Lincoln University

Te Whare Wānaka o Aoraki

CHRISTCHURCH • NEW ZEALAND

# Lincoln University Digital Thesis

# FARM PLANNING UNDER RISK : AN APPLICATION OF THE CAPITAL ASSET PRICING MODEL TO NEW ZEALAND AGRICULTURE.

A thesis
submitted in the partial fulfilment
of the requirements for the degree
of
Master of Agricultural Science
at
Lincoln University

by
Prakash Narayan
1990

# ACKNOWLEDGEMENTS

Had it not been for the encouragement and the financial assistance of my parents, Mr Raj Gopal and Mrs Parvati Gopal, the writing of this thesis would have been an almost impossible task.

I would also like to thank my wife, Shanti, for her unmitigated support throughout the preparation of this thesis. The patience and understanding of my daughters, Payal and Shinal, were instrumental to my success.

Running away from Rabuka to write this thesis would not have been easy, had it not been for the help and guidance provided by Mr Stewart Pittaway. For her helpful comments and suggestions on writing this thesis, and her insistence on intellectual rigour and clarity of expression, my sincere thanks are due to my supervisor, Dr Sandra Martin. Her infinite patience in reading and re - reading every draft I put forward is gratefully acknowledged. I would like to thank Mr Tony Whatman for providing the farm data. I would further like to thank Dr Peter Nuthall and Mr Derek Newman for their helpful comments on my final draft.

Finally, I extend my deepest gratitude to the rest of the members of the Department of Farm Management and the Department of Accounting and Valuation, who have assisted me in a variety of ways, in the preparation of this thesis.

Abstract of a thesis submitted in partial
fulfilment of the requirements for the
Degree of M. Agr. Sc.

# FARM PLANNING UNDER RISK : AN APPLICATION OF THE CAPITAL ASSET PRICING MODEL TO NEW ZEALAND AGRICULTURE.

by
Prakash Narayan

With the removal of many forms of government intervention from the agricultural sector, risk management has become an increasingly important issue for New Zealand farmers. One strategy for managing risk is enterprise diversification, and there has been a great deal of research on how this might be done most appropriately. A recent suggestion is that the use of the Capital Asset Pricing Model (CAPM) may provide appropriate information.

The CAPM can be used to determine the proportion of systematic (or non - diversifiable), and non - systematic (or diversifiable) risk associated with each activity, the expected return for each activity, and whether activities are being compensated adequately for the amount of systematic risk associated with them. Ultimately, it could be used to generate optimal farm plans using much more simplified computational procedures than more traditional quadratic programming approaches. Unlike the traditional approaches to farm planning, the CAPM is able to measure the contribution that each farm activity makes to the variance of the total farm portfolio.

A Farm Sector Capital Asset Pricing Model (FSCAPM) was developed for New Zealand mixed cropping agriculture. It was observed that the model results were sensitive to various components of the model, including the choice of a farm sector portfolio, the way the activity returns were measured and whether the activity returns were deflated.

An application of the preferred variant of the FSCAPM to the Lincoln University Mixed Cropping Farm showed that high levels of systematic risk were associated with activities on this farm. This suggests that off - farm investment might be a more feasible strategy than on - farm diversification for reducing risk on the farm. The results also showed that all the farm activities examined were being adequately compensated for the level of systematic risk it was accepting.

This study makes an addition the limited research which has been undertaken on how to apply the CAPM framework to an agricultural setting.

Key words: Capital Asset Pricing Model, portfolio selection, farm sector portfolio, diversification, systematic risk, compensation, beta coefficient, mixed cropping.

# TABLE OF CONTENTS

Page No.

ACKNOWLEDGEMENTS ........ ii

Chapter 1 INTRODUCTION ........ 1

1.1 The Problem Rationale ........ 1

1.2 The Problem Defined ........ 3

1.3 Aims and Objectives ........ 6

1.4 Thesis Outline ........ 7

Chapter 2 A REVIEW OF FARM MANAGEMENT APPROACHES TO PLANNING IN A RISKY AND UNCERTAIN ENVIRONMENT ........ 9

2.1 Introduction ........ 9

2.2 A Conceptual Framework for the Analysis of Agricultural Risks ........ 9

2.2.1 The Concept of Bernoullian Utility ........ 9

2.2.1.1 Utility Measurement Techniques: Stochastic Dominance ........ 11

2.2.1.2 First Degree Stochastic Dominance ........ 12

2.2.1.3 Second Degree Stochastic Dominance ........ 14

2.2.1.4 Difficulties with Stochastic Dominance Techniques ........ 14

2.2.1.5 The Expected Return - Variance of Returns (E-V) Criterion ........ 15

2.2.2 Portfolio Theory and the E-V Criterion ........ 17

2.3 Techniques for Optimal Farm Planning that Incorporate Risk ........ 20

2.3.1 Introduction ........ 20

2.3.2 Systems Simulation ........ 21

2.3.3 Quadratic Risk Programming ........ 22

2.3.4 Linear Models ....................................................................24

a. LP - RS ....................................................................24

b. MOTAD ....................................................................26

c. The Focus - Loss Model ....................................................................30

d. Stochastic Programming ....................................................................31

e. Summary of Linear Models ....................................................................33

2.3.5 The Single - Index Models ....................................................................33

2.4 Conclusion ....................................................................37

Chapter 3 THE DEVELOPMENT OF A FARM SECTOR CAPITAL ASSET PRICING MODEL FOR THE ANALYSIS AND EVALUATION OF RISK IN TACTICAL FARM PLANNING ....................................................................39

3.1 Introduction ....................................................................39

3.2 The Theory of Capital Asset Pricing ....................................................................40

3.2.1 Deriving the CAPM ....................................................................40

a. The Capital Market Line ....................................................................40

b. The Security Market Line ....................................................................42

c. The Characteristic Line ....................................................................45

3.2.2 Systematic and Non - systematic Risk ....................................................................46

3.2.3 Diversification ....................................................................49

3.2.4 A Critique of The Capital Asset Pricing Model ....................................................................51

3.3 Agricultural Applications of the Capital Asset Pricing Model ....................................................................53

3.3.1 Historical Background ....................................................................53

3.3.2 The Assumptions of the Farm Sector Capital Asset Pricing Model ....................................................................53

3.3.3 An Appraisal of Farm Sector Capital Asset Pricing Model Studies ....................................................................55

a. Return on Activities ....................................................56

b. The Risk-free Asset ....................................................57

c. The Market Index ....................................................60

d. The Impact of Inflation ....................................................61

3.3.4 The Capital Market Line and Systematic Risk ....................................................62

3.4 Farm Portfolio Selection ....................................................62

3.5 Conclusion ....................................................63

Chapter 4 APPLICATION OF THE FARM SECTOR CAPITAL ASSET PRICING MODEL ....................................................64

4.1 Introduction ....................................................64

4.2 The Case Study Property ....................................................64

4.2.1 Rationale ....................................................64

4.2.2 Farm Situation Audit ....................................................66

4.2.3 Choice of Activities for the Model ....................................................68

4.2.4 Activity Returns ....................................................70

4.3 The Model ....................................................72

4.3.1 Introduction ....................................................72

4.3.2 Measures of Return on Activities ....................................................73

4.3.3 The Impact of Inflation ....................................................73

4.3.4 The Farm Sector Portfolio ....................................................74

4.3.4.1 Introduction ....................................................74

4.3.4.2 'New Zealand Agriculture' as a Farm Sector Portfolio ....................................................75

4.3.4.3 'New Zealand Gross Agricultural Production' as a Farm Sector Portfolio ....................................................79

4.3.4.4 'New Zealand Meat And Wool Boards' Economic Service Farm Class 8' as a Farm Sector Portfolio ....80

4.3.4.5 An 'Unweighted Index' as a Farm Sector Portfolio ....82

4.3.5 The Risk-Free Asset ....83

4.4 Summary ....84

Chapter 5 RESULTS AND DISCUSSION ....85

5.1 Introduction ....85

5.2 The Beta Coefficients ....86

5.3 The Farm Sector Capital Asset Pricing Model ....90

5.3.1 The Turvey and Driver Approach versus the Collins and Barry Approach ....90

5.3.2 Gross Revenue versus Gross Margin Models ....93

5.3.3 Deflated versus Non-deflated Models ....95

5.3.4 The Farm Sector Portfolio ....99

5.3.5 Sensitivity to Risk - Free Rate ....110

5.3.6 Summary ....111

5.4 Risk Analysis for the Lincoln University Mixed Cropping Farm Using the Preferred Farm Sector Capital Asset Pricing Model ....113

Chapter 6 SUMMARY AND IMPLICATIONS OF THE STUDY ....120

6.1 Summary ....120

6.2 Principal Findings and Implications of the Study ....122

6.3 Limitations of the Study and Inferences for Further Research ....124

6.4 Research Contributions of this Study ....126

REFERENCES ....127

## APPENDICES


4-1 Lincoln University Mixed Cropping Farm Accounts, Past Trends ........ 133

4-2 Lincoln University Mixed Cropping Farm Activity Gross Margins ........ 134

4-3 Farm Input Cost and Output Price Changes ........ 150

4-4 New Zealand Farm Holdings By Farm Type and Weightings For Different Enterprises ........ 151

4-5 New Zealand Dairy Farm Returns ........ 156

4-6 N.Z. Meat & Wool Boards' Economic Service Farm Class 8 Returns ........ 158

4-7 New Zealand Gross Agricultural Production ........ 159

5-1 Alternative Farm Sector Capital Asset Pricing Models for the Lincoln University Mixed Cropping Farm ........ 160

5-2 Alpha and Beta Coefficients and Their Standard Error Estimates, for the Lincoln University Mixed Cropping Farm Activities ........ 166

5-3 Goldfeld & Quandt Heteroscedasticity Tests ........ 170

5-4 Durban - Watson Autocorrelation Tests ........ 172

5-5 A Comparison of Beta Coefficients and Percent Systematic Risks with Alternative Farm Sector Portfolios; Gross Margin, Deflated Models ........ 174

5-6 Data for Farm Sector Security Market Lines: A Comparison of the four Farm Sector Portfolios ........ 175

5-7 The Unweighted Index - Undercompensation or Not? ........ 176

5-8 Sensitivity of FSCAPM to Alternative Values of Risk - Free Asset (Deflated, Gross Margin Models) ........ 181

5-9 FS - SML For the Lincoln University Mixed Cropping Farm ........ 182

5-10 Compensation for Systematic Risk for the Lincoln University Mixed Cropping Farm Activities ........ 183

# LIST OF FIGURES

Figure 2-1 Illustration of Stochastic Dominance ..... 13

Figure 2-2 Markowitz Mean - Variance Approach ..... 16

Figure 2-3 E - V Efficient Frontier and Marginal Utility of Risk ..... 17

Figure 2-4 The Capital Market Line ..... 36

Figure 3-1 The Security Market Line ..... 44

Figure 3-2 The Characteristic Line ..... 45

Figure 3-3 The CML and Systematic Risk ..... 49

Figure 4-1 Farm Accounts Trend for the Lincoln University Mixed Cropping Farm, 1978 - 1988 ..... 67

Figure 5-1 Security Market Line and the Impact of Inflation ..... 98

Figure 5-2 Annual Returns on Farm Sector Portfolio: A Comparison of the Farm Sector Portfolios ..... 102

Figure 5-3 Farm Sector Security Market Lines : A Comparison of the Farm Sector Portfolios ..... 103

Figure 5-4 Farm - Sector Security Market Line for the Lincoln University Mixed Cropping Farm ..... 116

Figure 5-5 The Farm Sector Capital Market Line for the Lincoln University Mixed Cropping Farm ..... 117

# LIST OF TABLES


Table 4-1 Cover Summary for the Main Block, Lincoln University Mixed Cropping farm (1988/89 Season) .......................... 66

Table 4-2 Activity Returns for the Lincoln University Mixed Cropping Farm .......................... 70

Table 4-3 Percent of Farms in Each Farm Type Group in New Zealand Agriculture .......................... 76

Table 4-4 Weightings for the Farm Sector Portfolio .......................... 77

Table 4-5 Percent of N.Z. Agriculture Represented by the Farm Type Groups .......................... 78

Table 4-6(A) $R_m$ = 'New Zealand Agriculture' (Non - deflated) .......................... 78

Table 4-6(B) $R_m$ = 'New Zealand Agriculture' (Deflated) .......................... 79

Table 4-7 $R_m$ = 'N.Z. Gross Agricultural Production' .......................... 80

Table 4-8 $R_m$ = 'New Zealand Meat and Wool Boards' Economic Service Farm Class 8' .......................... 81

Table 4-9 $R_m$ = 'Unweighted Farm Sector Portfolio .......................... 83

Table 5-1(A) Alpha and Beta Coefficients for the Lincoln University Mixed Cropping Farm Activities; Non - deflated Models .......................... 87

Table 5-1(B) Alpha and Beta Coefficients for the Lincoln University Mixed Cropping Farm Activities; Deflated Models .......................... 88

Table 5-2 Risk - Return Measures Using FSCAPM, for Gross Revenue, Non - deflated, Unweighted Farm Sector Portfolio Model .......................... 91

Table 5-3 Risk - Return Measures Using FSCAPM, for Gross Margin, Deflated, Unweighted Farm Sector Portfolio Model .......................... 92

Table 5-4 Gross Revenue versus Gross Margin Models for Measuring Risk - Return Trade - Offs .......................... 94

Table 5-5 Deflated versus Non - deflated Gross Margin Models for Measuring Risk - Return Trade - Offs .......................... 96

Table 5-6 A Comparison of the four Farm Sector Portfolios .......................... 100

Table 5-7 Sensitivity of the Unweighted Index to Portfolio Size........................107

Table 5-8 Sensitivity of the FSCAPM to Alternative Values of the Farm Sector Portfolio ............................................................109

Table 5-9 Sensitivity of FSCAPM to Alternative Values of Risk - Free Asset ......................................................................110

Table 5-10 Risk - Return Measures for the Lincoln University Mixed Cropping Farm Using the FSCAPM .......................................114

# Chapter 1

# Introduction

## 1.1 The Problem Rationale

Prior to 1984, agriculture was a highly regulated sector of the New Zealand economy, with many forms of government intervention in place, including input subsidies, production subsidies, development schemes, producer board subsidies, interest rate concessions, investment allowances, export incentives, industry controls, producer board legislation, and state ownership (Rayner, 1987). The reasons why New Zealand found itself with a highly regulated economy are very complex, although in the agricultural sector, the government felt it appropriate to stabilise farm incomes and to reduce the impact of volatile overseas commodity prices on farmer investment decision - making. In 1984 alone, the fiscal cost of these agricultural policies to the government was estimated by the New Zealand Treasury to be $1,087 million or 3.2 percent of the country's Gross Domestic Product (Rayner, 1987). These forms of assistance helped to generate a series of large fiscal deficits, and the growth rate of the official debt became insupportable (Ross, 1987).

A change in the attitude of the government towards agriculture occurred when the incoming Labour administration assumed office in late 1984. As a result, agriculture was changed from a highly regulated sector to one where it was subject to fewer interventions than had been the case for some considerable period of time. Fertiliser subsidies, land development encouragement loans, the agricultural investment allowance, the livestock incentive scheme and supplementary minimum prices have been abolished. Other forms of agricultural support have either been removed or greatly reduced. The financial markets have been decontrolled and the exchange rate floated.

The outcome is a greater exposure to market forces, and fewer inbuilt collective stabilisation measures (Johnson, 1987). In summary, the business of farming has become much more risky, and not surprisingly, farmers are now placing greater emphasis on the management of risk.[1]

This risk in farming can arise from a number of sources (Sonka and Patrick, 1984). These include:

(i) Production risk, which is the random variability in a farm's physical output, and is caused by weather, diseases, pest infestations, wind, theft, etc.;

(ii) Market risk or price risk, which is associated with variability in the price of purchased inputs and saleable commodities;

(iii) Technological risk, which is the potential that current decisions may be offset by technical improvements in the future, especially for durable assets;

(iv) Human sources of risk, which is the risk associated with the labour and management functions in farming, e.g. health problems of key operators can severely disrupt farm performance;

(v) Legal sources of risk, which is the risk arising from possible non - fulfillment of contractual obligations or from changes in government policy towards the agricultural sector; and

(vi) Financial risk, which is the random variability of net cash flows to the owners of equity, often induced by leverage.

The first five sources of risk are usually classified as business risk.

---

1. Contemporary discussions of agricultural decision - making tend not to distinguish between the terms "risk" and "uncertainty", which are often used interchangeably. In this study, either term is used to describe actions which have non - certain alternative outcomes (Boehlje and Eidman, 1984).

Various management strategies can be adopted to reduce exposure to both the business and financial risks associated with farming. Responses may be of a production, marketing or financial nature. Farmers may select more stable enterprises, or diversify their operations by combining enterprises which are not perfectly correlated. Farmers may adopt technical practices to respond to uncertainty, such as investing in excess machinery capacity to offset unfavourable weather or maintaining feed reserves to offset drought in the case of livestock farmers. Other responses may be supplemental irrigation to reduce the risk of drought, and substituting capital inputs for labour to respond to the risks associated with hired labour.

Price variability could be reduced by better inventory management, by forward pricing, and by spreading sales over time. Investment in on-farm storage for grain may provide the flexibility to sell storable commodities over a period of time. Forward contracting and hedging may also reduce price variability.

Changes in financial management may also provide protection from business risk; for example, more liquid assets may be held, insurance can be taken out against various contingencies, fixed - term payments may be restructured so that the annual drain on cash reserves falls, the cash conversion cycle can be shortened, and assets can be leased rather than owned. Financial risks may be reduced by selling spare unnecessary assets and using the proceeds to retire some debt. This may also be possible by reducing off-farm investments or reducing private drawings.

With increased producer exposure to risk, it is likely that increasing use has been made of these various risk management strategies. One of these particular strategies, enterprise diversification, has tended to have a relatively high profile, and farmers are often exhorted to increase their returns and reduce their risk by product diversification.

Some New Zealand farmers felt that this was an appropriate strategy and have diversified their farm businesses accordingly. For example, some pastoral farmers have added either deer or goats to their sheep and beef enterprises, while grain farmers have added process crops and small seed enterprises to their cereals and sheep units.

In many respects, these mixed cropping farmers are, by definition, committed to diversification as an appropriate farming strategy, since each season they make decisions on which range of crops to produce given their current set of resources. Deregulation of the economy has seen, among other things, the dismantling of marketing structures in wheat, and this has had a severe impact on the financial viability of many mixed cropping farmers. As a consequence, efforts to diversify appear to have been intensified by these farmers.

Diversification may be strategic, and thus require significant capital investment. For example, pastoral farmers diversifying into deer or goats would need to invest in stock, fencing, stock yards, some irrigation, and perhaps new pastures. In other instances, however, the diversification decision has much more of a tactical dimension, which involves rearranging the combination of possible enterprises without the need for additional capital injection[1]. Much mixed cropping diversification fall into this category, since a small seeds activity or a process crop activity, for example, could be added to the existing range of cropping activities by utilising existing machinery.

## 1.2 The Problem Defined

The issue of how to diversify appropriately in the face of risk, or to select an optimal portfolio of activities, has been well researched in the agricultural economics literature. A range of planning techniques have been developed to deal with the problem,

1. The distinction between strategic and tactical farm planning used here is based on a relative time scale. Strategic planning refers to long term planning where investments in fixed assets are also involved. Tactical planning refers to short term planning, such as for one production season or one year, and no investment in additional fixed assets is assumed.

with most of these being based on quadratic programming techniques, or linear approximations to these. However, despite the volume of research effort expended in this direction, these techniques have not been adopted by farmers as planning tools to assist in their diversification decisions. One reason for this is thought to be their complexity. Thus the need continues for new approaches to measuring and analysing risks which provide appropriate management information, and which are less complex than the more traditional approaches and, therefore, more likely to be adopted by farmers.

Recently, attempts have been made to apply simple single - index regression models to diversification issues in agriculture. These models are much more simple than the more traditional research approaches which have been used and hence are worthy of further investigation. Underlying the various models which have been developed to assist in the diversification decision are a variety of risk concepts. In the literature it is possible to observe such fundamentally different risk concepts as probability of loss, variance of profit and size of the maximum possible loss. Allied to these different concepts are different procedures for measuring risk. For example, the quadratic programming approaches and their approximations, utilise a concept of risk based on the variance of returns, and these models seek to minimise this variance for any given level of expected return.

However, an alternative view of risk which has emerged from the finance literature and which appears to be gaining credence, suggests that viewing risk in terms of overall variance is too crude. It is argued that risk is composed of two components, a diversifiable (or non - systematic) component and a non - diversifiable (or systematic) component. It is argued that the systematic risk is caused by factors which simultaneously affect all activities. Such factors include economy wide variables, such as inflation, exchange rate fluctuations, changes in government policies, etc. The non - systematic risk, however, is unique to an individual farm activity. It is claimed that this non - systematic risk can be eliminated by appropriate diversification, whereas it is not possible to eliminate systematic risk in this way. Therefore, it has been suggested that it may be more appropriate to use these more refined concepts of risk when examining the issue of enterprise diversification.

These concepts of risk have been operationalised using the simple single - index regression models mentioned previously, since these allow the systematic and non - systematic risk associated with any particular enterprise to be isolated. The most well known of these is the Capital Asset Pricing Model, which emanates from the financial management literature. It appears therefore, that these simple models may be able to combine a more subtle understanding of risk with a reasonable degree of simplicity in construction.

Given the fact that the increased exposure to risk since the deregulation is likely to lead to increased diversification activity, it would seem to be timely to investigate how these emerging approaches to evaluating the riskiness of alternative activities or combinations of activities can assist New Zealand farmers in determining whether a range of alternative enterprises can reduce risk. An investigation such as this is likely to be much greater relevance to farmers, such as mixed cropping farmers, who consciously use diversification as a risk management strategy. Since these farmers tend to make short - term tactical rather than long - term strategic decisions on which activities to incorporate into the farm plan, it would seem sensible to initially restrict any study to a consideration of those activities which can be undertaken using the existing resource base of the farm.

## 1.3 Aims and Objectives

The aim of this study is to evaluate the feasibility of using a single - index model, in an appropriate New Zealand setting, to determine whether it can be used to assess what form of diversification activity may be appropriate.

The consequential objectives of the study include:

1. To review the development of the literature on the appropriate choice of a set of farm activities in a risky environment, with a view to evaluating the claim that the concept of systematic risk, and the single - index portfolio models which emanate from it, offers additional insights over more traditional approaches.

2. To evaluate the feasibility of using a specific single - index portfolio model for the analysis and evaluation of systematic risk in tactical farm planning.

3. To apply the concept of a single - index portfolio model to an appropriate New Zealand farming situation, in order to evaluate whether the use of this technique is likely to be feasible in practice.

## 1.4 Thesis Outline

In Chapter Two, more traditional farm management approaches to planning under a risky and uncertain environment are reviewed, and single index models and the concepts of systematic and non - systematic are introduced. A particular single - index model, the Capital Asset Pricing Model is reviewed in much greater depth in Chapter 3. The potential application of this model to a farm planning situation is also evaluated here.

