcare and TRC, 1993). The main focus has been the development of strategies to reduce soil erosion on pastoral hill country. Management of risk in farming has also been receiving increased attention as a result of the deregulation of the financial sector, and the phasing out of farm input and output subsidies over the last decade (Martin and Lee, 1990; Johnson 1992).

The choice of farm diversification options must address not only the sustainable management of the physical resources of a farm, but also farm viability and the reduction of the risk of farm business failure. When considering the options for the diversification of an existing farming enterprise, one needs to consider both business risk (ie risk associated with variable yields and prices) and financial risk (ie risk associated with not being able to meet a fixed target income, such as debt repayment, using cash generated from the farm). The combined effects of these risk factors can be measured as the expected net farm income, and the distribution of net farm income that falls below a target income or the downside risk (Pederson and Bertelsen, 1986; Parton and Cumming, 1990).

A model that uses the downside risk concept to determine the optimal combination of pastoral and forestry enterprises for a hill country pastoral farm in the Taranaki region is described in this study. Variables that describe animal performance and their role in determining which pastoral enterprises are included in the optimal enterprise mix are highlighted in this paper.

## METHODS

### The Risk Model

The model used in the study is derived from the MOTAD (Minimisation of total absolute deviation) risk programming technique (Hazell, 1971). An application of the MOTAD model used in this study is the Target-MOTAD model which is concerned with minimising negative deviation of net revenue from a target income (Parton and Cumming, 1990). In essence, the model selects enterprise combinations in order to maximise expected net revenue subject to constraints on available land classes, seasonal pasture yield, target income and an acceptable mean negative deviation of revenue from a target income. The optimum enterprise combination is said to be risk efficient since it yields the highest net revenue that can be achieved for a specific level of risk. The risk model comprises two main components, a simulation model and a linear programming model. These are described briefly below (Figure 1).

### Simulation Model

Gross margin templates were developed for the following enterprises; (a) sheep breeding flock, (b) breeding cows weaner policy, calving 3 yr old heifers, (c) bull beef policy and (d) Pinus radiata plantation forestry. A Monte Carlo simulation approach was used to select values from statistical distri-

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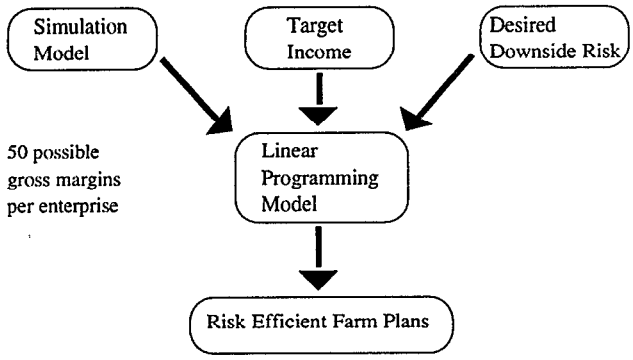
**FIGURE 1:** A schematic representation of the risk model.




butions of animal production, stock mortality, plantation forestry yield and prices. These were then used to calculate possible gross margin values. Correlation between variables were maintained using estimated Spearman's rank correlation coefficients between variables.

The distributions used were estimated from time series data applicable to Taranaki hill country. The main sources of data were a number reports on the weighted average schedule meat prices from the NZ Meat and Wool Boards' Economic Service (1992), Ministry of Agriculture and Fisheries farm monitoring reports (1992), McRae (1988), New Zealand forestry statistics from the Ministry of Forestry (1993) and the Lincoln University Financial Budget Manual (1992). Estimated parameters of some of the distributions are shown in Table 1.