Sources of data and details of the case study farm which was used in the application of the Capital Asset Pricing Model are described and discussed in Chapter Four. The components of the model, and potential variations of the model are also discussed in this Chapter. These alternative models are then evaluated in Chapter Five, where the results are presented and discussed. The preferred model is then used for risk analysis on the chosen case study farm.

Finally, the conclusions and the summary of this study are presented in Chapter Six. The principal research findings and their implications are discussed, as are limitations of this research and recommendations for further research.

# Chapter 2

# A Review of Farm Management Approaches to Planning In A Risky and Uncertain Environment.

## 2.1 Introduction

The purpose of this chapter is to review farm management approaches to planning in a risky and uncertain environment. The progression of concepts of risk and techniques for farm planning under risk are clearly traced, which then allows the concepts of systematic and non - systematic risk and their associated single - index models to be evaluated in an appropriate context. The first section reviews concepts of risk which have been specifically used in farm management analysis. Section 2.3 reviews models which have traditionally dealt with the evaluation of risky farm alternatives for farm planning, and an attempt is made to ascertain whether these traditional approaches have been helpful in assisting farmers to choose the appropriate range of farm activities for a given set of resources.

## 2.2 A Conceptual Framework for the Analysis of Agricultural Risks.

### 2.2.1 The Concept of Bernoullian Utility

Risk and uncertainty are traditionally reflected in variability of outcomes. When the focus is on different enterprises with variable returns, as in this study, some means must be found of ranking these alternative risky prospects. The concept of Bernoullian Utility provides a means of doing this. This is based on the view that farmers' responses to uncertainty are guided by utility maximisation rather than profit maximisation (Lin, Dean, and Moore, 1974).

This expected utility model infers that decision makers who obey certain axioms should choose actions that maximise their expected utility. The axioms are considered to be assumptions of how people behave, and they amount to a general assumption that people are rational and consistent in choosing among risky alternatives (Robison, Barry, Kliebenstein and Patrick, 1984). Robison et.al. set out the axioms as:

1. Ordering of Choices

   For any two action choices, $a_1$ and $a_2$, the decision maker either prefers $a_1$ to $a_2$, prefers $a_2$ to $a_1$, or is indifferent between them.

2. Transitivity among Choices

   If $a_1$ is preferred to $a_2$, and $a_2$ is preferred to $a_3$, then $a_1$ must be preferred to $a_3$.

3. Continuity

   If $a_1$ is preferred to $a_2$ and $a_2$ is preferred to $a_3$, a subjective probability exists ($P(a_1) > 0$) such that the decision maker is indifferent between $a_2$ and a lottery yielding $a_1$ with a probability, $P(a_1)$, and $a_3$ with a probability $(1 - P(a_1))$. This implies that faced with a risky prospect involving a good and a bad outcome, a person will take the risk if the probability of getting the bad outcome is low enough.

4. Independence

   If $a_1$ is preferred to $a_2$, and $a_3$ is some other choice, a lottery with $a_1$ and $a_3$ as its outcome will be preferred to a lottery with $a_2$ and $a_3$ as outcomes when $P(a_1) = P(a_2)$. This suggests that preferences persist independently of successive probability resolutions in evaluating compound lotteries.

Bernoulli's principle may be deduced from these axioms and may be stated as follows: a utility function exists for a decision maker whose preferences are consistent with the axioms of ordering, transitivity, continuity, and independence, this function U associates a single real utility value with any risky prospect, and has the following properties (Anderson, Dillon and Hardaker, 1977, p68).

1. If $a_1$ is preferred to $a_2$, then $U(a_1) > U(a_2)$, and vice versa.

   Where $a_1$, $a_2$ and $a_j$ are risky prospects and we denote the utility value of $a_j$ by $U(a_j)$.

2. The utility of a risky prospect is its expected utility value, i.e. $U(a_j) = E[U(a_j)]$.

3. The scale on which utility is defined is arbitrary, analogous to a temperature scale.

Bernoulli's principle provides the means for ranking risky prospects in order of preference, the most preferred being the one with the highest (expected) utility (Anderson, Dillon, and Hardaker, 1977). It brings together the decision maker's degrees of belief and degrees of preference, which are the important subjective inputs in decision analysis.

#### 2.2.1.1 Utility Measurement Techniques : Stochastic Dominance

It is difficult to accurately measure a decision maker's preferences, because of the shortcomings in interview procedures, problems in statistical estimation and individuals' lack of knowledge about their preferences (King and Robison, 1984). Different elicitation methods are likely to give different results. Also, if the consequences are changed, the probabilities may also vary.

Dillon (1979) criticized the Bernoullian approach noting that it depends on farmers' responses to questions about the relative attractiveness of gambles which may not resemble farmers' perceptions of reality. Wright (1983) also criticized the use of gambling devices to represent real decision choices.

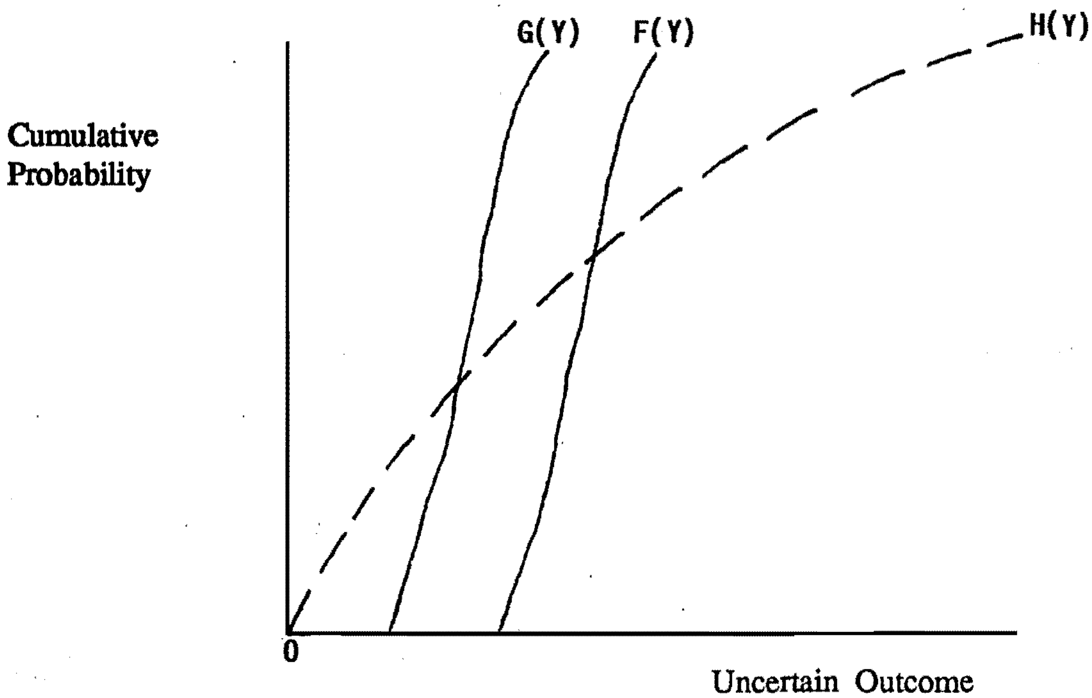
Limitations to the measurement or direct elicitation of utility functions can be eliminated by using an efficiency criterion to order choices. An efficiency criterion divides the decision alternatives into two mutually exclusive sets : an efficient set and an inefficient set, where the efficient set contains the preferred choice of every individual whose preferences conform to the restrictions associated with the criterion (Levy and Sarnat, 1972).

The most well known of the efficiency criteria are the Stochastic Dominance techniques, including the First Degree Stochastic Dominance, Second Degree Stochastic Dominance and Stochastic Dominance with Respect to a Function.

#### 2.2.1.2 First Degree Stochastic Dominance (FSD)

FSD assumes that decision makers have a positive marginal utility for a particular performance measure, such as expected returns. Direct utility elicitation can then be derived in terms of the cumulative probability distribution of a stochastic alternative. This is demonstrated in Figure 2-1.

**Figure 2-1: Illustration of Stochastic Dominance**




A stochastic alternative described by a cumulative probability distribution, F(Y), is preferred to a second stochastic alternative, G(Y), if

$$F(Y) \leq G(Y) \quad \text{........................ Equation 2.1}$$

for all possible Y. In this case, F(Y) is said to dominate G(Y).

However, FSD provides little help in ranking distributions that neither dominate another distribution nor are dominated by another distribution. For example, F(Y) and H(Y) cannot be ranked by FSD, since over some range of the distribution F(Y) dominates H(Y), while over some other range H(Y) dominates F(Y).

According to Boehlje and Eidman (1984), experience with decision - making under uncertainty suggests that distributions which cross are the rule rather than the exception. This suggests that, in practice, First Degree Stochastic Dominance may provide little assistance in ranking alternative outcomes. However, the use of Second Degree Stochastic Dominance may help overcome this.

### 2.2.1.3 Second Degree Stochastic Dominance (SSD)

In this case it is further assumed that in addition to preferring more to less, the decision maker is also risk averse. The stochastic alternative is ordered according to the area below the cumulative probability function. For example, F(Y) in Figure 2-1, is preferred to H(Y) by all risk averse decision makers if the area under the cumulative probability distribution function of F(Y) is less than or equal to the area under H(Y). Unlike FSD, SSD can rank cumulative distribution functions that intersect, such as F(Y) and H(Y) in Figure 2-1. However, there are also difficulties associated with the application of SSD.

### 2.2.1.4 Difficulties with Stochastic Dominance Techniques

The difficulty with both FSD and SSD is that they assume that investment opportunities are mutually exclusive, or that there exists a set of independent investment opportunities (Turvey, 1985). As such, each opportunity is guided by a unique set of resources. However, many diversification studies focus on a single vector of resources, rather than attempting to discriminate between investments in two or more independent resource bases.

Both FSD and SSD, require pair-wise comparisons between alternatives. When large numbers of distributions must be reviewed in this fashion, the work can become exceedingly tedious because they are not well suited for use in mathematical programming models (King and Robison, 1984).

It is possible to go to higher order stochastic dominance if SSD cannot help discriminate between outcomes, but more restrictive general assumptions about preferences would be required. The assumptions which must be made can become quite unrealistic. However, one criterion which has more discriminatory power than FSD and SSD is Stochastic Dominance With Respect to a Function (SDRF), which allows for greater flexibility in representing preferences (King and Robison, 1984). Unfortunately, this requires more detailed information on preferences. The SDRF orders uncertain choices for decision makers whose absolute risk aversion functions lie within specified lower and upper bounds (King and Robison). It thus requires specific information on the lower and upper bounds for a decision maker's absolute risk aversion function. King and Robison argue that this criterion does not always reduce the efficient set to a minimal number of strategies, despite the increased informational requirements of SDRF.

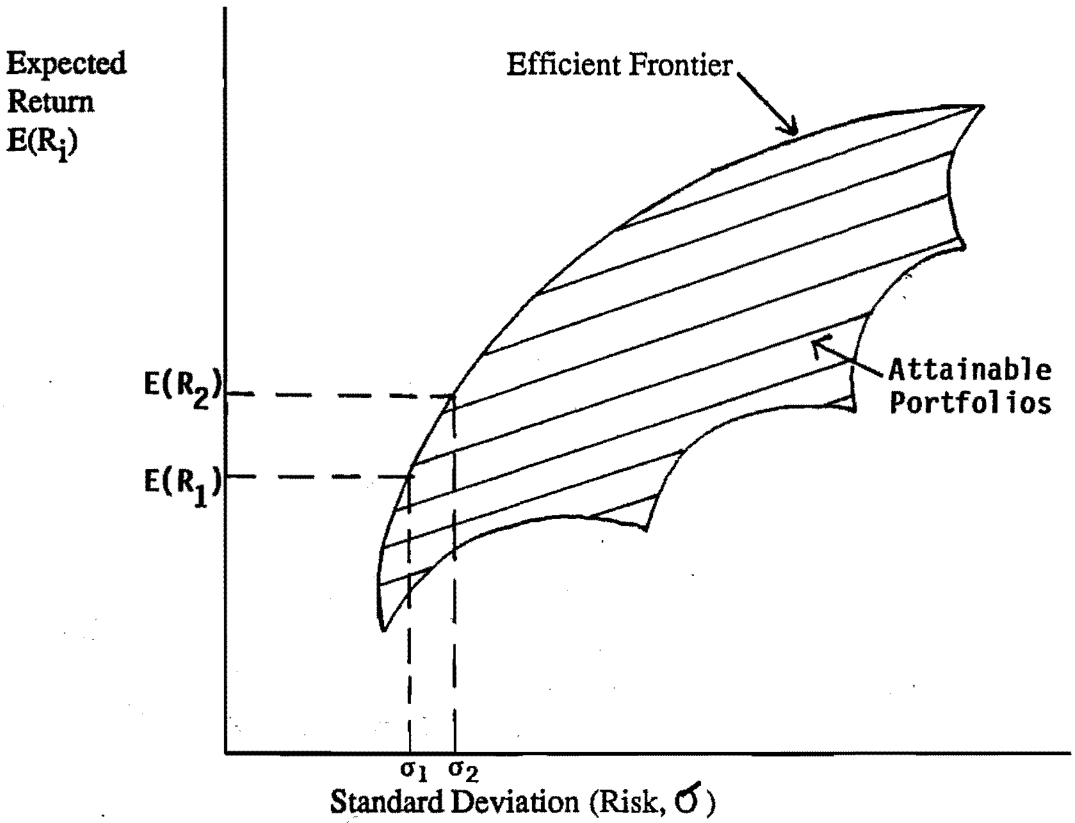
As with FSD and SSD, SDRF cannot be incorporated into a standard mathematical programming model, although SDRF can be incorporated into Monte Carlo simulation techniques. However, this technique is more difficult to use and less efficient computationally than are linear and quadratic programming algorithms (King and Robison, 1984).

It may be possible to get around these practical difficulties encountered with the Stochastic Dominance efficiency criteria by utilising a concept known as the mean - variance efficiency criterion. With normally distributed probability distributions, the ranking of alternatives by mean - variance criterion will be equivalent to those of the SSD criterion. However, the mean - variance criterion, unlike SSD criterion, can discriminate between the allocation of resources for a unique resource base (Turvey, 1985).

#### 2.2.1.5 The Expected Return - Variance of Returns (E-V) Criterion

The mean - variance efficiency criterion or the expected return - variance of returns (E-V) criterion (Markowitz, 1959) requires that decision makers select a portfolio based on a decision rule that minimises the variance of returns for a given level of expected return. When the level of expected return is varied, this approach yields an efficiency frontier where standard deviation (i.e. square root of variance) is the measure of risk. This is illustrated in Figure 2-2, where $\sigma_1$ represents the minimum level of risk associated with the expected return, $E(R_1)$, while $\sigma_2$ represents a higher level of risk that requires a higher level of expected return $E(R_2)$.

**Figure 2-2: Markowitz Mean - Variance Approach**

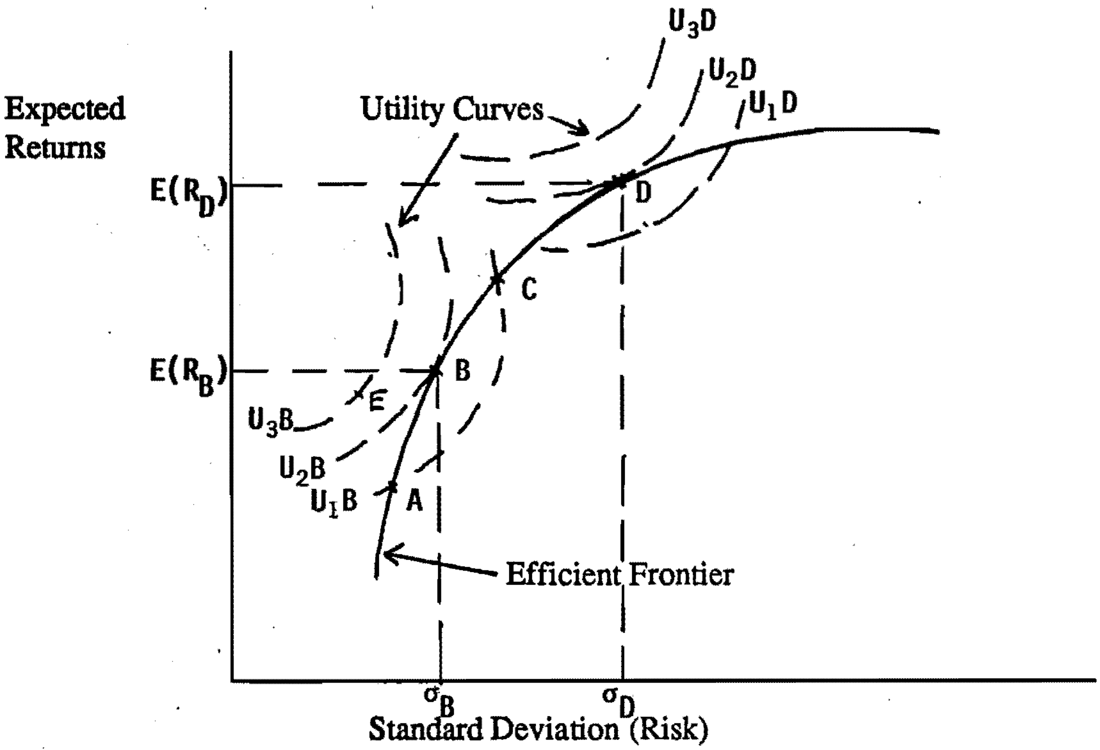



The E-V efficiency criterion requires that the decision maker be risk averse, that the outcome distributions be normal, and that the decision maker's utility function be quadratic. Under these conditions, all relevant information concerning the probability distributions of alternative choice can be conveyed by the means and variance (King and Robison, 1984).

The selection of an optimal farm plan, through the process of evaluating and delimiting risky strategy choices along an E-V efficient frontier will lead to a utility maximising point of tangency between the individuals' utility function and the E-V frontier. This is illustrated in Figure 2-3.

Figure 2-3 shows a family of indifference curves as well as the convex set of portfolio choice offered by various percentages of investment into the risky assets represented by the efficient frontier. If the risk - return trade - off is known, the possibilities offered by combinations of risky assets is also known and expected utility is maximised at point B. This is where the indifference curve is tangent to the opportunity set offered by combinations of risky assets. Moving from left to right in Figure 2-3, the indifference curve $U_1$ has less total utility than indifference curve $U_2$, and so on. All money could be invested in one asset giving the risk and return at point A. However, point B represents an improved position. Point E has a higher total utility than point B, but it is not feasible because the opportunity set offered by the risky assets does not extend that far.

**Figure 2-3: E-V Efficient Frontier and Marginal Utility of Risk**




## 2.2.2 Portfolio Theory and the E-V Criterion

A portfolio is a collection of two or more assets or activities. Markowitz (1952) laid down the cornerstones of modern portfolio theory by stating that

> " The investor must contemplate the various efficient combinations of average returns and standard deviations. He must choose one combination of average and standard deviation which, more than any other, satisfies his needs and preferences with respect to risk and return" (p.79).

Portfolio theory states that the contribution of two activities the returns of which are not fully correlated will provide a combined volatility that is less than that of either asset. The manager attempts to reduce volatility by seeking activities having a small or negative correlation between returns in the managed portfolio, and tries to reduce volatility without reducing the total return. This theory provides a measure of risk which is, in theory, both objective and quantifiable; and provides a framework in which risk and return are considered at the same time. It provides a method to construct portfolios which will generate the greatest return for any desired level of risk. It also identifies the most efficient form of diversification.

Portfolio theory uses three pieces of data, the expected return on an activity, the standard deviation of the return and the co-variance between returns on different activities. The standard deviation is used as the proxy for risk in Portfolio theory, while the co-variance is a measure of the extent to which returns on two activities move in the same or opposite directions. That is, the higher the standard deviation of an activity the less stable and so the riskier the return.

The expected return on a portfolio ($R_p$) is the weighted average return of the individual activities in the portfolio, with the weights being the proportion of the total funds invested in each activity. That is,

$$R_p = x_1 R_1 + x_2 R_2 + \ldots\ldots + x_n R_n \quad \text{..........................................Equation 2.2}$$

where $x_1$ is the fraction of the portfolio held in activity 1;

$x_n$ is the fraction of the portfolio held in activity n;

$R_1$ is the expected return on the activity 1; and

$R_n$ is the expected return on the activity n.

The standard deviation of the portfolio, $\sigma_p$, is determined by

a. the standard deviation of each activity;

b. the correlation between each pair of activities; and

c. the amount invested in each activity.

That is,

$$\sigma_p = \sqrt{\sigma_p^2} = \sqrt{\sum_{j=1}^{N} x_j^2 \sigma_j^2 + \sum_{j=1}^{N} \sum_{\substack{k=1 \\ j \neq k}}^{N} COV(x_j x_k)} \quad \ldots \text{ Equation 2.3}$$

where $COV(x_j x_k) = r_{jk} \sigma_j \sigma_k$ ;

$r_{jk}$ is the correl. coefficient between activities j and k;

$\sigma_p^2$ is the var. of the return on the portfolio;

$\sigma_j^2$ is the var. of the return on the j'th activity; and

$\sigma_k^2$ is the var. of the return on the k'th activity.

A portfolio is inefficient if either some other portfolio exists which has a higher average return and no greater standard deviation, or alternatively has a lower standard deviation and no lower average return.

The efficient set, which is also known as the efficient frontier, and corresponds to the E-V frontier (Figure 2-2), consists of all activities and portfolios that lie on this curve and indicates the minimum variance of returns for given levels of expected returns.

Movement along the E-V frontier reflects a tradeoff between the expected returns and the variance of those returns. Finding all portfolios along this frontier constitutes what has become known as the portfolio problem. The selection of a portfolio by the investor on this efficient frontier is defined by that individual's utility function and degree of risk aversion. This is illustrated in Figure 2-3, where a farmer who selects a portfolio (or a farm plan) at point B is exhibiting a higher degree of risk aversion, than a farmer who selects point D, since the farmer who selects point B is opting for a lower level of risk and expected returns than the farmer who selects point D. For an individual farmer, therefore, the optimum or the risk-efficient farm plan, is the point of tangency between the efficient frontier and the E-V utility curves.

The E-V efficiency criterion is preferable to stochastic dominance when tactical diversification issues are important, since it is able to discriminate between allocation of resources for a unique resource base. The means and variances of returns are easy to work with, and not surprisingly, a lot of theoretical work on decision making under uncertainty has used the E-V criterion for analytical convenience (King and Robison). It is also well suited for use in mathematical programming models.

The efficient E-V set of farm plans can be derived with the aid of quadratic programming or by linear programming approximating techniques such as the Linear Programming - Risk Simulator (LP-RS), and the Minimisation Of Total Absolute Deviation (MOTAD). These techniques are discussed in the next section.

## 2.3 Techniques for Optimal Farm Planning that Incorporate Risk.

### 2.3.1 Introduction

In this section various farm planning techniques which incorporate risk and can be used for tactical decision - making are outlined and any theoretical and practical limitations of them are evaluated.

Whole farm planning and budgeting, gross margins analysis, and standard linear programming techniques do not formally take account of the riskiness associated with the activities under consideration. In linear programming, for example, single-value expectations of input-output coefficients are assumed. Although conservative estimates may be used to incorporate risk, but this can be highly subjective and thus run the risk of inconsistency and bias. While the use of these conservative estimates reduces the danger of management decisions based on an incorrect plan, it does not provide the farmer who has an aversion to risk with "best plan" or "efficient" alternatives that measure the trade-off between quantitatively measured income and risk (Driver and Stackhouse, 1976). Sensitivity analysis can help determine the appropriate impact of the change in one or more variables on the outcome and thus give a general indication of the more important variables for consideration in risk analysis.

As a consequence, a great deal of research has been directed to more formal methods of incorporating various concepts of risk into farm planning. The remainder of Section 2.3 evaluates the more prominent of these, which include systems simulation models, quadratic programming and some linear programming approximations that use the E-V efficiency criterion such as MOTAD, LP-RS, focus-loss, stochastic programming, and single-index models.

### 2.3.2 Systems Simulation

Computer based simulation model can mimic complex situations characterized by uncertainty and change over time (Dent and Blackie, 1979). Uncertainty can be incorporated in systems models by way of random values for prices, costs, etc. Although simulation is not an optimizing technique, risk may often be incorporated by using Stochastic Dominance techniques to rank alternatives. However, in risk analysis researchers are frequently interested in identifying actions that will be optimal according to some criteria (Mapp, Jr. and Helmers, 1984).

Another major limitation is the uniqueness of each farm business. Elaborate models of the operation of a 'representative' whole farm business may therefore prove to be too general to be used to give sensible, individual farm management advice (Malcolm, 1988). On the other hand, to provide a detailed simulation model of an individual farm system would be too expensive. Hence, simulation is likely to be a very expensive and time-consuming method of studying the effects of diversification among activities within a farm business.

### 2.3.3 Quadratic Risk Programming

Markowitz (1959) proposed that decision makers select a portfolio based on a decision rule that minimizes the variance of return for a given level of expected return. This approach formally incorporates risk into the planning framework.

Markowitz conceptualised the portfolio selection problem in a quadratic programming framework and specified the objective to minimize portfolio variance for alternative levels of expected returns. The model as outlined by Mapp and Helmers (1984) is as follows:

$$\text{Minimize} \quad V(Z) = \sum_{i=1}^{n} \sum_{j=1}^{m} q_i \, \sigma_{ij} \, q_j \quad \text{............ Equation 2.4}$$

$$\text{subject to} \quad \sum_{i=1}^{n} q_i \, U_i \geq M$$

$$\sum_{i=1}^{n} q_i = 1$$

$$q_i \geq 0 \text{ for } i = 1, \ldots, n$$

where $q_i$ = proportion of each risky investment i;

$U_i$ = the expected return for investment i;

$\sigma_{ij}$= the variance - covariance matrix; and

M = the expected income level.

The system is solved iteratively through parametric variations in the expected income level, M, to define a set of risk efficient (minimum-variance) solutions.

Quadratic risk programming, as an expected utility approach, is consistent with the existing body of decision theory (Mapp, Jr. and Helmers, 1984). The objective function here corresponds to a quadratic utility function having expected income and variance of income as the objects of utility (Section 2.2.1.5). The quadratic programming model takes account of the variance of each activity separately and the co-variance of different pairs of activities. These covariances are fundamental for efficient diversification among farm enterprises as a means of hedging against risk (Heady (1952); and Markowitz (1959)).

The mean-variance model has proved popular in farm planning analysis. However, applying the Markowitz approach by using quadratic programming requires a great deal of data. For example, 100 activities requires 100 expected returns, 100 variances, and no less than 4950 correlation coefficients between returns of different activities (Dobbins and Witt, 1983). In addition, the need to use a quadratic programming algorithm is often troublesome. Hazell and Norton (1986) contend that the lack of widely available trouble-free solution algorithms have restricted the application of quadratic programming as a practical decision aid in solving applied management problems. To overcome these problems, several methods have been proposed for obtaining approximate solutions to the mean-variance problem.

### 2.3.4 Linear Models

(a) Linear Programming - Risk Simulator (LP-RS)

One approximation to the quadratic programming solution is the Linear Programming-Risk Simulator (LP-RS) model developed by Driver and Stackhouse (1976). This model utilizes a risk simulator in conjunction with a linear program to examine efficient E-V trade-offs. Turvey (1985) concludes that E-V combinations generated from LP-RS should closely approximate those generated by the quadratic programming models since the constraint set forms a convex polyhedral and defines a number of small linear surfaces. Optimal solutions do not occur along these linear surfaces as in the quadratic programming model, but they occur at the corner points. Turvey (1985) noted that when a large number of constraints were in the program the distance between corner points was small, and therefore it approximated the E-V efficient quadratic programming frontier.

Turvey presents this model as follows:

Maximise $(c - ks)' x_j$ ....................................................................Equation 2.5

subject to

$$A x_j < b$$
$$x_j > 0$$
$$ENFI_j = c'x_j$$
$$SDNFI_j = x_j' Q x_j$$

where c is a 1 x N vector of expected monetary returns,

k is a parametric discount scalar,

s is a 1 x N vector of standard deviations of returns,

x is a 1 x N vector of real activities,

A is an M x N matrix of technical coefficients,

b is an M x 1 vector of resource constraints,

$ENFI_j$ is the expected net farm income of the j'th strategy derived from LP-RS,

$SNDFI_j$ is the standard deviation of the expected net farm income for the j'th strategy derived from LP-RS,

$x_j'Q x_j$ is the square of the standard deviation of expected net farm income, for any ENFI equal to or greater than the ENFI of the j'th plan of LP-RS,

Q is an N x N variance - covariance matrix.

Turvey notes that the LP-RS model did indeed display a high correlation with quadratic programming when statistical tests of significance were calculated to compare the two E-V sets. However, he observed that the number of constraints decreased as the risk scale k was increased, thereby increasing the distance between the corner points. Turvey also concludes that LP-RS would only provide an efficient E-V frontier if there were a large number of constraints in the constraint set. Finally, LP-RS does not incorporate the variance-covariance matrix, and therefore any positive or negative correlation between the farm activities is not taken into account (Driver and Stackhouse, 1976).

(b) Minimisation Of Total Absolute Deviations (MOTAD)

Another linear programming alternative which can be used in E-V analysis is the Mean Absolute Deviation (MAD) model, developed by Hazell (1971). Hazell defined MAD as;

$$MAD = \frac{1}{s} \sum_{n=1}^{s} \left| \sum_{j=1}^{n} (c_{hj} - g_j)\, x_j \right| \quad \ldots\ldots \text{ Equation 2.6}$$

where MAD is an unbiased estimator of the population mean absolute deviation,

s denotes the number of observations of gross margin returns,

$c_{hj}$ is the nominal return of the j'th commodity in the h'th time period,

$g_j$ is the expected return of the j'th commodity, and

$x_j$ is the constrained activity vector.

Using MAD as a measure of uncertainty and E as expected income level, it is possible to select a farm plan on the basis of E-MAD (Hazell, 1971). Efficient E-MAD farm plans are those having minimum mean absolute income deviation for given expected income level E. The E-MAD criterion has an important advantage over quadratic programming techniques in that it can be used in a linear programming model.

Hazell (1971) illustrates how this can be achieved by recognising that the sum of the total absolute positive deviations was equal to the sum of the total absolute negative deviations; i.e.

$$y_h = \sum_{j=1}^{n} c_{hj}x_j - \sum_{j=1}^{N} g_jx_j \quad \text{.......... Equation 2.7}$$

(for all h, h = 1,.......,s)

such that

$$y_h = y_h^+ - y_h^-$$

and $y_h^+ , y_h^- \geq 0$

that is, such that $y_h$,(h = 1 ,..., s), are unconstrained in sign. Then, if $y_h^+$ and $y_h^-$ are selected in some minimal way so that one or the other is zero, $y_h = y_h^+ + y_h^-$, (h = 1 ,..., s).

$Y_h$ = the absolute value of the negative total gross margin deviations;

$Y_h^+$ = the deviation of farm income from its mean is positive;

$Y_h^-$ = the deviation of farm income from its mean is negative;

$\sum_{j=1}^{n} c_{hj}.x_j$ = the total gross margin of a particular farm plan evaluated with observed gross margins for the h'th sample observations; and

$\sum_{j=1}^{n} g_j.x_j$ = the total gross margin for the same farm plan evaluated with sample mean gross margins.

However, according to Hazell, we can do this concurrently while seeking optimal vector $x_j$, $(j = 1, ..., n)$, in the following linear programming model.

$$\text{Minimise} \quad s\ MAD = \sum_{h=1}^{s} (y_h^{+} + y_h^{-}) \quad \ldots\ldots\ldots\ldots \text{Equation 2.8}$$

such that

$$\sum_{j=1}^{n} (c_{hj} - g_j)\, x_j - y_h^{+} + y_h^{+} = 0 \quad \ldots\ldots \text{Equation 2.9}$$

(for all h, h = 1,......,s)

and

$$\sum_{j=1}^{n} f_j x_j = \lambda \quad (\lambda = 0 \text{ to unbounded})$$

$$\sum_{j=1}^{n} a_{ij}\, x_j \leq b_i \quad (\text{for all } i,\ i = 1, \ldots, m)$$

$x_j, y_h^{+}, y_h^{-}$ > or = 0 (for all h,j).

Where

$a_{ij}$ represents the technical requirements of the j'th activity on the i'th resource;

$b_i$ = the i'th constraint level

$y_h$ = the absolute value of the negative total gross margin deviations;

$\lambda$ = a scalar representing a required net income or gross margin.

Since the objective function in the model is the Minimisation Of the Total Absolute Deviations, Hazell called it the MOTAD model. Mapp, Jr. and Helmers (1984) note that the MOTAD approach does not require a variance-covariance matrix, unlike the quadratic programming approach. However, MOTAD does consider the covariance relationships among activities.

However, Turvey (1985) concludes that MOTAD is limited in its estimation of the variance, and cannot be regarded as a good alternative to quadratic programming techniques but as a proxy unbiased estimator.

Turvey suggests further limitations of MOTAD which were raised by Hazell. The first is that a type II error may occur in the statistical specification of the population variance and lead to the selection of the wrong farm plan.[1] The reverse, however, is not necessarily true, since the selection of the farm plan depends not only on the imputed variance for a given required income, but also on the sensitivity of the true farm plans to changes in the variance and on the rigidity of the resource constraints in forcing the farm plan (Turvey, 1985).

1. Type II decision error occurs when we accept the null hypothesis falsely rather than reject it when alternative hypothesis is true.

(c) The Focus - Loss Model

A further linear variation of the quadratic risk programming model is the 'focal-loss' model. Hazell and Norton (1986) defined the focal loss of a risky activity as the level of loss that a decision maker would be "very surprised" to realize.

This model was developed by Boussard and Petit, who approximated focal loss values for different farm activities using "decennial catastrophies", which they described as the worst gross margin that might occur once in a decade (Hazell and Norton, 1986). Given this "worst" gross margin (call it $c_j^*$) for each activity, and the expected gross margin, $\bar{c}_j$, the focal loss is defined as $f_j = \bar{c}_j - c_j^*$, for all j (Hazell and Norton).

For any farm plan, a maximum permitted loss (call it LOSS) is defined by Hazell and Norton, as the difference between expected total gross margin, $\sum \bar{c}_j, X_j$, and the minimum income (MINI) required to cover farm fixed costs, essential family living costs, and debt repayment. That is,

$$\text{LOSS} = \sum_j \bar{c}_j X_j - \text{MINI} \quad \text{.............. Equation 2.11}$$

A requirement is imposed that no single activity may have a total focal loss $f_j X_j$ greater than 1/k of the maximum permitted loss for the farm plan. These constraints are $f_j X_j \leq 1/k$ (LOSS), for all j.

This model can be solved by standard linear programming codes, and it requires relatively little information about possible gross margin outcomes. However, it ignores covariance relations between activity gross margins and the model assumes that the focal loss of each activity can occur in the same year (Hazell and Norton, 1986). In addition, Hazell and Norton note that the focal loss coefficients are inherently difficult to measure.

The focal-loss model, like any other safety-first models, does not penalize large deviations below the mean as does the mean-variance model. Selly (1984) concludes that the safety-first rules cannot be derived from the maximisation of expected utility and are therefore frequently characterized as ad hoc.

(d) Stochastic Programming

Stochastic linear programming is another form of risk programming. It assumes that both the input-output coefficients and some resource stocks are stochastic. For example, on a sheep farm both the nutritional requirements per head of sheep and the feed resources available may be affected by weather. The range of possible values for each variable subject to risk variation is specified as a probability distribution. Its use involves solving a number of linear programmes with values of the variables drawn from the probability distributions. Thus a procedure is required for obtaining sets of random variations from the complete range (Barnard and Nix, 1979).

The difficulty in its application is the estimation of the probability distributions for all items to be included in the matrix that are likely to be subject to random variation. The technique is also demanding of computer time.

Anderson, Dillon and Hardaker (1977) classified stochastic programming problems into two broad groups of non - sequential problems and sequential problems.

I. Non-sequential Stochastic Programming

In non-sequential decision problems, all decisions are made at one point in time, or if spread through time, there is not the interleaving of decisions and uncertain events (Anderson, Dillon, and Hardaker, 1977). However, these authors argue that solving non-sequential stochastic programming with a non linear utility function is quite complicated. A realistic farm planning matrix would be massive and perhaps uneconomical.

Chance-constrained programming has been suggested as one possible mathematical programming approach which could solve this problem. In this approach the objective function, such as expected profit, is optimised subject to a set of constraints. Each resource constraint is considered in turn and must at least be satisfied at its specified level of probability. However, Anderson, et al described this as a crude and generally unsatisfactory method for whole-farm planning under risk, and noted that it suffers from the arbitrary choice of probability levels.

II. Sequential Stochastic Programming

Sequential decision problems involve making two or more related decisions at different points in time. Later decisions may be influenced both by the earlier decisions and by stochastic parameters whose values become known to the decision maker after the first decisions but before the later decisions (Anderson, Dillon and Hardaker, 1977). Many of the farm decision problems are sequential in nature.

None of the mathematical programming methods currently available is capable of solving these sequential decision problems, although discrete stochastic programming comes closest to it.

Anderson, Dillon and Hardaker described discrete stochastic programming as a programming formulation of a decision tree in which the essential feature is an explicit specification of the available acts and possible events in their proper time sequence. In the programming model, act forks are usually represented in terms of continuous decision variables, but event forks can be represented only in terms of a relatively small number of discrete outcomes.

A separate submatrix is required for each set of decision variables following each event. As the number of events increases so does the size of the matrix. With real farm situations, the size of the matrix can get very large and models can quickly reach unmanageable proportions (Anderson et al). The technique also requires a large amount of data.

(e) Summary of Linear Models

A range of linear alternatives to quadratic risk programming techniques exist. The LP-RS model requires a large number of constraints in the constraint set. It does not incorporate the variance-covariance matrix, and therefore any positive or negative correlation between the farm activities is not taken into account. The MOTAD model is limited in its estimation of the variance and it cannot be regarded as a good alternative to quadratic programming techniques. The focal-loss coefficients in the Focus-Loss Models are difficult to measure and the model is frequently characterised as ad hoc. With Stochastic Programming techniques the difficulty is estimating the probability distributions, and the technique is demanding of computer time.

The failure of the linear models, and the massive data requirement, together with the difficulty of developing adequate computer codes for quadratic programming techniques, have encouraged many researchers to look for other ways of producing risk efficient farm plans. Some of these (Barry, 1980; Turvey, 1985; Collins and Barry, 1986; Turvey and Driver, 1987; and Turvey, Driver, and Baker, 1988) have suggested the use of single-index portfolio models.

## 2.3.5 The Single-Index Models

With a view to simplifying the computational procedure and reducing the quantity of data required for the Markowitz quadratic programming approach, a new approach was suggested by Sharpe (1964) and Lintner (1965) who developed the market (or single-index) model in the context of capital market investments. This assumes that each asset's price movement can be related to the price of the market portfolio, which is a portfolio comprising a weighted average of all the assets traded on the market. The returns of the various assets in the asset universe are assumed to be related to each other only through common dependence upon this market index, and hence the necessity to specifying the covariance of returns between every pair of assets is eliminated.

The market model generates a characteristic line

$$R_i = a_i + B_i R_m + e_i \qquad \text{Equation 2.12}$$

where $R_i$ is the return on the i'th asset, $R_m$ is the return of the market portfolio, $a_i$ and $B_i$ are parameters, and $e_i$ is a random error term. The estimates of $a_i$, and $B_i$ are usually obtained from time series regression analysis.

In this market model the only reason why assets vary together, systematically, is because of a common co-movement with the market. There are no effects beyond the market that account for co-movements between assets. Therefore, it is possible to split the return on an asset into two parts, that which is correlated with the market return (systematic) and that which is independent of the market return (non-systematic). Since the systematic return is correlated with the market return, it may be expressed as a factor B (beta) times the market return. The coefficient $B_i$ therefore indicates the expected responsiveness of an asset i's return to changes in the level of the market index (Dobbins and Witt, 1983). Thus, the mean return of an asset i, $E(R_i)$, is given by

$$E(R_i) = a_i + B_i R_m \qquad \text{Equation 2.13}$$

An asset's variance also has a systematic and a non-systematic component. The variance of an asset's return, $\sigma_i^2$, is given by

$$\sigma_i^2 = B_i^2 \sigma_m^2 + \sigma_{ei}^2 \quad \text{.................. Equation 2.14}$$

where $\sigma_i^2$ is the variance of the return of the i'th asset,
$\sigma_m^2$ is the variance of returns on the market portfolio,
$\sigma_{ei}^2$ is the variance of the regression residuals.

Thus, expected return and risk can be estimated for any portfolio of assets if we have an estimate of $a_i$ for each asset, an estimate of $B_i$ for each asset, and estimate of $\sigma_{ei}$ for each asset, and finally an estimate of both the expected return $E(R_m)$ and variance ($\sigma_m^2$) for the market, all of which can be derived from a time series of returns for each individual asset and the market index.

This market model was initially used by Sharpe to simplify the process of evaluating efficient portfolios in the Markowitz framework. Determining these portfolios involves following a similar procedure to that required by the original Markowitz formulation. It is again necessary to solve a quadratic programming problem, but with a considerably reduced number of inputs. To follow 150 assets, this model requires 452 estimates, where as 11,175 correlation estimates would be required when no simplifying structure is assumed as in quadratic programming (Elton and Gruber, 1987). There is no requirement for direct estimates of the joint movement of assets, only estimates of the manner in which each asset moves with the market.

Although the Sharpe simplification resulted in the Markowitz model having much greater practical value, attention soon shifted to the development of the capital asset pricing model (CAPM), for which Sharpe's market model provided the conceptual foundation (Dobbins and Witt, 1983, p53).

The Markowitz mean-variance model was modified by introducing into the analysis the concept of a risk-free asset, such as treasury bills, whose returns are guaranteed especially if for under twelve months duration. They are supposed to have zero risk with low positive returns. Once a risk-free asset is introduced, a Capital Market Line (CML) can be generated, as illustrated by the line $R_f$ - H, in Figure 2-4, where $R_f$ represents the risk - free rate. Thus a new set of portfolios as depicted by the CML is derived, which dominates the Markowitz efficient frontier at all levels of utility. This becomes possible because an investor now has the option to borrow assets to supplement what he already owns, or he can lend some or all of his own assets at a risk-free rate. That is, the borrowing and lending opportunities at a risk-free rate permits the investor to move to a higher level of utility than would otherwise be possible. This is shown by the two utility curves in Figure 2-4. The particular point chosen on the line will depend upon the individual's utility function, which will be determined by his attitude towards risk and expected return.

**Figure 2-4: The Capital Market Line**

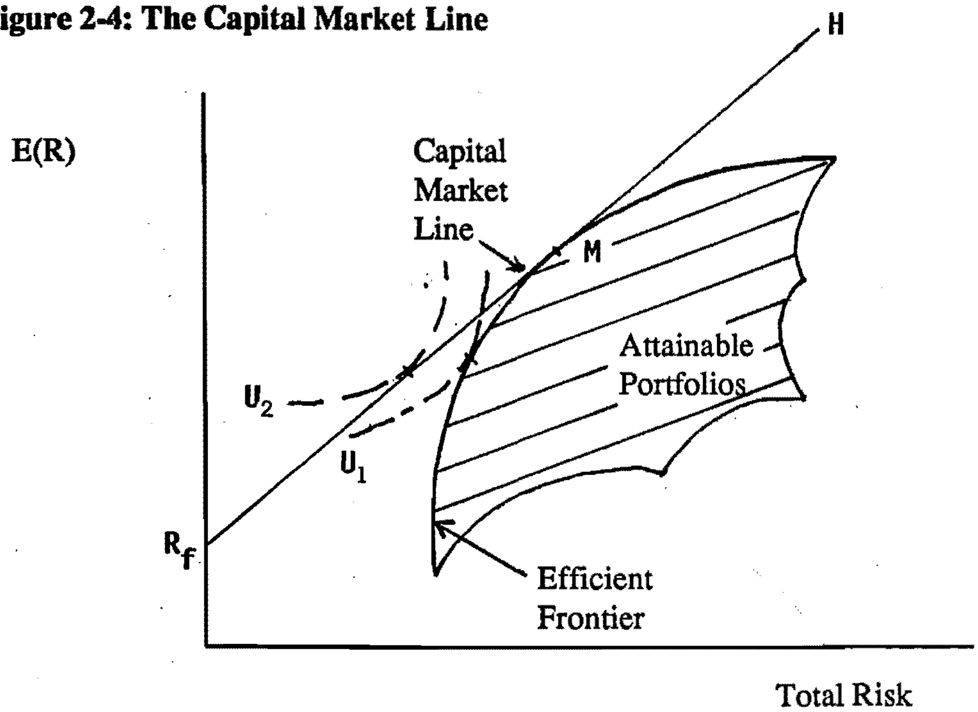



Figure 2-4 shows that investors who are very risk-averse would select portfolio along the segment $R_f$ - M and place some of their money in a riskless asset and some in risky portfolio M. Others who are much more tolerant of risk would hold portfolios along the segment M - H, borrowing funds and placing their original capital plus the borrowed funds into portfolio M. Still others would place the total of their original funds in the risky portfolio M. Thus, for the case of riskless lending and borrowing, identification of portfolio M constitutes a solution to the portfolio problem (Elton and Gruber, 1987) since this will determine the slope and position of the CML and Portfolio M is the market portfolio. As discussed above, a market portfolio is a portfolio comprising a weighted average of all the assets traded on the market.

As with all E-V models, the CAPM is suitable for use in tactical decision making. In addition, however, it is simpler than other risk incorporating planning techniques and it does not require massive data input.

Although applications of the CAPM are new to agricultural economics and farm management research, Turvey (1985), Collins and Barry (1986), Turvey and Driver (1987) and Turvey, Driver and Baker (1988) have demonstrated that the CAPM can be used to distinguish between diversifiable and non-diversifiable components of the total risk facing farmers. They have also demonstrated that this distinction can assist farmers in the selection of optimal farm plans, and have shown that the model can generate an optimal farm plan not significantly different from a quadratic programming solution. It can also provide a measure of riskiness of each enterprise relative to the market and information on whether enterprises or activities are being adequately compensated for risk. In Chapter Three, the capital asset pricing model is discussed in greater detail.