**TABLE 1** Distribution of some of the variables used to simulate enterprise gross margins.

| | Mean | Min | Max | Beta distribution shape parameter[1] c | d |
|---|---|---|---|---|---|
| Production Parameters | | | | | |
| Lambing-survival to sale (%) | 91.9 | 87.0 | 99.0 | 1.3 | 2.0 |
| Wool weight (kg/stock unit) | 5.4 | 5.1 | 5.8 | 1.0 | 1.6 |
| Prime wether lamb carcass, wt (kg) | 13.7 | 12.4 | 15.0 | 1.6 | 1.4 |
| Calving-survival to sale (%) | 85.4 | 83.0 | 88.0 | 1.3 | 1.5 |
| Bull beef carcass, wt (kg) | 228.7 | 208.0 | 246.6 | 1.0 | 0.8 |
| Pinus radiata recoverable yield site rating 34, age 28yrs ($m^3$/ha) | 679.2 | 0.0 | 747.1 | 0.9 | 0.1 |
| Pinus radiata recoverable yield site index 28, age 28yrs ($m^3$/ha) | 579.7 | 0.0 | 637.7 | 0.9 | 0.1 |
| Prices | | | | | |
| Prime wether lamb schedule price (c/kg) | 236.7 | 129.1 | 464.7 | 0.8 | 1.7 |
| Wool price ($/kg) | 4.8 | 2.4 | 7.3 | 1.5 | 1.5 |
| Pinus radiata stumpage ($/$m^3$) | 29.4 | 19.0 | 37.7 | 1.7 | 1.3 |
| Heifers 30 month schedule price (c/kg) | 277.0 | 192.9 | 379.0 | 1.4 | 1.7 |
| Bull beef schedule price (c/kg) | 298.3 | 207.8 | 405.8 | 1.4 | 1.7 |

[1]The shape parameters can be used to infer the skewness of the distribution (Anderson, Dillon and Hardaker, 1977).

The simulation model was solved using the @Risk package (Palisade Corporation, 1990), a spreadsheet based Monte Carlo simulation package, to yield 50 realisations of enterprise gross margins. The effect of management practices and research on animal performance will modify the distribution of the production variables, and hence modify the distribution of enterprise gross margins.

## Linear Programming Model

The linear programming model was developed for a 651 ha Taranaki hill country case study farm. Data on pasture dry matter production of 7 classes of land, seasonal pasture production for the region, and the seasonal feed required by the 3 livestock enterprises were used as coefficients and resource constraints in the linear programming model (Scott *et al.*, 1980; MAF, LandCare and TRC, 1993). Together with gross margins derived from the simulated model, the linear programming model was solved using the Beeline package (Ashley Software, 1989), a spreadsheet based linear programming package, to determine enterprise combinations that maximised expected net farm revenue for given levels of downside risk. The target income used for the farm in the study was $180,000. It comprised provisions for depreciation, personal drawings, and debt and interest repayment.

## RESULTS AND DISCUSSION

The distribution of enterprise gross margins derived from the simulation model are shown in Table 2. Bull beef is the most profitable and least risky pastoral enterprise since the expected, minimum and maximum gross margins are higher than corresponding values of the other pastoral enterprises.

**TABLE 2** Distribution of enterprise gross margins.

| | Mean | Min | Max | Beta distribution shape parameter[1] c | d |
|---|---|---|---|---|---|
| Sheep breeding flock ($/su) | 35.7 | 18.1 | 57.0 | 2.15 | 2.59 |
| Breeding cows-weaner policy; calve 3 yr old heifers ($/su) | 39.6 | 27.0 | 59.1 | 1.62 | 2.50 |
| Bull Beef policy ($/su) | 95.1 | 57.6 | 136.9 | 1.95 | 2.18 |
| Pinus radiata - site index 34 ($/ha) | 667.0 | -23.9 | 940.0 | 3.55 | 1.40 |
| Pinus radiata - site index 28 ($/ha) | 548.6 | -26.5 | 782.0 | 3.64 | 1.48 |

[1]See Table 1 for explanation.

The gross margins per ha calculated for Pinus radiata was based on a rotation length of 28 years, and assumed all age classes were equally represented in the forest crop. The simulation model indicated that the minimum gross margin from forestry could be negative.