## 2.4 Conclusion

This review has indicated that the use of the E-V efficiency as the efficiency criterion to order uncertain choices is most appropriate for tactical decision making and where the level of resources are assumed fixed.

There are a number of risk - incorporating farm planning techniques that use the E-V efficiency criterion, but in practical farm management work none of these appear to be used. They either require a massive amount of data, or are mathematically too complex for any practical benefit. Despite efforts to simplify them, they are still unlikely to be adopted by farmers to assist in on-farm planning. For example, a survey by Lockhart (1989) showed that approximately sixty percent of New Zealand farmers prepare cash forecast budgets, but only forty six percent do this as a planning exercise. The rest of the farmers either undertake no planning or use less formal methods. It is useful to bear in mind that cash budgeting is one of the simplest formal planning techniques and it does not incorporate risk.

This review has suggested that the Capital Asset Pricing Model is relatively computationally simple and the quantity of data required is much reduced. In addition, it is able to distinguish between diversifiable and non-diversifiable risk components, thereby allowing only that risk component which cannot be diversified to be focussed on. Although the model can be used to derive optimal farm plans in a more simplified way, it is still unlikely that such models would be used by farmers. However, the CAPM model generates a range of information on the riskiness and return of alternative activities, which could be used intuitively by farmers to assist them with tactical diversification decisions. A detailed review of the Capital Asset Pricing Model will be presented in the next Chapter, and its relevance and potential application to risk management in agriculture will be analysed.

# Chapter 3

# The Development of a Farm Sector Capital Asset Pricing Model for the Analysis and Evaluation of Risk in Tactical Farm Planning

## 3.1 Introduction

The purpose of this chapter is to evaluate the use of the Capital Asset Pricing Model which can provide useful information for farmers and researchers on risk management. Such a model will provide a measure of the riskiness of each enterprise relative to some chosen market index, and information concerning whether enterprises or activities are being adequately compensated for risk. The feasibility of using the Capital Asset Pricing Model to determine whether diversification activity is appropriate is also evaluated.

It was concluded at the end of Chapter 2 that this particular model may be an appropriate method of evaluating risk in agriculture. Its computation is simpler than alternative models as it does not require a massive data input. It also distinguishes between the diversifiable and non-diversifiable risk components, and uses the E-V efficiency criterion to order uncertain choices. Such a model can also be used to generate risk-efficient, optimal farm plans that should not be significantly different from quadratic programming solutions (Turvey, 1985).

The first section of this chapter reviews the Capital Asset Pricing Model (CAPM). Section 3.3 looks at the application of the CAPM to the agricultural sector, in particular to farm planning. The use of Betas, generated from the CAPM, in farm portfolio selection is briefly described in Section 3.4.

## 3.2 The Theory of Capital Asset Pricing

### 3.2.1 Deriving The Capital Asset Pricing Model (CAPM)

#### a. The Capital Market Line

A number of assumptions underlie the CAPM. These include risk aversion, identical time horizons and expectations for all investors with respect to each financial asset, unrestricted borrowing and lending at the risk-free rate, no taxes or transaction costs, and investors choosing portfolios on the basis of their expected mean and variance of returns. These assumptions are further discussed in an agricultural context in Section 3.3.2.

The above assumptions imply that the investor can mix risk-free assets with a universe of risky assets to construct a new set of possible investment portfolios as depicted by the Capital Market Line (Turvey, 1985, p28), which was illustrated in Figure 2-4. The portfolios on this Capital Market Line (CML) offer greater return for a given level of risk than portfolios on the Markowitz efficient frontier. The particular point chosen on the line will depend upon the individual's utility function. Tobin (1958) derived what has become known as the separation theorem which states that an investor's choice of risk level is completely independent of the problem of deriving the optimal portfolio of risky assets.

As discussed in Section 2.3.5, all portfolios along the CML are theoretically efficient in that they have no diversifiable risk, and the expected return of any portfolio along the CML is function of the total risk of the portfolio (Dobbins and Witt, 1983). The CML thus shows the return expected from any efficient portfolio.

The expected return on the efficient portfolio is

$$E(R_p) = aR_f + (1-a)E(R_m) \quad \text{.......... Equation 3.1}$$

where $E(R_p)$ = expected return on an efficient portfolio,

$R_f$ = return on holdings of a risk-free asset,

a = proportion of wealth invested in $R_f$, and

$E(R_m)$ = expected return on the market portfolio, M.

Since the standard deviation of the risk-free asset is zero, the standard deviation of the efficient portfolio on this line is

$$\sigma_p = (1 - a)\ \sigma_m \quad \text{.......... Equation 3.2}$$

where $\sigma_p$ = standard deviation of returns from the efficient portfolio, P; and

$\sigma_m$ = standard deviation of returns from the market portfolio, M.

Substituting $(1-a) = \sigma_p/\sigma_m$ into the returns equation (3.1), we get

$$E(R_p) = R_f\ (1-\sigma_p/\sigma_m) + E(R_m)\ \sigma_p/\sigma_m$$

$$= R_f + \left[\frac{(R_m) - R_f)}{\sigma_m}\right]\sigma_p \quad \text{.......... Equation 3.3}$$

The term $[(E(R_m) - R_f) / \sigma_m]$ can be thought of as the market price of risk for all efficient portfolios (Elton and Gruber, 1987). It is the extra return that can be gained by increasing the level of risk on an efficient portfolio by one unit. Thus the second term on the right - hand side of this equation represents the market price of risk times the amount of risk in a portfolio. It represents that element of required return that is due to risk. The first term can be said to represent the price of time or the return that is required for delaying potential consumption for one period given perfect certainty about the future cash flow. The expected rate of return from a portfolio on the CML thus comprises the risk - free rate of return plus a risk premium. This premium is given by the market price of risk, $[E(R_m) - R_f] / \sigma_m$, multiplied by the risk of the portfolio, $\sigma_p$.

The CML establishes the return on an efficient portfolio but not on nonefficient portfolios or on individual assets. An extension of the portfolio theory into the Security Market Line allows for the estimation of such returns.

## b. The Security Market Line

Sharpe (1964) extended the CML theory to all assets and portfolios, whether efficient or inefficient, by introducing Beta as a measure of risk and the Security Market Line (SML) to show the relationship between expected return and risk.

For a perfectly diversified portfolio the non-diversifiable risk component will be equivalent to total risk since it is not possible to diversify any further. That is, the correlation between the portfolio and the market, $r_{pm}$, is perfectly positive, thus $\sigma_p$ in Equation 3.3 is equivalent to $r_{pm}\,\sigma_p$. However, for portfolios that are less than perfectly diversified or for individual assets, the non-diversifiable risk and total risk will not be equivalent, because they are less than perfectly correlated with the market. It has been established that the SML which uses non-diversifiable risk as its risk measure and not total risk, is the appropriate risk-return relationship for assets and for portfolios that are less than perfectly diversified (Farrell, 1983).

That is, the expected return on an efficient portfolio, P, or on an individual asset, i, becomes

$$E(R_i) - R_f = \left[ \frac{E(R_m) - R_f}{\sigma_m^2} \right] r_{im} \, \sigma_i \quad \ldots\ldots \text{ Equation 3.4}$$

where $E(R_i)$ = expected return on an asset;

$\sigma_i$ = standard deviation of return on asset i;

$r_{im}$ = correlation coefficient between asset i and the market portfolio;

and other terms are defined in equations 3.1 and 3.2.

This equation shows that the expected return of a asset in excess of the risk-free rate, $E(R_i) - R_f$, is proportional to the non-diversifiable (i.e. systematic) risk of the asset, $r_{im}\sigma_i$.

The SML equation can be restated as

$$E(R_i) - R_f = \left[ \frac{COV(R_i R_m)}{\sigma_m^2} \right] [ E(R_m) - R_f ]$$

Now since $\quad r_{im} = \dfrac{COV(R_i R_m)}{\sigma_i \sigma_m}$

where $COV(R_i R_m)$ = covariance of returns between asset i and the market portfolio.

Then, $\quad \dfrac{COV(R_i R_m)}{\sigma_m^2} = B_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{ Equation 3.5}$

where $B_i$ (or Beta) represents the extent to which the return of an individual asset or portfolio moves with some broad - based market index representative of the total economy, $R_m$.

The SML thus becomes

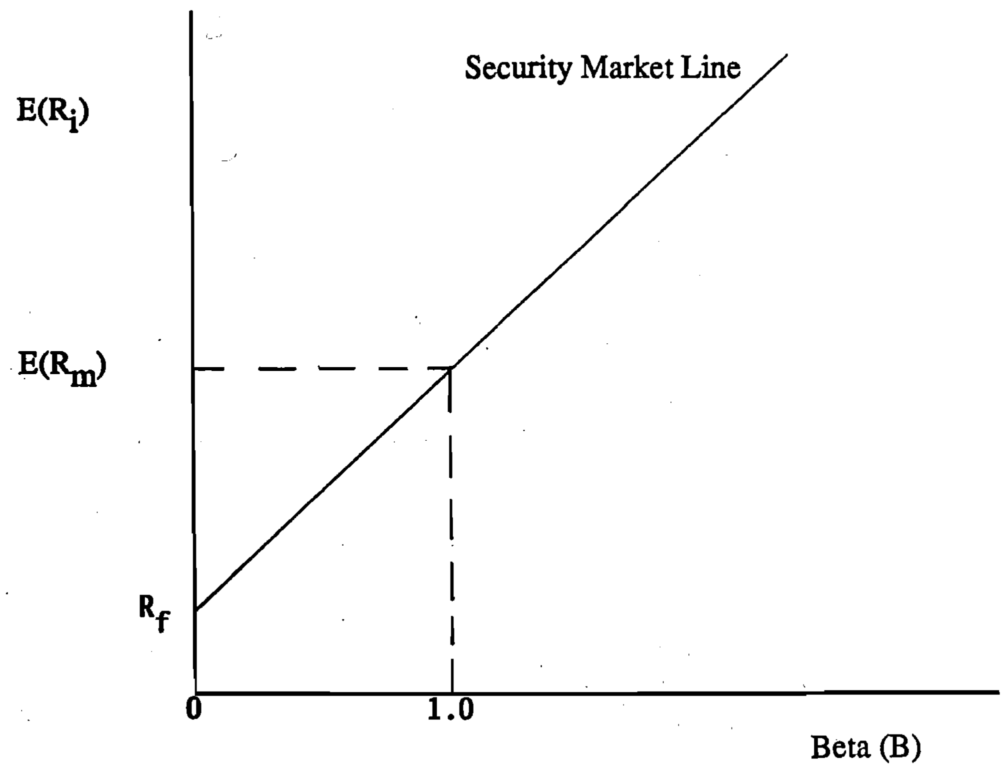
$$E(R_i) = R_f + B_i\,(E(R_m) - R_f) \quad \text{..........} \quad \text{Equation 3.6}$$

where the terms in this equation are in equations 3.1, 3.2 and 3.4.

The SML is usually plotted with the expected return, $E(R_i)$, on the vertical axis and the Beta coefficient, $B_i$, on the horizontal axis, as shown in Figure 3.1.

In equilibrium all assets and portfolios will plot along the SML, shown in Figure 3-1, whether efficient or inefficient (Farrell, 1983). Thus the line provides a direct and convenient way of determining the expected return on an asset. The whole term $B_i(E(R_m) - R_f)$ represents the risk premium; that is, the additional return required to compensate investors for assuming a given level of risk.

**Figure 3-1: The Security Market Line**




The Beta coefficient and the levels of systematic and non-systematic risks can be determined by regressing the return for an individual asset, $R_i$, against the return on the market portfolio, $R_m$, and this is termed the characteristic line.

### c. The Characteristic Line

A simple linear regression of $R_i$ against $R_m$ produces the Characteristic Line. That is,

$$R_i = a_i + B_i R_m + e_i \quad \text{..........Equation 3.7}$$

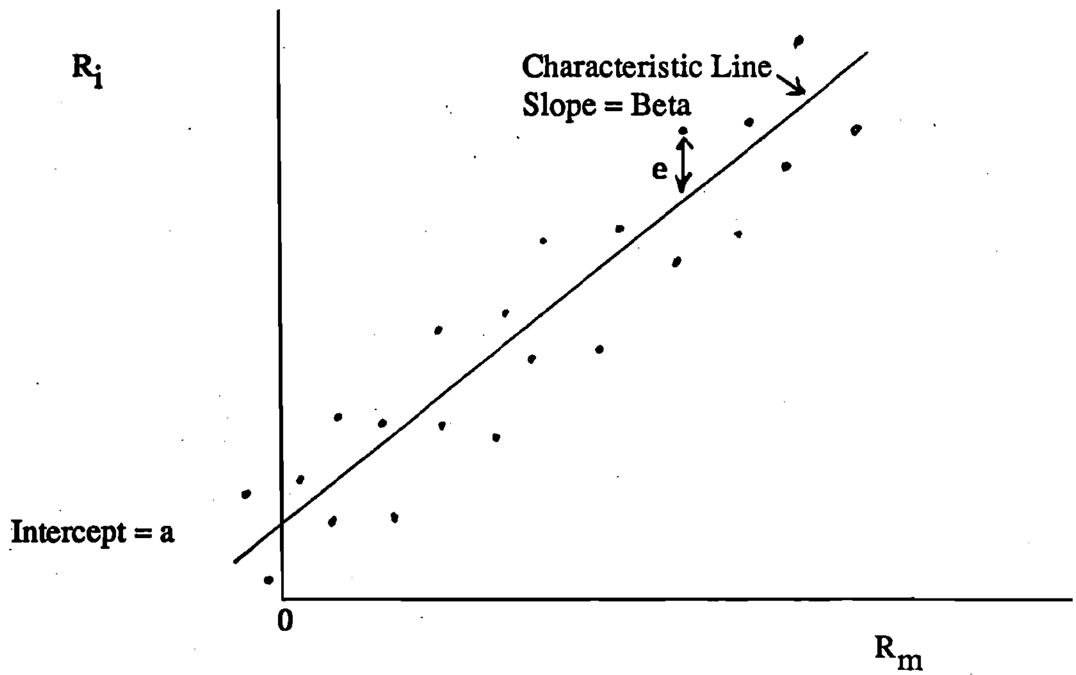
where $a_i$ = the value of the intercept term;

$e_i$ = a random error term;

and other terms are defined in equations 3.1 and 3.4.

The error term is assumed to satisfy the usual properties required by the classical linear regression model: it has a mean of zero and finite variance; the error terms are independent of each other; and $R_m$ is independent of the error term. The return on an asset may therefore be split into two parts, that which is perfectly correlated with the market return (systematic) and that which is independent of the market return (non-systematic). The characteristic line is illustrated in Figure 3.2.

**Figure 3-2: The Characteristic Line**



The points in Figure 3.2 represent a set of time series observations on the return of the asset and the market return. The slope of the characteristic line represents a measure of the systematic risk. The vertical distance from any observation to the characteristic line is given by the error term, and this represents the non - systematic risk for that asset. Fitting Equation 3.7 to the points in Figure 3-2, using ordinary least - squares regression techniques, gives estimates of $a_i$ and $B_i$. The intercept term of the characteristic line, $a_i$, gives the expected return of the asset when the market return is zero, and represents the average value over time of the non - systematic returns of the asset (Dobbins and Witt, 1983, p51).

### 3.2.2 Systematic and Non - systematic Risk

As with the returns, an asset's variance also has a systematic and a non-systematic component. This can be derived as follows.

The variance of an asset i, $\sigma_i^2$, can be represented by

$$\sigma_i^2 = E [ R_i - E(R_i) ]^2 \quad \text{............ Equation 3.8}$$

where E denotes expected value.
Substitution of the characteristic line (Equation 3.7) into Equation 3.8, gives

$$\begin{aligned} \sigma_i^2 &= E [a_i + B_i R_m + e_i - E (a_i + B_i R_m + e_i ]^2 \\ &= E ( B_i [ R_m - E(R_m) ] + [ e_i + E(e_i) ] )^2 \\ &= B_i^2 \sigma_m^2 + \sigma_{ei}^2 \quad \text{.................... Equation 3.9} \end{aligned}$$

It is important to note that i can represent either a single asset or a portfolio (Rao, 1987, p354). However, if the portfolio is fully diversified, the last term in the above equation

(Equation 3.9) is zero because all non - systematic risk can be diversified away (Rao, 1987). Thus for a fully diversified portfolio, equation 3.9 becomes

$$\sigma_i^2 = B_i^2 \sigma_m^2$$

or $$\sigma_i = B_i \sigma_m \text{ ......... Equation 3.10}$$

where $\sigma_i$ = standard deviation of returns from asset i,

$\sigma_m$ = standard deviation of returns from the market portfolio, M,

and

$\sigma_{ei}$ = standard deviation of the regression residuals.

That is, the standard deviation of an asset, i, consists of two components, $B_i \sigma_m$ and $\sigma_{ei}$. Let's investigate the first component in more detail.

Recall from equation 3.5 that

$$B_i = \frac{COV\ (R_i R_m)}{\sigma_m^2}$$

Now $$\frac{COV\ (R_i R_m)}{\sigma_i \sigma_m} = r_{im}$$

Therefore, $$B_i = \sigma_i r_{im} \text{ ......... Equation 3.11}$$

where $r_{im}$ = correlation coefficient between the return on the i'th asset and the return on the efficient market portfolio.

Therefore, $B_i \sigma_m$ reduces to $r_{im} \sigma_i$. Thus, the systematic risk of an asset is that proportion of its total risk which is correlated with the market risk. The total risk of an asset, $\sigma_i$, comprises a systematic component ($B_i \sigma_m$) and a non-systematic component ($\sigma_{ei}$).

This dissection of the total risk into the systematic and non - systematic components can be illustrated using the Capital Market Line (Ben-Horim and Levy, 1980; Turvey, 1985; Turvey and Driver, 1987; and Barr and Knight, 1988). For example, asset S (Figure 3-3) has total risk $\sigma_i$. The expected return on this asset (V) is equivalent to the expected return on efficient portfolio P on the CML, by which S is dominated due to its higher risk for the same level of expected return as P. From the CAPM, $B_i = B_p$ (Barr and Knight, 1988). Since systematic risk is given by $B_i\sigma_m$, the systematic risk for both asset i and portfolio P is the horizontal distance between V and P in Figure 3-3. The distance VS, represents the total risk ($\sigma_i$) of asset S and the CML dissects VS at P separating total risk into a systematic component VP and a non - systematic component PS.

Explaining this, Barr and Knight derived the following from Figure 3-3.

"Since triangles ($R_f$, P, X) and ($R_f$, M, Z) are similar, it is clear from the diagram that:

$$\frac{R_f X}{R_f Z} = \frac{\sigma_{is}}{\sigma_m} = \frac{E(\bar{R}_i) - R_f}{E(\bar{R}_m) - R_f} \quad \text{........... Equation 3.12}$$

**where** $\sigma_{is}$ = a measure of the systematic risk of portfolio P (and $\sigma_{is} = \sigma_p$)

Therefore from Equation 3.12 and CAPM

$$B_i = \frac{\sigma_{is}}{\sigma_m} = \frac{E(\bar{R}_i) - R_f}{E(\bar{R}_m) - R_f}$$

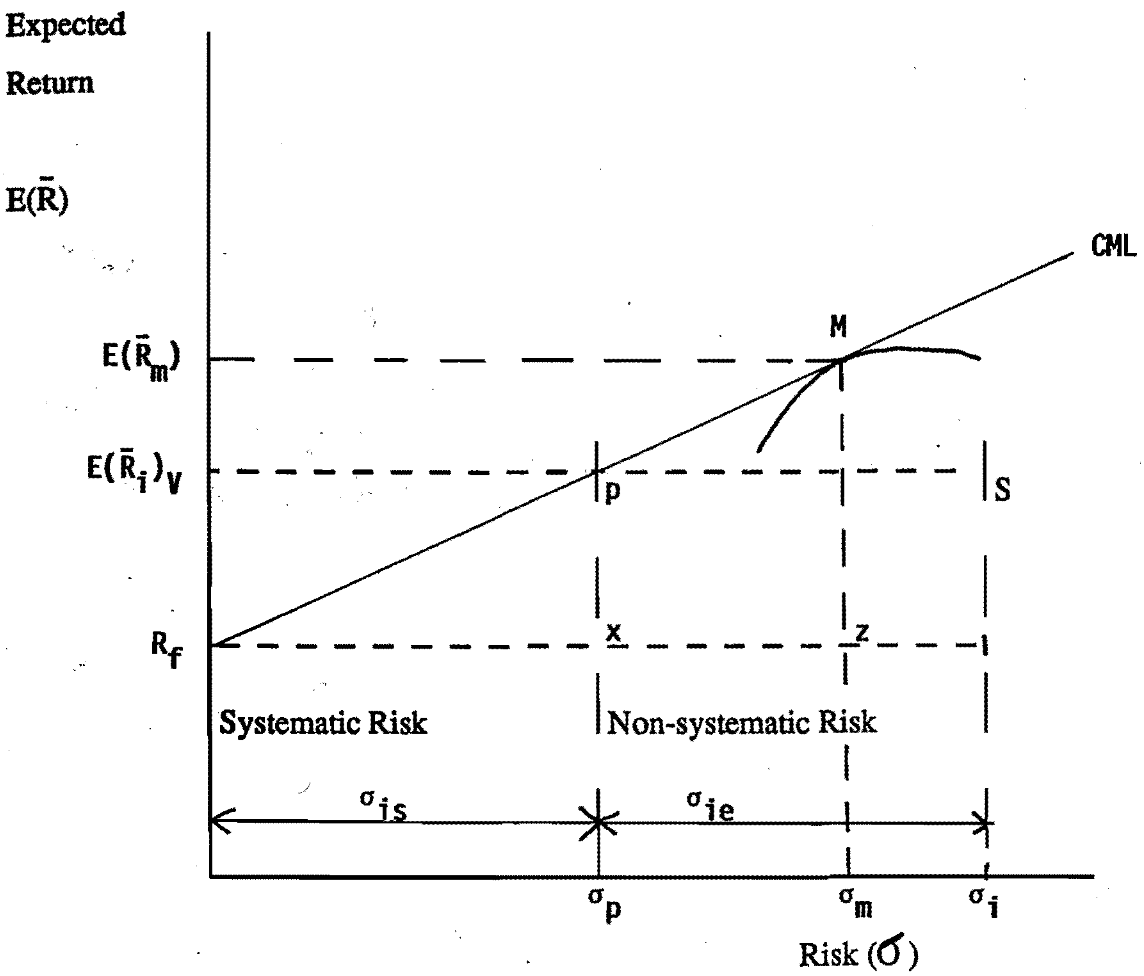
and thus

$$\sigma_{is} = B_i \sigma_m$$

This is the standard characterisation of systematic risk from the CAPM" (p440).

Thus the CAPM dissects VS at point P separating total risk (VS) into a systematic component (VP) and a non - systematic component (PS).

**Figure 3-3: The CML and Systematic Risk**




In a finance setting, systematic risk is usually thought to compose of economy - wide perils which are likely to threaten all businesses, such as changes in the money supply, interest rates, the exchange rate, prices of commodities, government spending and the performance of overseas economies.

### 3.2.3 Diversification

The aim of diversification is to eliminate or reduce the risk and uncertainty which is reflected in variability of outcomes.

In traditional risk analysis, this is dealt with in the following way. The variance of a portfolio, $\sigma_p^2$, is determined by the variance of returns of each asset, $\sigma_i^2$, as well as by their covariances, $\sigma_{ij}$,

$$\text{i.e.} \quad \sigma_p^2 = \sum_{i=1}^{N} X_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{j=1}^{N} X_i X_j \sigma_{ij} \quad \ldots\ldots \text{ Equation 3.13}$$

where, $X_i$ = the covariance of asset i in the portfolio, and
$\sigma_{ij} = COV\ (R_i R_j) = r_{ij}\ \sigma_i \sigma_j$

That is, the covariance, $\sigma_{ij}$, is equal to the correlation coefficient between two assets, $r_{ij}$, times the standard deviation of each asset, $\sigma_i$ and $\sigma_j$. If the standard deviations are held constant, the lower the correlation between the two assets, the lower the covariance added by the two assets in a portfolio, $\sigma_{ij}$, and vice versa. Hence, the lower the correlation between assets, the lower will be the overall risk of the portfolio, while the higher the correlation, the higher will be the overall risk of the portfolio (Farrell, 1983).

The correlation coefficient varies in value from positive one, indicating a perfectly positive correlation, to negative one, indicating a perfectly negative correlation. There are always gains from diversification in terms of reducing risk, provided that the returns of the assets included in the portfolio are not perfectly positively correlated, i.e. the correlation coefficient is less than one (Dobbins and Witt, 1983, p28).

In terms of the CAPM, Elton and Gruber (1987, p100 - 115) demonstrated that the correlations between assets can be expressed as a function of Beta

That is,

$$r_{ij} = \frac{B_i B_j \sigma_m^2}{\sigma_i \sigma_j}$$

or, it covariance $\sigma_{ij} = B_i B_j \sigma_m^2$ .............. Equation 3.14

The risk associated with a well - diversified portfolio depends on the average beta of the assets included in the portfolio (Brealey and Myers, 1984). The beta of a portfolio is the weighted average of each asset's beta. That is,

$$B_p = \sum_{i=1}^{n} X_i B_i \qquad \text{Equation 3.15}$$

where $B_p$ = the beta coefficient for the portfolio P; and

$X_i$ = proportion of asset i in the portfolio.

A diversified portfolio of low beta assets is less risky than a diversified portfolio of high beta assets. For example, the standard deviation of a well diversified portfolio of assets with a beta of 0.5 would be 0.5 times that of the market portfolio. The standard deviation of a well - diversified portfolio of assets with a beta of 1.5 would be 1.5 times the standard deviation of the market portfolio. Thus, an asset's contribution to portfolio risk depends on the assets's Beta.

### 3.2.4 A Critique of the Capital Asset Pricing Model

The Capital Asset Pricing Model is able to distinguish between systematic and non - systematic risks. This is important, as it allows an analyst to concentrate on systematic risk since the non - systematic risk can be eliminated through diversification by an individual investor.

It was concluded in Chapter 2 that the CAPM is easier to compute and requires a lesser quantity of data than the full variance-covariance quadratic programming model. Also, the risk-efficient solutions obtained from the two models are not significantly different. The CAPM provides a measure of risk which is, in theory, both objective and quantifiable; and provides a framework in which risk and return are considered at the same time; the Security Market Line provides a direct and convenient way of determining the expected return on an asset.

The CAPM can be used to distinguish between diversifiable and non-diversifiable components of the total risk facing farmers, thereby allowing them to focus on the risk component which cannot be diversified. The CAPM can provide a measure of riskiness of each enterprise.

The CAPM has been extensively tested. Various studies have examined the implications of relaxing the major assumptions upon which the CAPM is constructed. Jensen (1972) concluded that the results of such studies indicate that the theory is reasonably robust when these assumptions are relaxed. He added that many of these assumptions are not essential for the derivation of the important results of the CAPM.

Turvey (1985) notes that tests of CAPM by Blume and Friend (1973), Black, Jensen and Scholes (1972), and Fama and Macbeth (1973), have shown a strong positive relationship between risk and returns. The returns however, were not as great as the CAPM predicted. Farrell (1983) also concluded that empirical results were generally consistent with some sort of a risk - return trade - off in the marketplace.

However, Roll (1977) criticized these empirical tests of CAPM and questioned the very testability of the CAPM. He claimed that empirical testing used only a proxy measure for the market portfolio, and unless the market portfolio is identified exactly, it is impossible to accept or to reject the CAPM. He argued that the market portfolio should include all risky assets and it should be mean-variance efficient. Even a small departure from the true market portfolio making the test invalid. He further adds that identifying this market portfolio is a difficult task, as it requires some mechanism or ability to capture investor expectations. However, Copeland and Weston (1988) argue that many tests of the CAPM have shown that Betas do contain useful ex - ante predictive power and a strong positive relationship between risk and return. They claim that Roll's arguments do not imply that the CAPM is an invalid theory, but that tests of the CAPM must be interpreted with great caution.

Farrell (1983) seems to support Copeland and Weston by suggesting that recent studies have shown that misestimation of the market proxy may have limited practical significance. He comments that investors can obtain usable estimates of Betas and gauge the risk - return relationship by using a generally representative market index.

## 3.3 Agricultural Applications of the Capital Asset Pricing Model

There have been a few agricultural applications of CAPM, and these will now be reviewed. The background to these agricultural adaptations will be considered in order to give a historical perspective. The interpretation of the assumptions of CAPM in an agricultural situation will then be outlined, and the use of these agricultural applications will then be critically reviewed.

### 3.3.1 Historical Background

Heady (1952) was the first to make any significant analysis of the income variance problem in agriculture. However, it was Johnson (1967) who developed an analytical framework similar to the single-index portfolio model as developed by Sharpe (1964) and Lintner (1965), and introduced the feasibility of an alternative risk free opportunity such as the rental value of land. Johnson concluded that when land is substituted for the individual capital endowment and risk enterprises are substituted for the asset options, the portfolio model can be shown to apply to the farm diversification problem.

Barry (1980) was the first to formally apply the CAPM to farm real estate, when he examined the risk-returns contribution of holding farm land in a portfolio of capital market assets. However he did not examine the systematic risk for those assets held in a farm-sector portfolio.

Turvey (1985) developed a farm sector CAPM (FSCAPM) to identify the role that systematic risk plays in the structural composition of E-V efficient farm plans. He concluded that the theory of capital asset pricing works well and can be used to explain and evaluate the systematic risk that an individual farm activity contributes to the total risk of a farm portfolio. Turvey also maintains that the Beta coefficients derived from a FSCAPM can be easily generated and that these coefficients could have significant value in aiding farmers to make tactical, short-term, farm management decisions. This was followed up by Collins and Barry (1986) and Turvey and Driver (1987) who arrived at a similar conclusion. Collins and Barry's study involved crop and livestock activities in Imperial Valley, America, and Turvey and Driver's study was with crop and livestock activities in Ontario, Canada.

### 3.3.2 The Assumptions of the Farm Sector Capital Asset Pricing Model

The critical assumptions of the CAPM are still of considerable importance to the development of the FSCAPM, although their interpretation must change. Turvey (1985) provided the following interpretation:

a. "There are no taxes or transaction costs: The FSCAPM would require that a farmer has a resource base which would allow any of the portfolio activities to be grown, or raised, on his farm. Transaction cost in this instance refers to the set-up costs of switching from one activity to another as the risk-return relationship becomes desirable."

b. "Perfect information and homogeneous expectations: Farmers have access to market information. This information is costless and accurate thus allowing certain movement within the farm sector. Hence, the farm sector is constantly in equilibrium. As such, all of the variability in the farm sector portfolio (market index) is systematic."

c. "All participants in the market can borrow and lend money at the risk-free rate of interest: This provides the opportunity for farmers to loan and borrow money along the capital market line. As an alternative, farmers may rent their own land to other farmers (as a landlord) or rent land from other farmers (as a tenant). The value of rental land is the same for both the landlord and the tenant."

d. "The investment period for all participants is one year: That is, portfolio decisions are more of a tactical nature than of a long term strategic nature."

e. "Participants are risk averse and make decisions based on the mean-variance rule."

f. "Participants make tactical decisions based first on what activities they will hold in their farm-portfolio and second, the weight that each activity will contribute to the portfolio (the Separation Theorem)."

### 3.3.3 An Appraisal of Farm Sector Capital Asset Pricing Model Studies

The appropriate application of CAPM to the farm sector seems to hinge on a number of factors. These include how returns on activities are measured, which market index is chosen, how inflation is treated and how an appropriate risk - free rate can be incorporated into the model. The treatment of these factors will now be considered in the following appraisal.

### a. Return on Activities

The CAPM, as used for portfolio selection in business finance, measures return on activities on 'rates of return' basis. This is theoretically the most appropriate method because as far as investment in equities is concerned, returns come in two forms - dividends and capital gains. The periodic return on an individual investment or portfolio is measured as follows:

$$R_t = \frac{P_t - P_{t-1} + D_t}{P_{t-1}} \qquad \text{.........Equation 3.16}$$

where $R_t$ = Periodic return on an asset;

$P_t$ = Price of an asset at the end of the period;

$P_{t-1}$ = Price of an asset at the beginning of the period; and

$D_t$ = Dividend received at the end of the period.

Historic rates of returns however, are difficult to determine for farm businesses due to lack of adequate data. Also, if a farmer does not evaluate the paper gains associated with holding farm capital when making business decisions, this form of return measurement may not be appropriate (Turvey, 1985). When Turvey used this rate of return measure, the performance of the model was disappointing due to data inadequacies. Two possible alternatives to using the 'rate of return' approach are the gross revenue and the gross margin approaches, which use only the gross revenue or the gross margin per hectare respectively, to calculate the portfolio mean and the Beta coefficients.

Johnson (1967) was the first to advocate the use of Beta coefficients on a net return, rather than a 'rate of return' basis, as used in capital market portfolio selection. He was followed by Collins and Barry (1986) who used the gross margin approach, and Turvey (1985) and Turvey and Driver (1987) who went a stage further and used the gross revenue approach. Obviously, these researchers have concluded that the 'rate of return' approach is not practical. Apart from the data problem with this rate of return approach, Turvey added that with such complex approaches the probability of making a type II decision error[1] was much greater than when using the more simple models.

However, the net revenue approach could be considered to be equivalent to the 'rate of return' approach if the farm sector CAPM assumptions are not violated. If the farmer is capable of producing any of the portfolio activities from the farm's resource base, then it might be possible to argue that comparing the rate of return of different activities which utilise the same resource base is no different to comparing the net returns from these activities directly.

Turvey (1985) used the gross revenue approach and justified this by assuming that the factor prices and the factor input mix are known at the start of the production season, and hence the variance associated with gross revenue will be exactly the same as the variance associated with net revenues. This gross revenue approach is not necessarily theoretically appropriate, however, since the use of inputs such as pest and disease control, weed control, and harvesting costs may not necessarily be known exactly at the start of the season. Previous studies have shown that results obtained using the gross revenue approach (Turvey and Driver, 1987) contrast with those from the gross margin approach (Collins and Barry, 1986). However, these two studies had other factors varying as well which could have contributed to the observed differences. However, it is possible that the systematic risk and the Beta coefficients may be sensitive to different definitions of revenue.

## b. The Risk-Free Asset

Johnson (1967), when introducing the rental value of land as the risk-free asset, illustrated the separation theorem for farm enterprises; that is, the optimal strategy for combining risky enterprise options is independent of the ratio of the amount of land in

---

1. Type II decision error: i.e we accept the null hypothesis falsely rather than reject it when alternative hypothesis is true.

risky enterprises to the amount of land owned. This is shown below.

Let $R_f$ = net return/hectare on the riskless option for land;

$R^*$ = net return/hectare on a particular configuration of risky options;

$L$ = amount of land owned by the farmer;

$L^*$ = amount of land devoted to risky enterprises; and

$L^{**}$ = amount of additional land acquired at rate $R_f$ for allocation to risky enterprises.

Then E(R), the net return per hectare of land, is given by

$$E(R) = (1-Q)R_f + Q R^* \quad \text{.......... Equation 3.17}$$

$$= R_f + Q (R^* - R_f),$$

where $Q = \dfrac{L^* + L^{**}}{L}$ and $0 \leq Q < \infty$

The value Q indicates the composition of the farm in terms of risky and riskless enterprise options.

Let $E(R^*)$ = mean of $R^*$

$V(R^*)$ = standard deviation of $R^*$

Then, from Equation 3.17, the mean and variance of net return per hectare with the riskless option included are :

$$E(R) = R_f + Q ( E (R^*) - R_f ) \quad \text{.......... Equation 3.18}$$

$$V(R) = Q (V(R^*)) \quad \text{.......... Equation 3.19}$$

Using the above two equations Johnson eliminated Q, and obtained a direct relationship between the expected returns and standard deviation of the net return on a hectare of land, the rate of return on the riskless option, and the parameters associated with a particular mix of risky enterprises. This relationship he called the market opportunity line.

$$E(R) = R_f + \Theta V \quad \text{.......... Equation 3.20}$$

where $\Theta$, the slope of the market opportunity line, is given by

$$\Theta = \frac{E (R^*) - R_f}{V (R^*)} \quad \text{.......... Equation 3.21}$$

The expected net return, E ($R^*$), and the standard deviation of net return, V ($R^*$), and the rate of return on the riskless option, $R_f$, determine values for $\Theta$. However, $\Theta$ and $R_f$ define the market opportunity line. Hence, strategies for combining risky alternatives can be viewed in terms of an associated market opportunity line. Suppose the farm decision maker selects the strategy in the feasible set which maximizes the value $\Theta$. Since the feasible set is concave, the related point will be unique and on the upper bound of the feasible set i.e. on the Markowitz efficiency frontier. The market opportunity line associated with this strategy will lie entirely above the feasible set and thus above the market opportunity lines for other feasible $\Theta$'s or other strategies. From the characteristics of the indifference curves, it follows that points on the market opportunity line corresponding to the maximum $\Theta$ are the only candidates for the optimum (Johnson, 1967).

Johnson (1967) concluded from this, that farm management decisions with respect to risky enterprises can be viewed in two parts :

1. the choice of a risky enterprise mix which maximises the slope of the market opportunity line; and

2. given this market opportunity line, the choice of the amount of land to be devoted to risky enterprises, or alternatively, the value of Q.

Studies looking at the application of CAPM to the agricultural sector (Turvey, 1985; Collins and Barry, 1986; and Turvey, Driver and Baker, 1988), all agree with Johnson that, as long as a risk-free alternative to using land exists, holding rental land in combination with the efficient farm sector portfolio results in a portfolio combination that dominates all other portfolios in the feasible set. This development facilitates the application of the CAPM to the agricultural sector.

### c. The Market Index

A market portfolio in the capital market stock portfolio is a weighted average of all assets which can be traded and/or sold. Each asset is held in the market portfolio in the proportion that represents the proportion of that asset's total market value of all risky assets. For example, if Brierley Investments represent 5 percent of all risky assets, then the market portfolio contains 5 percent Brierley stock. This theoretical portfolio has to be a perfectly diversified portfolio. However, it is difficult to precisely determine this index, and therefore a proxy is often used.

If the CAPM is to be applied to agriculture in general, a farm sector portfolio is required. This should ideally consist of all agricultural production activities. Such a perfectly diversified portfolio will only contain systematic risk and no non-systematic risk. Any departure from this weighted portfolio is likely to contain some non-systematic (diversifiable) risk. However, due to inadequate data, inclusion of all farm activities and in their correct weightings, is virtually impossible. A Beta coefficient derived from using a limited size farm sector portfolio cannot be defined in terms of the systematic risk associated with holding (or raising) an activity in the efficient capital market portfolio but it may indicate the systematic risk within that farm sector portfolio, which is still consistent with the separation theorem (Turvey, 1985). The more representative the farm sector portfolio is of the true market portfolio, the more indicative the expected return from production activities will be of the return on the efficient market portfolio.

However, assumption (a), in Section 3.3.2, of no transaction costs or no set - up costs of switching from one activity to another, may create some difficulty. If a farmer is only capable of producing a sub - set of agricultural activities with a given resource base, then it could be argued that only this sub - set of activities which are capable of being produced is the appropriate 'market' index. Otherwise, the assumption of no transaction costs would be violated when farmers have to invest in fixed resources to take up new activities.

The studies of both Collins and Barry (1986), and Turvey and Driver (1987), used an unweighted index of returns of the activities under consideration. Collins and Barry suggest that other proxies are possible; for example, rainfall might work well in dryland farming areas.

However, Turvey and Driver (1987) found that their results contrasted with those of Collins and Barry (1986). They concluded that the Beta coefficients and the systematic risk coefficients may not be directly comparable between different studies because they may be sensitive to the definitions of market portfolios. Turvey, Driver and Baker (1988) also concluded that a different market portfolio, such as a value-weighted portfolio or a portfolio comprised of different activities, would provide different Beta values. Different results might also arise from models which include all of the reference portfolio activities rather than a subset. Therefore, it is possible that Beta coefficients may be quite sensitive to the proxy used to represent the true market portfolio.

## d. The Impact of Inflation

The impact of inflation is an intricate issue and is not well developed in CAPM analysis (Barry, 1980).

Collins and Barry (1986), using deflated returns, found low levels of systematic risk in agriculture. On the other hand, Turvey and Driver (1987), who used nominal returns, found levels of systematic risk in agriculture to be high. This is quite a critical difference since the diversification strategy to adopt depends on the type of risk in the system, because on - farm diversification is only really viable when non - systematic levels of risk are high. Although there were other differences between these two studies which might explain this difference, it is quite possible that the issue of whether to deflate or not to deflate the returns is a critical issue.

Turvey and Driver argue that by using nominal dollars, systematic risk is able to capture inflationary effects common to all farm activities, and that by deflating the returns a very significant component of systematic risk gets eliminated. However, it could also be argued that the data should be de - trended or deflated because the inflation rates of the past are unlikely to be exactly the same in the future, and for the single production season for which the FSCAPM have been used, the inflation rates can be predicted.

However, unanticipated changes in inflation rates often occur. Therefore, such predictions may not always be correct. Glutekin (1983); Solnik (1983); and Geske and Roll (1983) showed that there was a consistent lack of positive relation between stock returns and inflation. For farm returns, inflation may introduce an element of uncertainty.

### 3.3.4 The Capital Market Line and Systematic Risk

Turvey (1985) and Turvey and Driver (1987) have demonstrated that the relationship between the Capital Market Line and systematic risk, as illustrated previously in Figure 3-3, applies for the farming sector in the same way that it does for the capital market portfolio, with no adaptation being required.

## 3.4 Farm Portfolio Selection

The selection of optimal farm plans has generally been regarded as a strategy choice along an E-V efficient frontier, depicted in Figure 2-4. All the points along the Capital Market Line in Figure 2-4 reflect the most efficient portfolios because all of the risk is systematic. This implies that the entire opportunity set is dominated by the CML.

The separation theorem, according to Turvey (1985), is fundamental to the theory of capital asset pricing and the adoption of Beta coefficients as a tactical farm planning tool. However, as the traditional strategy choice criteria demands efficiency in the E-V frontier, the separation theorem demands efficiency in the predictive power of the theoretical returns, vis a vis the actual returns (Turvey, 1985). The value of the Beta-risk coefficients and corresponding returns along the SML must be efficient with respect to an ex-post predictive E-V model.

The separation theorem requires that farmers attach subjective weights to those activities they have chosen to include in their portfolio. If the ex-ante predictive characteristics of the FSCAPM are not ex - post efficient then errors in the portfolio composition can be made (Turvey, 1987).

## 3.5 Conclusion

Previous studies have shown that the CAPM can be adapted to an agricultural context, and indicate that the Beta and systematic risk coefficients could be used as an extension tool to assist farm managers in making portfolio decisions. They have also shown that the portfolio selections made using the systematic risk criterion are very similar to those using the total risk criterion, and that the single-index solutions closely approximate the E-V frontier which is derived using the full-variance-covariance matrix, as discussed in Chapter 2.

However, the discussion in this Chapter indicates that some important issues associated with single-index portfolio models need to be considered if they are to be adopted seriously as planning tools in agriculture. This conclusion is supported by Turvey, Driver and Baker (1988). These issues relate primarily to the choice of farm sector portfolio, the way the activity returns are measured, the impact of inflation and the value of the risk-free asset.

# Chapter 4

## Application of the Farm Sector Capital Asset Pricing Model

## 4.1 Introduction

In this Chapter, the Farm Sector Capital Asset Pricing Model (FSCAPM) will be applied in an appropriate New Zealand context, and the issues identified in the previous Chapter will be further explored empirically. The case study property that will be used to test the adaptation of this model to agriculture is described. This is followed by a discussion of possible methods of measuring returns on activities, the impact of inflation, and the alternative farm-sector portfolios.

## 4.2 The Case Study Property

### 4.2.1 Rationale

Many New Zealand farmers will have considered diversification of their farming operations as an option for reducing exposure to both business and financial risk associated with farming. This is more pronounced among the mixed cropping farmers, because their resource base allows them to add or subtract farming activities without incurring much capital expenditure. In addition, the portfolio decisions which they make are more likely to be of a tactical nature than of a long term strategic nature as might be the case with other farm types. Since these farmers produce a range of activities from a given resource base, the CAPM assumptions are/likely to be violated, and the concepts of /not systematic and non - systematic risk appear to be valid for this type of farming system. For these reasons, mixed cropping was chosen as the most appropriate farm type on which to test the model.

Having settled on a farm type, the question then arises as to whether regional aggregate farm data or single farm data are more appropriate.

Previous studies involving FSCAPM (Turvey, 1985; Collins and Barry; 1986 and Turvey and Driver, 1987) used aggregate yield and price data. However, a study by Debrah and Hall (1989) illustrated that the use of aggregate data seriously underestimates the income variability an individual farmer faces and consequently can result in the selection of unrealistic farm enterprise portfolios. Farmers face variable incomes from year to year primarily because of variable weather conditions, disease and pest attacks and uncertainties in input and product markets. Some farmers hedge or sell on contract to mitigate the effects of price variability, and some use enterprise diversification or insurance to provide protection against income variability due to random variations in production yields (Debrah and Hall).

In particular, Debrah and Hall found that individual - farm yields for crops studied to be far more variable than the county aggregate yields. Eisgruber and Schuman (1963) obtained similar results. Debrah and Hall also found that for every level of expected income, the standard deviation from the farm - level model was larger than that from the aggregate model. This implies that aggregate data may underestimate the income variability (risk) that farmers face in choosing a farm plan. Debrah and Hall also concluded that due to lack of information on the number of farms represented in the aggregate data for the particular crops as well as the yield correlations between farms, it may be difficult to adequately adjust aggregate data to provide reasonable estimates of farm - level variances.

For these reasons, and because individual crop and livestock data are not available on a national or regional basis, a case study property was used and an attempt was made to obtain individual crop and livestock data which were appropriate for this property. In particular, the Lincoln University Mixed Cropping Farm was chosen as the case study property, due to the availability of reliable data.