Using the distribution of gross margins in the linear programming model, the optimum expected net revenue for the 651 ha case study property was $497,591 (Table 3, column 2). The optimum enterprise mix was 250 ha forestry and 401 ha (or 3,791 stock units) in bull beef. Sheep and traditional weaner cattle were not in the optimum solution.

This combination of pastoral and forestry enterprises could be farmed with little or no downside risk, as indicated by the zero mean negative deviation. These results were expected since the bull beef enterprise was more profitable and less risky than the sheep and traditional breeding cattle systems (Table 2).

**TABLE 3:** Optimum farm enterprise mix for different sheep:cattle ratios on a 651 ha Taranaki hill country farm and an assumed minimum target income of $180,000.

| | No restriction on sheep/cattle ratio | 70:30 stock units sheep cattle ratio | |
|---|---|---|---|
| Mean negative deviation ($) | 0 | 0 | 750 |
| Expected net revenue ($) | 497,591 | 348,884 | 353,612 |
| Forestry (ha) | 250 | 310 | 389 |
| Pastoral (ha) | 401 | 341 | 262 |
| Pastoral (su) | 3,791 | 3,310 | 2,415 |
| Sheep (su) | 0 2,317 | 1,691 | |
| Cattle-bull beef (su) | 3,791 | 993 | 725 |
| Maximum negative deviation ($) | 0 0 | 37,500 | |
| Number negative deviation (from 50) | 0 | 0 | 1 |

The usual livestock policy in the study area combines sheep and cattle at a stock unit ratio of 70:30. Using this ratio in the model, the expected maximum net farm revenue reduced to $348,884 for no downside risk (Table 3, column 3). The area under forestry increased to 310 ha and the area pastures reduced to 341 ha. Bull beef was still the preferred cattle policy. The inclusion of sheep, in effect, reduced the performance of the pastoral system, and resulted in forestry replacing pastoral enterprises.

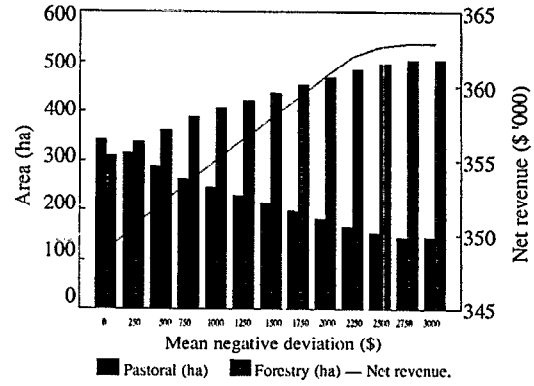
It was possible, however, to increase the expected net revenue at a sheep:catle su ratio of 70:30 by increasing the acceptable downside risk. For example, if the downside risk was increased to a mean negative deviation of $750 per farm, then net revenue increased to $353,612 (Table 3, column 4). The area in forestry also increased to 389 ha. There was 1/50 chance that the system would not be able to generate sufficient cash to meet the target income of $180,000. The maximum negative deviation could reach $37,000.

Expected net farm revenue increased to a maximum of $363,000, when the acceptable mean negative deviation was increased to $2500. As expected, pastoral farming was replaced with the more profitable but riskier forestry enterprise (Figure 2). The results describe the trade off between risk and net revenue for a target income of $180,000. Similar results can be obtained for different levels of target income that might result, for example, from changes in the farm debt-equity ratio.

The risk model described allows the effect of modifying the distribution of animal production parameters (Table 1) on the pastoral/forestry enterprise mix to be investigated. The extent to which such modifications become important depend on the variability of product prices which are normally beyond the control of the farmer.

This paper does not address the transition from the current pastoral-based system to the desirable risk efficient enterprise mix. It may well mean that the risk efficient levels of forestry reported here may not be desirable or attainable, because of the loss of farm income and increased downside risk when significant areas of the farm are in immature forest. This issue will be addressed in a future study.

**FIGURE 2:** Risk efficient production frontier and enterprise mix for a 651 ha Taranaki hill country farm with a target income of $180,000 and a sheep:bull beef stock unit ratio of 70:30.

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