### 4.2.2 Farm Situation Audit

The Lincoln University Mixed Cropping farm is a 253 hectare property located in Lincoln, approximately 20 kilometres from Christchurch. All the land on this property is flat, and is a good Canterbury mixed cropping farms, in terms of topography, soil type and drainage. The soil is very versatile. Half the property is under irrigation. Fencing and subdivisions suit both cropping and sheep activities very well. Machinery is more than adequate to efficiently produce good quality cereals, small seeds, process crops and sheepmeat activities. The farm supervisor and the farm manager are well trained and possess a great deal of skill and experience in process crops, grains, small seeds and sheep.

The property comprises two blocks. The Hart Block (40 hectares) is not very developed, but the fully developed Main Block (213 hectares) currently has a well balanced cover, of small seeds, grazing, cereals and process crops. During 1981 to 1984, over half of the farm was in wheat and barley, and the rest was in clover and grass seed, with no livestock. This was seen to be appropriate at that time because of the then high price for wheat and barley. However, in recent years their prices have dropped. In addition, that farming pattern gave rise to high incidence of disease in wheat, and spraying for weeds became difficult because of undersowing. The farm supervisor hoped that the 1988/89 season cropping pattern would spread the risk better. No strict rotation is followed. Crops are selected more on the basis of net returns.

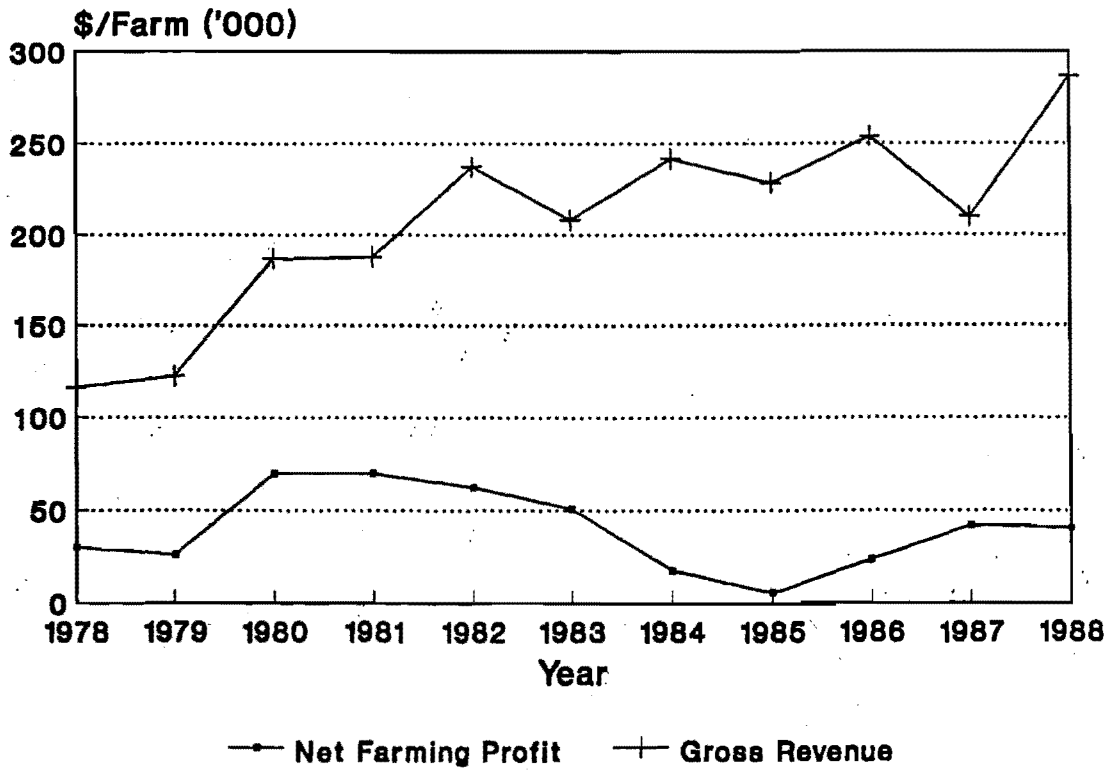
**Table 4-1: Cover Summary for the Main Block, Lincoln University Mixed Cropping Farm (1988/89 Season)**

| Cover | Total Area (ha) | Percent of Total (%) |
|---|---|---|
| Small Seeds | 41 | 19 |
| Grazing | 34 | 16 |
| Wheat and Barley | 71 | 33 |
| Process Crops | 67 | 32 |
| Total | 213 | 100 |

Yields have not been very consistent over the years. However, the farm supervisor feels that with good soil type, irrigation and by being able to plant and harvest early and efficiently with heavy machinery, the yield variability is lower than most other farms. The farm accounts trend in Figure 4-1 (Data in Appendix 4-1) below however, show that profits and gross revenues have fluctuated to some extent over the last decade.

The property is a reasonably typical mixed cropping farm, except that it has no debt. This gives a high protection from interest rate fluctuations that many farmers currently face. The performance of this property, being well developed, located close to all amenities and infrastructure, and with good management, is among the best of the mixed cropping farms in Canterbury.

**Figure 4-1: Farm Accounts Trend for the Lincoln University Mixed Cropping Farm, 1978 to 1988.**
(Reference: Lincoln College Farm Accounts)



### 4.2.3 Choice of Activities for the Model

Wheat, barley, field peas, frozen peas, frozen beans, white clover, and ryegrass crops have been grown on this property almost every year over the last twenty years. Sheep activities, mainly breeding stock as well as some fattening stock have also been a regular feature of the property over this period. Crops such as potatoes, lentils, lupins, kale, oilseed rape, oats and tickbeans have only been grown in a few seasons. Although lentils have yielded well in some seasons, the rich soil on this property produces a bulky crop of lentils and fungal diseases become a problem. Lupins are difficult to harvest as they tend to shake at harvesting.

Although grain prices are favourable at the moment, any long term price prediction is difficult to make, because of rebuilding of stocks in the United States after their drought during 1988 and their export subsidy program (Australian Bureau for Agricultural and Resource Economics, 1988).

Drought during the 1988/89 season in New Zealand and a shift to fine wool production both in New Zealand and in Australia, are boosting saleyard prices for sheepmeat due to reduced supply. With the deregulation of the New Zealand economy, the future for sheepmeat and livesheep export appears to be favourable. However, with expanding white meat production in the United Kingdom and in the European Community, a downward pressure on the real prices for New Zealand lamb is expected over the next few years. The market outlook for small seed production looks uncertain, and prospects for field peas are not bright either. However, contracts for process crops such as frozen peas and beans are steady.[1]

---

1. The market outlook for these activities was based on that provided by 'Situation and Outlook for N.Z. Agriculture, 1988'.

It is possible to have farm activities such as deer, dairy, onions, garlic[1], or a range of horticultural activities, including vegetables, on this property. However, resources such as plant and machinery, shelters, subdivisions and irrigation are either not currently available, or are inadequate. The incorporation of these activities would involve long term decisions and not tactical decisions as required by the agricultural application of the CAPM. Dairying is also difficult to incorporate with cropping, as heavy animals can damage the soil structure, causing problems for subsequent cropping[2].

The required data for vegetable activities for farm portfolio analysis are either not easily available or if they are available are not necessarily very reliable[3]. It also appears that vegetable yields may be engineered to keep market prices up, since growers have been known to restrict supply to keep prices up while harvesting everything available when prices are good[4]. In addition, open market prices fluctuate a lot, even on a day to day basis. Although prices for contract growing are fixed, these contracts are a relatively new system[3].

Therefore, the following activities have been chosen for analysis to evaluate the feasibility of using the capital asset pricing model for the chosen property.

1. Wheat
2. Feed Barley
3. Field Peas
4. Frozen Peas
5. Frozen Beans
6. Process Potatoes
7. Ryegrass
8. White Clover
9. Ryegrass/White Clover
10. Sheep BOR (Breeding own replacement ewes)
11. Sheep PR (Purchasing all replacement ewes)

---

1. G. Hill, Reader in Agronomy, Lincoln University (Per. Com.).
2. A. Whatman, Farm Supervisor, Lincoln University (Per. Com.).
3. R. Crowder, Lecturer in Horticulture, Lincoln University (Per. Com.).
4. M. Lilley, Vegetable Grower, Southbridge (Pers Comm).

### 4.2.4 Activity Returns

Details of returns and expenditures for each of the above farm activities can be found in Appendix 4-2. The calculated gross revenues and gross margins for the activities are presented in Table 4-2, below.

**Table 4-2: Activity Returns for the Lincoln University Mixed Cropping Farm ($/hectare)**

| YrEnd 30/6 | | Wheat | Feed Barl. | Field Peas | Frzn. Peas | Frzn. Beans | Proc. Potat | Rye-grass | White Clovr | Gras/ Clvr[5] | Sheep BOR[1] | Sheep PR[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70/71 | GR[3] | 180 | 144 | 161 | 210 | 520 | 1690 | 122 | 305 | 427 | 91 | 153 |
| | GM[4] | 126 | 94 | 113 | 142 | 415 | 1106 | 44 | 239 | 291 | 75 | 57 |
| 71/72 | GR | 174 | 122 | 210 | 210 | 434 | 1493 | 194 | 208 | 402 | 89 | 136 |
| | GM | 119 | 75 | 153 | 142 | 319 | 882 | 108 | 150 | 267 | 73 | 40 |
| 72/73 | GR | 219 | 105 | 244 | 281 | 315 | 1042 | 287 | 293 | 580 | 190 | 262 |
| | GM | 157 | 54 | 178 | 212 | 199 | 515 | 196 | 224 | 428 | 170 | 143 |
| 73/74 | GR | 200 | 201 | 615 | 160 | 1265 | 1718 | 678 | 721 | 1399 | 209 | 290 |
| | GM | 134 | 138 | 513 | 68 | 1125 | 930 | 555 | 607 | 1173 | 188 | 144 |
| 74/75 | GR | 294 | 294 | 538 | 420 | 782 | 1243 | 148 | 233 | 381 | 122 | 194 |
| | GM | 201 | 221 | 396 | 348 | 617 | 353 | 5 | 130 | 151 | 99 | 122 |
| 75/76 | GR | 524 | 312 | 268 | 354 | 220 | 1908 | 261 | 437 | 697 | 186 | 270 |
| | GM | 392 | 207 | 147 | 237 | 28 | 821 | 90 | 299 | 411 | 160 | 145 |
| 76/77 | GR | 586 | 418 | 338 | 619 | 1067 | 2640 | 466 | 659 | 1125 | 286 | 406 |
| | GM | 432 | 275 | 219 | 489 | 847 | 1531 | 261 | 466 | 753 | 257 | 208 |
| 77/78 | GR | 468 | 340 | 293 | 625 | 1017 | 1716 | 804 | 564 | 1368 | 247 | 316 |
| | GM | 319 | 196 | 124 | 486 | 770 | 737 | 569 | 392 | 992 | 221 | 150 |
| 78/79 | GR | 548 | 252 | 404 | 690 | 1216 | 2782 | 361 | 720 | 1080 | 282 | 357 |
| | GM | 380 | 129 | 223 | 575 | 962 | 1176 | 116 | 448 | 657 | 246 | 184 |
| 79/80 | GR | 714 | 505 | 465 | 942 | 1059 | 1632 | 814 | 552 | 1366 | 333 | 427 |
| | GM | 475 | 257 | 242 | 807 | 757 | 203 | 467 | 286 | 861 | 293 | 160 |
| 80/81 | GR | 878 | 424 | 711 | 1003 | 2002 | 3132 | 413 | 1044 | 1457 | 356 | 510 |
| | GM | 589 | 193 | 412 | 836 | 1683 | 529 | 22 | 706 | 856 | 306 | 274 |
| 81/82 | GR | 629 | 627 | 770 | 1102 | 2135 | 624 | 704 | 1040 | 1743 | 413 | 632 |
| | GM | 354 | 348 | 446 | 925 | 1806 | -1105 | 262 | 691 | 1089 | 358 | 402 |
| 82/83 | GR | 1122 | 585 | 1053 | 1326 | 2609 | 1793 | 782 | 679 | 1461 | 402 | 617 |
| | GM | 731 | 272 | 676 | 1099 | 2271 | -470 | 228 | 319 | 720 | 335 | 415 |
| 83/84 | GR | 1102 | 615 | 1249 | 1061 | 1731 | 2902 | 960 | 972 | 1931 | 450 | 655 |
| | GM | 714 | 294 | 839 | 834 | 1393 | 286 | 383 | 576 | 1132 | 383 | 453 |
| 84/85 | GR | 1227 | 611 | 907 | 1043 | 2889 | 5734 | 1142 | 425 | 1567 | 603 | 957 |
| | GM | 830 | 267 | 525 | 751 | 2521 | 1993 | 541 | 14 | 786 | 526 | 745 |
| 85/86 | GR | 1428 | 666 | 856 | 1632 | 4049 | 4449 | 1115 | 831 | 1946 | 452 | 648 |
| | GM | 937 | 268 | 404 | 1300 | 3571 | 938 | 480 | 359 | 1096 | 371 | 439 |
| 86/87 | GR | 1389 | 758 | 1380 | 1481 | 3421 | 2556 | 1655 | 826 | 2480 | 530 | 794 |
| | GM | 869 | 235 | 815 | 1103 | 2883 | -98 | 963 | 312 | 1528 | 449 | 552 |
| MEAN[6] | GR | 688 | 411 | 615 | 774 | 1572 | 2297 | 641 | 618 | 1259 | 308 | 448 |
| | GM | 456 | 207 | 378 | 609 | 1304 | 607 | 311 | 366 | 776 | 265 | 273 |

1. BOR refers to breeding own replacement ewes.
2. PR refers to purchasing all replacement ewes.
3. GR refers to gross revenue ($/ha).
4. GM refers to gross margin ($/ha).
5. Ryegrass/Clover activity : Clover is undersown. After ryegrass seed harvest, clover is maintained for later seed harvest.
6. Mean is the 17 year average for each activity.

The output prices are actual prices as at January of any one season. These are recorded in the Lincoln College Financial Budget Manuals for the respective years.

Exceptions are freezer peas, freezer beans and process potatoes where prices have been obtained from Watties Frozen Foods Ltd., Hornby. These prices are the best approximation available of the actual farm prices which would have been received if each activity had been grown or raised each year.

Lamb and sheep sale prices, and the timing of sales would influence the weight and possibly the quality of meat. However, the Financial Budget Manual figures are consistent in these aspects, and therefore are the most appropriate available data. Lambing percentages are as for Ellesmere County when breeding their own replacements, but adjusted up by ten percent when buying five year old ewes. A stocking rate of 17 ewe equivalents per hectare is used. Sheep activities have not always been present on this property and even when present the records kept are inadequate. Hence, these data represent the best approximation to on - farm yields. Yield data for wheat, barley, freezer peas, ryegrass, and white clover are from Lincoln College (L.C.) Farms Programmes, L.C.Farms Bulletins, L.C.Farms Accounts and the Farm Supervisor. Field peas yield data are a combination of Lincoln College records and Ceres Research Station. Frozen bean yields are from Watties, Hornby. Yield data for process potatoes is from a D.S.I.R. potato specialist at Lincoln, and this was later verified with Watties field officers.

The input costs are from the Lincoln College Financial Budget Manuals. They are actual prices as at December of any one season. This is the most reliable and consistent data series available. The input items and the quantity used are based on the Enterprise Gross Margins as presented in the 1988 and the 1989 Lincoln College Financial Budget Manuals. It is assumed that they were the same for seasons going back to 1970/71 season. This is because the format of the gross margins in the previous manuals have not always been consistent, and Lincoln University farm records do not have sufficient of the required data to work out the direct cost of each enterprise for many of these seasons.

Although enterprise gross margins are based on irrigation, the irrigation costs have been excluded. This is because the required information is unavailable and the irrigation expenses are unlikely to differ between activities.

There appears to be very little variation in variable inputs prices over any one season. Although items such as cost of replacement ewes and rams do vary, these are difficult to observe when looking at a seventeen year historic data series.

All data used to derive Table 4-2 have been verified for applicability to this farm unit with the Farm Supervisor.

## 4.3 The Model

### 4.3.1 Introduction

The basic components of the CAPM are captured in the following CAPM equation

$$E(R_i) = R_f + B_i\,(E(R_m) - R_f) \quad \text{..........Equation 3.6}$$

where $R_i$ = return on the i'th activity held in the farm sector portfolio;

$E$ = expected value;

$R_f$ = return on the Risk-free asset;

$B_i$ = Beta coefficient of the i'th activity; and

$R_m$= return on the farm sector portfolio, M;

The Beta coefficients can be determined by the Characteristic Line

$$R_i = a_i + B_i\,R_m + e_i \quad \text{..........Equation 3.7}$$

where $a_i$ = an intercept term; and

$e_i$ = the disturbance term.

Hence, the Capital Asset Pricing Model has three basic data components.

1. The return on the i'th activity held in the farm sector portfolio, $R_i$;
2. The return on the Risk-free asset, $R_f$; and
3. The return on the farm portfolio, $R_m$.

The Beta coefficients are then determined through the Characteristic Line. The Risk-free asset is a fairly straight forward measure and is usually the rental value of the farm land. However, appropriate measures of the return on individual activities and on the farm portfolio are not so easily determined, and will be discussed below.

### 4.3.2 Measures of Return on Activities

It was previously concluded (Section 3.3.3 (a)) that gross revenue per hectare and gross margin per hectare are the two preferred approaches to measure returns on activities for the Farm Sector Capital Asset Pricing Model, although the 'rate of return' measure is theoretically the best in the finance setting. On theoretical a priori criteria, the gross margin approach is superior to the gross revenue approach, since the latter does not take into account the variability in input costs. However, both the gross margin and the gross revenue approaches are evaluated in Chapter 5, using empirical data from Table 4-2.

### 4.3.3 The Impact of Inflation

It was pointed out in Section 3.3.3 (d) that the impact of inflation is not well developed in CAPM analysis, and that the Beta and the systematic risk coefficients may be sensitive to whether the data has or has not been deflated. A comparison of the two approaches is presented in Chapter 5, where the input costs have been deflated using the New Zealand Farm Input Cost Index and the output prices have been deflated using the New Zealand Farm Output Price Index. These indices are published in the 'Monthly

Abstract of Statistics' by the Department of Statistics, New Zealand, and are reproduced in Appendix 4-3. The 1986/1987 season was chosen as the base year when deflating these data.

### 4.3.4 The Farm Sector Portfolio

#### 4.3.4.1 Introduction

It was noted in the previous Chapter (Section 3.3.3 (c)), that a farm sector portfolio, M, should ideally consist of all agricultural production activities if it is to adequately represent New Zealand agriculture. However, it was also argued that it might be more appropriate to use that sub - set of agricultural activities which a farmer was capable of producing on the farm type in question.

Regardless of which portfolio definition is most appropriate, it is difficult to precisely determine the portfolio, and therefore a proxy is often used. Previous studies of agricultural application of the CAPM have concluded that the Beta coefficients and the systematic risk coefficients may be sensitive to the proxies used, although they did not test this supposition.

In this study of FSCAPM, four proxies for the farm sector portfolio ($R_m$) for Lincoln University Mixed Cropping Farm are evaluated, and these are discussed below. In each case, the following calculation is used to derive the farm sector portfolio.

$$R_m = \frac{1}{T} \sum_{i=1}^{m} R_{m,t} \quad \text{.......................... Equation 4.1}$$

where $R_{m,t}$ = mean return per hectare on the farm sector portfolio in time period t ;

$R_m$ = mean return per hectare on the farm sector portfolio;

### 4.3.4.2 'New Zealand Agriculture' as a Farm Sector Portfolio

The first proxy market index used is 'New Zealand Agriculture'. Its inclusion is based on the following logic.

For a farm sector portfolio to be perfectly diversified it should represent the total New Zealand agricultural sector. Turvey and Driver (1987) argue that by using cash rent as a risk-free asset and examining a portfolio choice problem based on the separation theorem, implies this equilibrium condition within the farm sector by construction. This portfolio should therefore contain each and every agricultural activity in the correct proportion.

Any proportional representation based on the total national area under each activity would be inappropriate because some activities, such as bees and poultry are intensive enterprises and some, such as beef and sheep, are extensive, requiring large areas of land. For land based activities, such as beef and sheep, productivity depends also on the class of land on which the farm is located. It may be appropriate to determine the proportional representation of the different farming enterprises based on the total number of holdings of each enterprise in New Zealand. This data is published in the New Zealand Monthly Abstract of Statistics.

The major enterprise groups in N.Z. agriculture are presented in Table 4-3. This is based on the number of holdings of each different farm type, in any one year, as shown in Appendix 4-4. Published enterprise production and returns data are available for Town Supply Dairy, Factory Supply Dairy, and for Sheep and Beef enterprises published annually by the New Zealand Meat and Wool Boards' Economic Service. Therefore, using Table 4-3 the weightings for these three enterprise groups can be determined, to form the farm sector portfolio. These weightings are presented in Table 4-4. Column 1 in Table 4-5 shows the actual percent of New Zealand agriculture this farm sector portfolio, $R_m$, will represent. Since idle land, forestry and educational properties are not part of agriculture, column 2 in Table 4-5 shows that this farm sector portfolio is more representative of New Zealand agriculture. This is further extended in column 3 to include horticultural and crop land, since many of these are a part of sheep and beef units. It can be seen from Table 4-5 that this farm sector portfolio includes a high proportion of New Zealand agricultural activities.

**Table 4-3: Percent of Farms in Each Farm Type Group in New Zealand Agriculture**

| Year | 1. Dairy Town Supply | 2. Dairy+ others | 3. Sheep+ Beef+ others +mx/stk. | 4. Crop+ others | 5. Orch.+ Pltry.+ Veges+ Fls+etc | 6. Idle+ Rsch.+ Educ.+ Ptn.etc | 7. OTHERS | 8. TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1970/71 | 1.750 | 28.981 | 54.639 | 2.008 | 6.278 | 2.061 | 4.283 | 100.0 |
| 1971/72 | 1.750 | 28.981 | 54.639 | 2.008 | 6.278 | 2.061 | 4.283 | 100.0 |
| 1972/73 | 1.750 | 26.958 | 55.541 | 1.851 | 7.247 | 3.048 | 3.605 | 100.0 |
| 1973/74 | 1.750 | 23.616 | 51.891 | 2.435 | 7.351 | 8.980 | 3.978 | 100.0 |
| 1974/75 | 1.750 | 23.616 | 51.891 | 2.435 | 7.351 | 8.980 | 3.978 | 100.0 |
| 1975/76 | 1.750 | 23.616 | 51.891 | 2.435 | 7.351 | 8.980 | 3.978 | 100.0 |
| 1976/77 | 1.750 | 22.676 | 51.843 | 2.450 | 7.353 | 9.662 | 4.267 | 100.0 |
| 1977/78 | 1.750 | 21.966 | 52.158 | 2.333 | 7.369 | 10.418 | 4.007 | 100.0 |
| 1978/79 | 1.750 | 21.077 | 52.722 | 2.297 | 7.314 | 11.043 | 3.797 | 100.0 |
| 1979/80 | 1.768 | 20.076 | 53.782 | 1.966 | 7.303 | 11.694 | 3.411 | 100.0 |
| 1980/81 | 1.925 | 19.192 | 58.085 | 1.835 | 8.062 | 8.660 | 2.241 | 100.0 |
| 1981/82 | 1.871 | 18.903 | 53.615 | 2.005 | 6.178 | 15.555 | 1.874 | 100.0 |
| 1982/83 | 1.612 | 19.130 | 52.084 | 1.974 | 7.571 | 15.163 | 2.466 | 100.0 |
| 1983/84 | 1.489 | 19.304 | 51.664 | 2.096 | 9.925 | 11.875 | 3.647 | 100.0 |
| 1984/85 | 1.414 | 18.861 | 50.702 | 2.087 | 10.085 | 12.586 | 4.265 | 100.0 |
| 1985/86 | 1.285 | 18.783 | 50.197 | 2.133 | 10.437 | 12.531 | 4.634 | 100.0 |
| 1986/87 | 1.750 | 17.580 | 49.345 | 2.437 | 10.298 | 13.551 | 5.039 | 100.0 |

**Table 4-4: Weightings for the Farm Sector Portfolio**

| Year | 1. Dairy Town Supply | 2. Dairy Fact. Supply | 3. Sheep,Beef & Mxd.Stock | TOTAL |
|---|---|---|---|---|
| 1970/71 | 2.05 | 33.95 | 64.00 | 100.00 |
| 1971/72 | 2.05 | 33.95 | 64.00 | 100.00 |
| 1972/73 | 2.08 | 32.00 | 65.93 | 100.00 |
| 1973/74 | 2.27 | 30.57 | 67.17 | 100.00 |
| 1974/75 | 2.27 | 30.57 | 67.17 | 100.00 |
| 1975/76 | 2.27 | 30.57 | 67.17 | 100.00 |
| 1976/77 | 2.29 | 29.73 | 67.97 | 100.00 |
| 1977/78 | 2.31 | 28.95 | 68.74 | 100.00 |
| 1978/79 | 2.32 | 27.90 | 69.79 | 100.00 |
| 1979/80 | 2.34 | 26.55 | 71.12 | 100.00 |
| 1980/81 | 2.43 | 24.23 | 73.34 | 100.00 |
| 1981/82 | 2.51 | 25.41 | 72.07 | 100.00 |
| 1982/83 | 2.21 | 26.27 | 71.52 | 100.00 |
| 1983/84 | 2.05 | 26.64 | 71.30 | 100.00 |
| 1984/85 | 1.99 | 26.57 | 71.43 | 100.00 |
| 1985/86 | 1.83 | 26.73 | 71.44 | 100.00 |
| 1986/87 | 2.55 | 25.60 | 71.85 | 100.00 |

Using the weightings from Table 4-4 and enterprise returns from Appendix 4-5, the farm sector portfolio can be calculated. This is presented in Table 4-6 (A). In Table 4-6 (B), these data are deflated.

However, these are aggregated data in which the variability of returns of the individual enterprises is likely to be reduced, which may influence the size of the Beta coefficients (see Equation 3.5).

**Table 4-5: Percent of N.Z. Agriculture Represented by The Farm Type Groups**

| Year | Percent of Total N.Z. Agriculture | | |
|---|---|---|---|
| | 1.<br>Dairy +<br>Sheep +<br>Beef +<br>Mxd.L/Stk. | 2.<br>Dairy + Sheep +<br>Beef + Mixd.L/Stck.+<br>Idle + Rsch.+ Educ.+<br>Plantation | 3.<br>Dairy + Sheep +<br>Beef + Mixd. /Stck.+<br>Idle + Rsch. Educ.+<br>Plantation + Crop +<br>Horticulture |
| 1970/71 | 85.37 | 87.43 | 89.44 |
| 1971/72 | 85.37 | 87.43 | 89.44 |
| 1972/73 | 84.25 | 87.30 | 89.15 |
| 1973/74 | 77.26 | 86.24 | 88.67 |
| 1974/75 | 77.26 | 86.24 | 88.67 |
| 1975/76 | 77.26 | 86.24 | 88.67 |
| 1976/77 | 76.27 | 85.93 | 88.38 |
| 1977/78 | 75.87 | 86.29 | 88.62 |
| 1978/79 | 75.55 | 86.59 | 88.89 |
| 1979/80 | 75.63 | 87.32 | 89.29 |
| 1980/81 | 79.20 | 87.86 | 89.70 |
| 1981/82 | 74.39 | 89.94 | 91.95 |
| 1982/83 | 72.83 | 87.99 | 89.96 |
| 1983/84 | 72.46 | 84.33 | 86.43 |
| 1984/85 | 70.98 | 83.56 | 85.65 |
| 1985/86 | 70.26 | 82.80 | 84.93 |
| 1986/87 | 68.68 | 82.23 | 84.66 |

**Table 4-6 (A): $R_m$ = 'New Zealand Agriculture' (Non-deflated)**

| Year | Gross Revenue $/ha | | | $R_{m,t}$ | Gross Margin $/ha | | | $R_{m,t}$ |
|---|---|---|---|---|---|---|---|---|
| | DairyTS | DairyFS | Shp/Bf. | $/ha | DairyTS | DairyFS | Shp/Bf. | $/ha |
| 1970/71 | 327.42 | 217.80 | 37.32 | 104.54 | 182.13 | 123.19 | 18.74 | 57.55 |
| 1971/72 | 397.37 | 278.84 | 41.56 | 129.41 | 234.83 | 166.29 | 21.68 | 75.14 |
| 1972/73 | 432.07 | 304.04 | 69.82 | 152.29 | 252.74 | 182.41 | 43.41 | 92.23 |
| 1973/74 | 486.11 | 326.47 | 67.61 | 156.22 | 273.12 | 191.13 | 36.87 | 89.38 |
| 1974/75 | 513.09 | 339.86 | 53.27 | 151.29 | 307.49 | 198.18 | 24.28 | 83.85 |
| 1975/76 | 512.14 | 368.23 | 80.22 | 178.04 | 307.98 | 228.91 | 44.89 | 107.10 |
| 1976/77 | 591.37 | 437.40 | 102.91 | 213.57 | 343.07 | 259.67 | 59.00 | 125.18 |
| 1977/78 | 638.32 | 438.20 | 95.10 | 206.96 | 372.77 | 249.97 | 47.14 | 113.37 |
| 1978/79 | 784.06 | 557.97 | 114.29 | 253.58 | 470.39 | 337.03 | 60.47 | 147.12 |
| 1979/80 | 847.90 | 681.02 | 144.90 | 303.65 | 450.09 | 385.52 | 75.66 | 166.67 |
| 1980/81 | 1028.15 | 852.79 | 155.90 | 345.97 | 559.11 | 475.87 | 75.02 | 183.92 |
| 1981/82 | 1189.88 | 1043.00 | 182.07 | 426.19 | 658.86 | 578.44 | 84.88 | 224.73 |
| 1982/83 | 1393.41 | 1187.13 | 201.87 | 487.05 | 743.54 | 669.41 | 96.18 | 261.09 |
| 1983/84 | 1488.73 | 1334.72 | 202.27 | 530.41 | 797.26 | 750.86 | 91.65 | 281.77 |
| 1984/85 | 1686.75 | 1538.58 | 257.02 | 626.05 | 931.47 | 884.10 | 128.43 | 345.23 |
| 1985/86 | 1826.10 | 1497.27 | 206.04 | 580.84 | 1014.79 | 837.63 | 98.24 | 312.65 |
| 1986/87 | 1826.10 | 1497.27 | 225.68 | 591.98 | 1014.79 | 837.63 | 121.20 | 327.37 |
| $R_m$ | | | | 319.88 | | | | 176.14 |

**Table 4-6 (B): $R_m$ = 'N.Z. Agriculture' (Deflated[1] to 1986/87 season)**

| Year | Gross Revenue $/ha | | | $R_{m,t}$ | Gross Margin $/ha | | | $R_{m,t}$ |
|---|---|---|---|---|---|---|---|---|
| | DairyTS | DairyFS | Shp/Bf. | $/ha | DairyTS | DairyFS | Shp/Bf. | $/ha |
| 1970/71 | 1744.38 | 1160.36 | 198.83 | 556.93 | 894.73 | 607.09 | 90.17 | 282.15 |
| 1971/72 | 1859.48 | 1304.82 | 194.48 | 605.55 | 970.31 | 689.12 | 85.73 | 308.70 |
| 1972/73 | 1407.39 | 990.36 | 227.43 | 496.06 | 534.32 | 398.20 | 98.85 | 203.68 |
| 1973/74 | 1625.79 | 1091.87 | 226.12 | 522.47 | 704.55 | 506.49 | 93.16 | 233.36 |
| 1974/75 | 2107.15 | 1395.73 | 218.77 | 621.32 | 1292.57 | 834.40 | 103.91 | 354.13 |
| 1975/76 | 1556.66 | 1119.24 | 243.83 | 541.17 | 840.05 | 630.23 | 119.82 | 292.16 |
| 1976/77 | 1553.78 | 1149.24 | 270.39 | 561.13 | 811.04 | 617.59 | 139.04 | 296.74 |
| 1977/78 | 1533.32 | 1052.61 | 228.44 | 497.14 | 811.32 | 540.83 | 98.04 | 242.69 |
| 1978/79 | 1321.08 | 940.13 | 192.57 | 427.27 | 563.60 | 406.59 | 62.60 | 170.17 |
| 1979/80 | 1432.51 | 1150.57 | 244.80 | 513.01 | 675.06 | 587.92 | 112.97 | 252.19 |
| 1980/81 | 1631.47 | 1353.21 | 247.38 | 548.98 | 888.49 | 756.15 | 119.27 | 292.29 |
| 1981/82 | 1615.59 | 1416.16 | 247.21 | 578.66 | 901.75 | 791.66 | 116.56 | 307.86 |
| 1982/83 | 1698.87 | 1447.37 | 246.12 | 593.82 | 867.30 | 784.90 | 110.88 | 304.68 |
| 1983/84 | 1701.60 | 1525.57 | 231.19 | 606.25 | 877.05 | 829.34 | 99.28 | 309.76 |
| 1984/85 | 1614.89 | 1473.03 | 246.07 | 599.38 | 839.21 | 800.87 | 114.01 | 310.98 |
| 1985/86 | 2022.26 | 1658.11 | 228.17 | 643.23 | 1181.09 | 974.19 | 116.41 | 365.18 |
| 1986/87 | 1826.10 | 1497.27 | 225.68 | 591.98 | 1014.79 | 837.63 | 121.20 | 327.37 |
| $R_m$ | | | | 559.98 | | | | 285.53 |

1. Gross revenue and variable costs were deflated using farm output price index and farm input cost index respectively, as presented in Appendix 4-3.

#### 4.3.4.3 'New Zealand Gross Agricultural Production' as a Farm Sector Portfolio

Sharpe (1970) argues that the $R_m$ variable should be any factor thought to be the most important single influence on returns. In the finance setting Gross National Product (GNP) has sometimes been used as a proxy for $R_m$. The market portfolio, M, is supposed to represent the New Zealand economy. On this basis, N.Z. Gross Agricultural Production (NZGAP) may be used as a proxy for New Zealand agriculture. Once again, a data aggregation problem is encountered when using NZGAP as a farm sector portfolio, although this same problem will occur when using GNP in the finance setting, which is often used.

This farm sector portfolio is presented in Table 4-7.

**Table 4-7: $R_m$ = 'N.Z. Gross Agricultural Production'**

| YEAR | NON - DEFLATED | | | DEFLATED[3] | |
|---|---|---|---|---|---|
| | Total Area of Farms[2] ('000 ha) | GROSS AGRICULTR. PRODCTN.[1] $ million | $R_{m,t}$ Grs.Agric. Prodn./ha. ($/ha) | GROSS AGRICULTR. PRODCTN. $ million | $R_{m,t}$ Grs.Agric. Prodn./ha ($/ha) |
| 1970/71 | 17422.8 | 1000 | 57.40 | 5327.7 | 305.79 |
| 1971/72 | 19030.4 | 1247 | 65.53 | 5835.3 | 306.63 |
| 1972/73 | 20667.4 | 1668 | 80.71 | 5433.2 | 262.89 |
| 1973/74 | 20772.0 | 1714 | 82.51 | 5732.4 | 275.97 |
| 1974/75 | 20937.8 | 1394 | 66.58 | 5724.8 | 273.42 |
| 1975/76 | 21223.7 | 1913 | 90.14 | 5814.6 | 273.97 |
| 1976/77 | 21225.5 | 2775 | 130.74 | 7291.1 | 343.51 |
| 1977/78 | 21254.4 | 2768 | 130.23 | 6649.1 | 312.83 |
| 1978/79 | 21231.3 | 3470 | 163.44 | 5846.7 | 275.38 |
| 1979/80 | 21237.3 | 4520 | 212.83 | 7636.4 | 359.58 |
| 1980/81 | 21249.6 | 4549 | 214.07 | 7218.3 | 339.69 |
| 1981/82 | 21263.6 | 5000 | 235.14 | 6788.9 | 319.27 |
| 1982/83 | 21266.1 | 5092 | 239.44 | 6208.2 | 291.93 |
| 1983/84 | 21224.3 | 5900 | 277.98 | 6743.6 | 317.73 |
| 1984/85 | 21376.8 | 7579 | 354.54 | 7256.1 | 339.44 |
| 1985/86 | 21331.0 | 6900 | 323.47 | 7641.2 | 358.22 |
| 1986/87 | 17795.0 | 6979 | 392.19 | 6979.0 | 392.19 |
| $R_m$ | | | 183.35 | | 314.62 |

1. Reference: N.Z. Agric. Statistics, Published annually, M.A.F., N.Z.
2. Reference: Ag.Statistics, Published annually, Dept.of Statistics, N.Z.
3. Gross Agric. Production deflated to 1986/87 season using Farm Output Price Index, presented in Appendix 4-3.

#### 4.3.4.4 'New Zealand Meat and Wool Boards' Economic Service Farm Class 8' as a Farm Sector Portfolio.

Although the 'N.Z. agriculture' proxy would be a well diversified portfolio for analysing any N.Z. farm activity, it may be more appropriate to use the New Zealand Meat and Wool Boards' Economic Service Farm Class 8 for analysing Lincoln University Mixed Cropping farm activities. Farm Class 8 represents mixed cropping and finishing farms of South Island, New Zealand. They are mainly in Canterbury with a high proportion of the income derived from grain and small seeds, as does the Lincoln University Mixed Cropping farm. The index is derived from a random sample of farms, stratified by geographical area and by flock size and farm class. As with other indices considered this far, the use of aggregate data may influence the magnitude of the Beta coefficients, and may not be entirely appropriate to a case study farm situation.

This farm sector portfolio contains all the farm activities that can potentially be carried out on the case study property. In addition, the activities included are weighted in terms of their contribution to the farm returns. Thus, it is a well diversified index for mixed cropping type of farming. This index is presented in Table 4-8, below.

**Table 4-8: $R_m$ = 'New Zealand Meat and Wool Boards' Economic Service Farm Class 8'[1]**

| Year end June | NON - DEFLATED | | DEFLATED to 1986/87[2] | |
|---|---|---|---|---|
| | $R_{m,t}$ Grs.Revenue[3] \$/ha | $R_{m,t}$ Grs.Margin[3] \$/ha | $R_{m,t}$ Grs.Revenue \$/ha | $R_{m,t}$ Grs.Margin \$/ha |
| 1970/71 | 114.17 | 62.02 | 608.26 | 303.29 |
| 1971/72 | 116.27 | 60.43 | 544.08 | 238.61 |
| 1972/73 | 169.81 | 97.45 | 553.13 | 200.89 |
| 1973/74 | 177.21 | 93.38 | 592.68 | 230.09 |
| 1974/75 | 146.47 | 57.84 | 601.52 | 250.37 |
| 1975/76 | 238.99 | 144.18 | 726.41 | 393.63 |
| 1976/77 | 260.95 | 150.87 | 685.63 | 356.34 |
| 1977/78 | 262.54 | 147.81 | 630.65 | 318.72 |
| 1978/79 | 301.77 | 170.33 | 508.46 | 191.05 |
| 1979/80 | 326.98 | 181.62 | 552.42 | 275.63 |
| 1980/81 | 437.94 | 248.04 | 694.92 | 394.11 |
| 1981/82 | 471.86 | 247.75 | 640.68 | 339.42 |
| 1982/83 | 578.73 | 262.63 | 705.60 | 301.12 |
| 1983/84 | 617.14 | 269.63 | 705.38 | 290.98 |
| 1984/85 | 720.18 | 341.65 | 689.50 | 300.74 |
| 1985/86 | 598.14 | 194.83 | 662.39 | 244.24 |
| 1986/87 | 595.20 | 257.88 | 595.20 | 257.88 |
| $R_m$ | 360.84 | 175.78 | 629.23 | 287.48 |

1. Reference: N.Z.Meat & Wool Boards' Economic Service Data.
2. Gross Revenue and working expenses were deflated using Farm Output Price Index and Farm Input Cost Index, respectively, as presented in Appendix 4-3.
3. Details of Revenues and Costs for Farm Class 8 are in Appendix 4-6.

### 4.3.4.5 An 'Unweighted Index' as a Farm Sector Portfolio

When using this index, all activities under analysis are included, in equal proportion, in the farm sector portfolio. Previous studies of FSCAPM (Turvey (1985); Collins and Barry (1986); Turvey and Driver (1987); and Turvey, Driver and Baker (1988)) used this index. The calculation involved is very simple and no extra data is required other than that used to determine returns on individual activities ($R_i$).

$$R_{m,t} = \frac{1}{m} \sum_{i=1}^{T} R_{i,t} \quad \text{...................... Equation 4.2}$$

Where $R_{m,t}$ = mean return per hectare on the farm sector portfolio in time period t ;

$R_{i,t}$ = observed return per hectare of the i'th activity included in the portfolio in time period t;

Equation 4.1 shows how to calculate mean return per hectare on the farm sector portfolio, $R_m$.

However, the activities are not weighted to reflect their size or proportion in the New Zealand agricultural sector or in the mixed cropping type of farming, as required of the market index in the capital market stock portfolio analysis. On the other hand, the index is derived from case farm data, thereby avoiding the problems encountered when using aggregated data.

This farm sector portfolio is presented in Table 4-9.

**Table 4-9: $R_m$ = 'Unweighted Farm Sector Portfolio' ($R_{m,t}$) $/ha[1]**

| Year | Non-deflated | | Deflated[2] | |
|---|---|---|---|---|
| | Gross Revenue | Gross Margin | Gross Revenue | Gross Margin |
| 1970/71 | 363.95 | 245.76 | 1939.00 | 1247.80 |
| 1971/72 | 333.67 | 211.68 | 1561.40 | 894.02 |
| 1972/73 | 346.98 | 225.18 | 1130.23 | 537.23 |
| 1973/74 | 677.74 | 506.92 | 2266.68 | 1527.83 |
| 1974/75 | 422.68 | 240.40 | 1735.84 | 1013.68 |
| 1975/76 | 494.27 | 267.01 | 1502.33 | 704.66 |
| 1976/77 | 782.74 | 521.52 | 2056.61 | 1275.20 |
| 1977/78 | 705.25 | 450.61 | 1694.09 | 1001.75 |
| 1978/79 | 790.15 | 463.19 | 1331.33 | 541.78 |
| 1979/80 | 800.71 | 437.04 | 1352.78 | 660.34 |
| 1980/81 | 1084.55 | 582.29 | 1720.97 | 925.36 |
| 1981/82 | 947.11 | 506.96 | 1285.96 | 694.29 |
| 1982/83 | 1129.90 | 599.54 | 1377.60 | 698.95 |
| 1983/84 | 1238.69 | 662.31 | 1415.81 | 728.50 |
| 1984/85 | 1554.95 | 863.47 | 1488.70 | 778.54 |
| 1985/86 | 1642.85 | 923.45 | 1819.33 | 1073.45 |
| 1986/87 | 1569.93 | 873.71 | 1569.93 | 873.67 |
| $R_m$ | 875.65 | 504.77 | 1602.86 | 892.77 |

1. Data for this table is presented in Appendix 4-2.
2. Revenues have been deflated using Farm Output Price Index and costs been deflated using Farm Input Price Index, as in Appendix 4-3.

### 4.3.5 The Risk - Free Asset

Previous studies of agricultural adaptation of the Capital Asset Pricing Model used an annual rental value of land for the risk free asset (Section 3.3.3 (b)). For agricultural land, this value depends on a number of factors, such as location of the property, the soil type, the state of farm development, and international as well as domestic market prices of farm produce. It is thus impossible to obtain any reliable published rental values of farm land unless it is a recent assessment for a specific farm unit.

Consultants[1] estimate the rental value of the Lincoln University Mixed

1. Mr. E. Moorhead, Senior Lecturer in Valuation, Lincoln University.
   Mr. A. Whatman, Farm Supervisor, Lincoln University.

Cropping farm to be between $150.00 and $190.00 per hectare. When evaluating the Farm Sector Capital Asset Pricing Model in Chapter 5, a cash rental value of $170.00 per hectare is used as the Risk-free rate. The sensitivity of the model however, is tested with the rental value at $150.00 per hectare and at $190.00 per hectare.

## 4.4 Summary

From the above discussion on the methods of measuring activity returns ($R_i$), different possible farm sector portfolios ($R_m$), a cash rental value of land to represent the Risk-free asset ($R_f$), and the impact of inflation, a number of models can be generated when adapting the CAPM to a mixed cropping situation. These include:

a. Four alternative measures of the farm sector portfolio ($R_m$):
   1. New Zealand Agriculture;
   2. New Zealand Gross Agricultural Production;
   3. New Zealand Meat And Wool Boards' Economic Service Farm Class 8;and
   4. Unweighted Index.

b. Two alternative measures of return on activities:
   1. Gross Revenue approach; and
   2. Gross Margin approach.

c. Deflated versus Non-deflated models.

d. Three estimates of the Risk-Free Asset.

Using the empirical data generated in this Chapter, the FSCAPM will be used in Chapter 5 to generate the Beta coefficients. The above set of models will then be evaluated.

# Chapter 5

# Results and Discussion

## 5.1 Introduction

The feasibility of using the Farm Sector Capital Asset Pricing Model (FSCAPM) has been investigated in overseas settings; for example, in Ontario, Canada by Turvey (see Turvey, 1985; Turvey and Driver, 1987; and Turvey, Driver and Baker, 1988), and in Imperial Valley, America by Collins and Barry (1986). The results of these studies were encouraging, although some of the conclusions drawn from them tended to conflict. However, the approaches taken in the two studies differed. In an attempt to explain these differences, both approaches are compared in Section 5.3, using the data from the current study.

The Beta coefficients which were generated for all models are first discussed in Section 5.2. The alternative Farm Sector Capital Asset Pricing Models (FSCAPM), including the Turvey and Driver (1987) and the Collins and Barry (1986) variants are evaluated in Section 5.3. In doing so, the proportion of systematic and non - systematic risk in the New Zealand mixed cropping farm activities is determined for these various models. These models are then evaluated. The preferred model is then used in Section 5.4 to determine the level of systematic risk in the Lincoln University Mixed Cropping Farm activities and to ascertain whether this farm had been adequately compensated for the level of systematic risk it had been facing. This analysis illustrates the potential of the FSCAPM in risk analysis and decision making in agriculture.

## 5.2 The Beta Coefficients

The Beta coefficients were generated by the Characteristic Line (Equation 3.7). This represents a simple linear regression of the return for an activity, $R_i$, against the return on the market portfolio, $R_m$. That is

$$R_i = a_i + B_i R_m + e_i \quad \text{..........Equation 3.7}$$

where $a_i$ = the intercept term;

$B_i$ = the Beta coefficient for activity i; and

$e_i$ = the random error term.

Standard error tests were then used to determine whether:

a. The intercept term of the Characteristic Line was not significantly different from zero, and
b. The slope of the Characteristic Line was significantly different from zero.

The Goldfeld and Quandt test for homoscedasticity and the Durban - Watson test for autocorrelation were used to check the validity of the OLS model.

The Beta coefficients, the intercept terms (alpha) and the results of the statistical tests are shown in Table 5-1 (A) for the non-deflated models, and Table 5-1 (B) for the deflated models. The independent (portfolio mean) and dependent variables (individual activity returns) used to generate the characteristic line for each of the models, and hence Beta coefficients, were discussed in Chapter 4.

**Table 5-1(A): Alpha and Beta Coefficients for the Lincoln University Mixed Cropping Farm Activities; Non-deflated Models, $R_f$ = $170/ha.**

| Activity | Gross Revenue | | | | Gross Margin | | | | Beta/ Alpha |
|---|---|---|---|---|---|---|---|---|---|
| | Farm Sector Portfolio | | | | Farm Sector Portfolio | | | | |
| | Unwght. | Farm Class8 | N.Z. Agric. | N.Z. G.A.P. | Unwght. | Farm Cls.8 | N.Z. Agric. | N.Z. G.A.P. | |
| Wheat | 0.95*1 | 2.03* | 2.26* | 3.79* | 1.09* | 2.73* | 2.69* | 2.38* | Beta |
| | -143 | -46 | -34 | -8 | -94 | -23 | -17 | 20 | Alpha |
| F.Barley | 0.43* | 0.94* | 1.06* | 1.78* | 0.22* | 0.68* | 0.58* | 0.50* | Beta |
| | 34 | 70 | 73 | 84 | 97 | 88 | 105 | 116 | Alpha |
| Field Peas | 0.73* | 1.61* | 1.81* | 2.95* | 0.70* | 1.83* | 1.83* | 1.56* | Beta |
| | -19 | 35 | 37 | 74 | 23 | 56 | 56 | 93 | Alpha |
| Frozen Peas | 0.98* | 2.09* | 2.36* | 3.99* | 1.35* | 3.53* | 3.46* | 3.14* | Beta |
| | -81 | 20 | 21 | 43 | -71 | -12 | -1 | 33 | Alpha |
| Frozen Bean | 2.46* | 4.89* | 5.62* | 9.40* | 4.12* | 8.49* | 9.37* | 8.29* | Beta |
| | -577 | -193 | -226 | -152 | -775 | -189 | -346 | -216 | Alpha |
| P. Potatoes | 2.14* | 4.19* | 4.49* | 7.52* | 0.07 | -1.64 | -1.35 | -1.24 | Beta |
| | 422 | 786 | 861 | 918 | 573 | 895 | 845 | 835 | Alpha |
| Ryegrass | 0.84* | 1.69* | 1.96* | 3.48* | 0.77* | 1.30 | 1.54* | 1.53* | Beta |
| | -96 | 32 | 15 | 4 | -77 | 83 | 41 | 30 | Alpha |
| Wht.Clover | 0.40* | 0.83* | 0.87* | 1.50* | 0.15 | 0.49 | 0.09 | 0.14 | Beta |
| | 268 | 319 | 341 | 343 | 292 | 280 | 350 | 340 | Alpha |
| Grass/Clovr | 1.24* | 2.52* | 2.82* | 4.97* | 1.28* | 2.70* | 2.55* | 2.50* | Beta |
| | 172 | 351 | 356 | 348 | 130 | 301 | 326 | 317 | Alpha |
| Sheep BOR | 0.33* | 0.74* | 0.80* | 1.37* | 0.52* | 1.45* | 1.28* | 1.15* | Beta |
| | 18 | 43 | 51 | 58 | 6 | 11 | 40 | 54 | Alpha |
| Sheep PR | 0.51* | 1.14* | 1.25* | 2.10* | 0.75* | 2.07* | 1.93* | 1.67* | Beta |
| | 3 | 36 | 48 | 64 | -104 | -91 | -68 | -33 | Alpha |

1. A * indicates that the estimate is statistically significant at the five percent level of significance. The standard error of the estimates are presented in Appendix 5-2.

**Table 5-1(B): Alpha and Beta Coefficients for the Lincoln University Mixed Cropping Farm Activities; Deflated Models, $R_f$ = $170/ha.**

| Activity | Gross Revenue | | | | Gross Margin | | | | Beta/ Alpha |
|---|---|---|---|---|---|---|---|---|---|
| | Farm Sector Portfolio | | | | Farm Sector Portfolio | | | | |
| | Unwght. | Farm Class8 | N.Z. Agric. | N.Z. G.A.P. | Unwght. | Farm Cls.8 | N.Z. Agric. | N.Z. G.A.P. | |
| Wheat | 0.11 | 3.04*[1] | 2.16 | 3.94* | 0.06 | 2.26* | 2.71* | 2.70 | Beta |
| | 984* | -749 | -41 | -74 | 696* | 101 | -24 | -99 | Alpha |
| F.Barley | 0.29 | 1.21 | 1.47 | 0.96 | 0.33 | 1.31 | 1.79 | -0.72 | Beta |
| | 280 | -11 | -75 | 447* | 94 | 13 | -123 | 616* | Alpha |
| Field Peas | 0.59 | 0.27 | 3.18 | -2.23 | 0.72* | -1.44 | 2.46 | -2.74 | Beta |
| | 158 | 941* | -670 | 1811* | 36 | 1091* | -25 | 1540* | Alpha |
| Frozen Peas | -0.08 | 1.40 | 2.17 | 4.70* | -0.24 | 1.73 | 3.51* | 4.81 | Beta |
| | 1442* | 437 | 108 | -158 | 1210* | 493 | -11 | -522 | Alpha |
| Frozen Bean | 2.07 | 1.75 | 7.98 | 9.96 | 2.22* | -1.68 | 9.15 | 10.82 | Beta |
| | -675 | 1542 | -1818 | -490 | 107 | 2570* | -526 | 1318 | Alpha |
| Potatoes | 4.35* | -0.67 | 0.57 | -9.50 | 3.96* | 0.79 | -0.37 | -7.59 | Beta |
| | -2331 | 5059* | 4317* | 7625* | -2147 | 1160 | 1494 | 3775* | Alpha |
| Ryegrass | 0.64 | -0.44 | -0.80 | 3.47 | 0.85* | -1.52 | -1.70 | 2.27 | Beta |
| | 84 | 1390* | 1560* | 21 | -242 | 954* | 1001* | -197 | Alpha |
| Wht.Clover | 1.04* | 0.09 | -2.90 | -3.16 | 1.12* | 1.52 | -2.46 | -3.74 | Beta |
| | -453 | 1161* | 2833* | 2209* | -260 | 304 | 1446* | 1920* | Alpha |
| Grass/Clovr | 1.68* | -0.35 | -3.69 | 0.31 | 1.84* | 0.03 | -3.76 | -0.06 | Beta |
| | -369 | 2550* | 4393* | 2231* | -239 | 1399 | 2480* | 1425 | Alpha |
| Sheep BOR | 0.11 | 0.27 | -0.40 | 0.09 | 0.12 | 0.40 | -0.39 | 0.19 | Beta |
| | 372* | 383* | 778* | 526* | 364* | 355* | 580* | 411* | Alpha |
| Sheep PR | 0.18* | 0.69 | 0.20 | 0.16 | 0.02 | 0.92 | 1.94* | 1.58 | Beta |
| | 509* | 371* | 691* | 752* | 380* | 137 | -155 | -97* | Alpha |

1. A * indicates that the estimate is statistically significant at the five percent level of significance. The standard error of the estimates are presented in Appendix 5-2.

In capital market portfolio analysis, the intercept term represents, on average, is the portion of an asset's return which is not associated with general movements in the economy (Dobbins and Witt, 1983, p13). It therefore represents the average return of an individual asset, when the return of the market index is zero. Since FSCAPM is an equilibrium model, the intercept term should not be significantly different from zero. The standard error tests on the intercepts of the Characteristic Lines in Tables 5-1 (A) and (B), show that in all cases when returns were not deflated, the intercept terms were not significantly different than zero. However, when the returns were deflated no such general conclusion could be drawn.

Positive Beta coefficients imply that there is a systematic component to the overall risk of the activities being analysed (Turvey, 1985, p77). The standard error tests in Table 5-1 (A) and Table 5-1 (B) show that for non - deflated models, all Beta coefficients, except for process potatoes and white clover gross margin models, were statistically significant. However, for deflated models, very few of the Beta estimates were statistically significant, although the two unweighted farm sector portfolio models performed better. The non - deflated models showed all statistically significant estimates to be positive. The same result was observed for the deflated models, although very few of these estimates were significant.

The Goldfeld and Quandt homoscedasticity test (see Appendix 5-3 for details) shows that apart from the non-deflated process potatoes activity, there was no heteroscedasticity present. This indicates that the standard error tests of statistical significance were valid for ordinary least squares techniques of estimation. The Durban - Watson Autocorrelation test (see Appendix 5-4) shows that autocorrelation is present in the majority of cases, with this phenomenon being more common with the deflated models than with the non - deflated models. This is not surprising since it is a common feature of economic data. However, even when autocorrelation is present, the estimates of the parameters remain statistically unbiased, although the ordinary least squares variances of the parameter estimates are likely to be larger than their true values.

## 5.3 The Farm Sector Capital Asset Pricing Model

### 5.3.1 The Turvey and Driver Approach versus the Collins and Barry Approach

Turvey and Driver (1987) used non - deflated gross revenue data in their Ontario study, with their farm sector portfolio (or the market index) being an unweighted index comprising all 28 activities being analysed. They observed that levels of systematic risk were high for the agricultural activities, and concluded that off - farm diversification was a more appropriate way of reducing total farm risk. They also concluded that farmers were being undercompensated for the level of systematic risk they were accepting for the majority of the agricultural commodities and crop mixes examined.

The non - deflated gross revenue model using the unweighted farm sector portfolio for the Lincoln University Mixed Cropping Farm is presented in Table 5-2.

The results of this model replicate those which Turvey and Driver found in their Ontario study. The Lincoln farm activities had high levels of systematic risk as a percentage of total risk, varying from 63.8 percent to 96.2 percent with eight of the eleven activities having a proportion of systematic risk greater than 85 percent. As shown by the 'Error' column, the farm was also undercompensated for the level of systematic risk, for the majority of the activities. With eight of the eleven activities were undercompensated. Turvey and Driver found 22 out of 28 activities undercompensated in their study.

However, Collins and Barry (1986) used deflated gross margin data as opposed to Turvey and Driver's non - deflated gross revenue approach in their analysis of Imperial Valley farm activities. They concluded that the level of systematic risk was low for the activities. This is diametrically opposed to Turvey and Driver's conclusion. The Collins and Barry approach was used on the Lincoln University Mixed Cropping Farm data to generate the Beta coefficients, systematic risk as a percentage of total risk and to evaluate the levels of compensation for the farm activities. The results of this analysis are presented in Table 5.3.

**Table 5-2: Risk - Return Measures Using FSCAPM, for Gross Revenue, Non - deflated, Unweighted Farm Sector Portfolio Model, ($R_f$ = $170/ha).**

| Activity | Beta $B_i$ | Corrln. Coeffn. $r_{im}$ | Histrc. Mean $R_i$ $/ha | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Percent Systmt. Risk % |
|---|---|---|---|---|---|---|---|
| Wheat | 0.95*[1] | 0.962 | 687.46 | 839.62 | 152.16 | 417.87 | 96.2 |
| F.Barley | 0.43* | 0.899 | 410.60 | 473.54 | 62.95 | 202.67 | 89.9 |
| Field Peas | 0.73* | 0.846 | 615.29 | 681.47 | 66.18 | 362.85 | 84.6 |
| Frozen Peas | 0.98* | 0.912 | 773.99 | 858.68 | 84.69 | 453.48 | 91.2 |
| Frozen Bean | 2.46* | 0.950 | 1572.23 | 1902.22 | 329.99 | 1094.62 | 95.0 |
| P.Potatoes | 2.14* | 0.735 | 2297.19 | 1681.33 | -615.86 | 1235.55 | 73.5 |
| Ryegrass | 0.84* | 0.875 | 641.42 | 764.37 | 122.95 | 407.98 | 87.5 |
| Wht.Clover | 0.40* | 0.638 | 617.97 | 451.70 | -166.27 | 265.33 | 63.8 |
| Grass/Clovr | 1.24* | 0.894 | 1259.38 | 1046.08 | -213.30 | 588.74 | 89.4 |
| Sheep BOR | 0.33* | 0.949 | 308.34 | 404.38 | 96.04 | 148.27 | 94.9 |
| Sheep PR | 0.51* | 0.939 | 448.36 | 528.82 | 80.46 | 229.59 | 93.8 |

1. A * indicates the estimate is statistically significant at the five percent level of significance. The standard error of the estimates are presented in Appendix 5-2.

**Table 5-3: Risk - Return Measures Using FSCAPM, for Gross Margin, Deflated, Unweighted Farm Sector Portfolio Model, ($R_f$ = $170/ha).**

| Activity | Beta $B_i$ | Correl. Coeffn. $r_{im}$ | Histrc. Mean $R_i$ $/ha | Expected Return $E(R_i)$ $/ha | Error $E(R_i)$-$R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Percent Systmt. Risk % |
|---|---|---|---|---|---|---|---|
| Wheat | 0.06 | 0.072 | 751.37 | 214.63 | -536.74 | 226.74 | 7.21 |
| F.Barley | 0.33 | 0.448 | 388.19 | 408.45 | 20.26 | 194.96 | 44.81 |
| Field Peas | 0.72*[1] | 0.483 | 678.33 | 689.77 | 11.44 | 394.30 | 48.30 |
| Frozen Peas | -0.24 | 0.178 | 991.25 | -6.69 | -997.94 | 363.70 | 17.80 |
| Frozen Bean | 2.22* | 0.589 | 2086.75 | 1773.04 | -313.71 | 996.63 | 58.93 |
| P.Potatoes | 3.96* | 0.623 | 1387.22 | 3030.98 | 1643.76 | 1681.86 | 62.33 |
| Ryegrass | 0.85* | 0.506 | 517.30 | 784.70 | 267.40 | 445.22 | 50.59 |
| Wht.Clover | 1.12* | 0.684 | 744.08 | 982.50 | 238.42 | 435.40 | 68.37 |
| Grass/Clovr | 1.84* | 0.701 | 1407.19 | 1502.63 | 95.44 | 696.84 | 70.07 |
| Sheep BOR | 0.12 | 0.389 | 469.22 | 254.88 | -214.34 | 79.96 | 38.89 |
| Sheep PR | 0.02 | 0.037 | 399.55 | 185.59 | -213.96 | 152.99 | 3.73 |

1. A * indicates the estimate is statistically significant at the five percent level of significance. The standard error of the estimates are presented in Appendix 5-2.

These results support those of the previous model with respect to undercompensation, indicating that the majority of activities were again being undercompensated for the levels of systematic risk that were being accepted by the farmer. However, Collins and Barry's concern was with the level of systematic risk. In contrast to Turvey and Driver, they found very low levels of systematic risk, ranging from zero to twenty percent for ten of the twelve activities. A lower proportion of systematic risk was also observed on the Lincoln University data. However, it remained quite significant for many of the activities, with seven of the eleven activities having a percentage of systematic risk over the total risk between forty and seventy percent.

Turvey and Driver (1987) gave three reasons for the difference between their result and that obtained by Collins and Barry. First, Collins and Barry used deflated dollars whereas Turvey and Driver used nominal dollars. Second, Turvey and Driver used gross revenues rather than net revenues. Third, Collins and Barry used 12 Imperial Valley crops as their farm sector portfolio whereas Turvey and Driver used 28 Ontario crop and livestock activities.

These differences in outcome between the two approaches are more fully explored in the following sections where a more generalised evaluation of the outcomes of the FSCAPM using the various models is undertaken. Section 5.3.2 compares the gross revenue approach with the gross margin approach, and Section 5.3.3 compares the deflated approach with the non - deflated approach. Alternative farm sector portfolios from Chapter 4 are analysed in Section 5.3.4. The sensitivity of FSCAPM to the risk - free rate is evaluated in Section 5.3.5.

### 5.3.2 Gross Revenue versus Gross Margin Models

Previous studies of FSCAPM have either used the gross revenue per hectare or the gross margin per hectare approaches to measure returns on activities. Although the 'rate of return' measure is theoretically more appropriate, it was discounted due to data problems. These were discussed in Section 3.3.3. Using the unweighted farm sector portfolio and non-deflated returns as an illustration, the two remaining approaches to measuring returns are compared in Table 5-4.

**Table 5-4: Gross Revenue versus Gross Margin Models for Measuring Risk - Return Trade - Offs[1]**

| Activity | Gross Revenue | | | | | | Gross Margin | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beta[2] | His-torc. Ret. $/ha | Exp. Ret. $/ha | Error $E(R_i)-R_i$ $/ha | Tot. Risk $/ha | % Sys. Risk | Beta[1] | His-torc. Ret. $/ha | Exp. Ret. $/ha | Error $E(R_i)-R_i$ $/ha | Tot. Risk $/ha | % Sys. Risk |
| Wheat | 0.95* | 687 | 840 | 153 | 418 | 96.2 | 1.09* | 456 | 535 | 79 | 268 | 90.7 |
| F.Barley | 0.43* | 411 | 474 | 63 | 203 | 89.9 | 0.22* | 207 | 243 | 36 | 81 | 60.1 |
| Fld.Peas | 0.73* | 615 | 681 | 66 | 363 | 84.6 | 0.70* | 378 | 406 | 28 | 228 | 68.8 |
| Fzn.Peas | 0.98* | 774 | 859 | 85 | 454 | 91.2 | 1.35* | 609 | 621 | 12 | 372 | 80.9 |
| Fzn.Bean | 2.46* | 1572 | 1902 | 330 | 1095 | 95.0 | 4.12* | 1304 | 1549 | 245 | 984 | 93.4 |
| P.Potato | 2.14* | 2297 | 1681 | -616 | 1236 | 73.5 | 0.07 | 607 | 193 | -414 | 713 | 2.1 |
| Ryegrass | 0.84* | 641 | 764 | 123 | 408 | 87.5 | 0.77* | 311 | 428 | 117 | 250 | 68.7 |
| W.Clover | 0.40* | 618 | 452 | -166 | 265 | 63.8 | 0.15 | 366 | 219 | -147 | 191 | 17.0 |
| Gras/Clv | 1.24* | 1259 | 1046 | -213 | 589 | 89.4 | 1.28* | 776 | 598 | -178 | 365 | 78.2 |
| SheepBOR | 0.33* | 308 | 404 | 96 | 148 | 94.9 | 0.52* | 265 | 342 | 77 | 126 | 90.9 |
| Sheep PR | 0.51* | 448 | 529 | 81 | 230 | 93.8 | 0.75* | 273 | 420 | 147 | 190 | 87.8 |

1. Unweighted farm sector portfolio and non-deflated returns were used to derive these Beta coefficients. $R_f$ = $170/ha.
2. A * indicates the Beta coefficients are statistically significant at the five percent level of significance.

The results in Table 5-4 show that in all cases, the percentage of systematic risk was higher if gross revenue was used, although for the majority of activities it was still very high even with the gross margin approach. This difference in the measurement of returns was obviously one of the reasons for the difference in results between the two studies cited by Turvey and Driver.

It is believed that by using gross margins, the variability in input costs could also be accounted for in the analysis. All input items and their amount of use, such as harvesting costs, pest and disease control and weed control, are not exactly known at the start of the season. With the gross margin approach, variability in return emanates from four sources, these being input quantity and prices, and product yields and prices, whereas with the gross revenue approach only product yields and prices are sources of instability. However, the results in Table 5-4 indicate that total risk is higher with the gross revenue approach. This may be because the magnitude of the returns are higher with the gross revenue approach, as shown in Table 5-4.

The results in Table 5-4 also show that the magnitude of the error term, was greater with the gross revenue approach than with the gross margin approach, although the results were identical in indicating which activities were adequately compensated for systematic risk. Similar results are obtained when comparing gross revenue with gross margin models, using deflated models and with different farm sector portfolios (see Appendix 5-1).

Where reliable input data are available, the gross margin approach to FSCAPM analysis is theoretically more appropriate. However, if lack of input data means that the gross revenue approach is used, then the above differences between the two approaches must be kept in mind.

### 5.3.3 Deflated versus Non - deflated Models

Another difference between the previous FSCAPM studies was that Turvey and Driver (1987) used non - deflated data whereas Collins and Barry (1986) used deflated data. A comparison of these two approaches using Lincoln University Mixed Cropping Farm data is presented in Table 5-5. The preferred measure of returns, gross margins were used, and the unweighted farm sector portfolio was also used since this was favoured by the authors of these previous studies.

**Table 5-5: Deflated versus Non - deflated Gross Margin Models for Measuring Risk - Return Trade - Offs[1]**

| Activity | Non - deflated, G.M. Model | | | | | | Deflated, G.M. Model | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beta[2] | Hist. Retn. $/ha | Expt. Retn. $/ha | Error $/ha | Tot. Risk $/ha | % Syst. Risk | Beta | Hist. Retn. $/ha | Expt. Retn. $/ha | Error $/ha | Tot. Risk $/ha | % Syst. Risk |
| Wheat | 1.09* | 456 | 535 | 79 | 268 | 90.7 | 0.06 | 751 | 215 | -536 | 227 | 7.2 |
| F.Barley | 0.22* | 207 | 243 | 36 | 81 | 60.1 | 0.33 | 388 | 408 | 20 | 195 | 44.8 |
| Fld.Peas | 0.70* | 378 | 406 | 28 | 228 | 68.8 | 0.72* | 678 | 690 | 12 | 394 | 48.3 |
| Fzn.Peas | 1.35* | 609 | 621 | 12 | 372 | 80.9 | -0.24 | 991 | -7 | -998 | 364 | 17.8 |
| Fzn.Bean | 4.12* | 1304 | 1549 | 245 | 984 | 93.4 | 2.22* | 2087 | 1773 | -314 | 997 | 58.9 |
| P.Potato | 0.07 | 607 | 193 | -414 | 713 | 2.1 | 3.96* | 1387 | 3031 | 1644 | 1682 | 62.3 |
| Ryegrass | 0.77* | 311 | 428 | 117 | 250 | 68.7 | 0.85* | 517 | 785 | 268 | 445 | 50.6 |
| W.Clover | 0.15 | 366 | 219 | -147 | 191 | 17.0 | 1.12* | 744 | 983 | 239 | 435 | 68.4 |
| Grs./Clv | 1.28* | 776 | 598 | -178 | 365 | 78.2 | 1.84* | 1407 | 1503 | 96 | 697 | 70.1 |
| SheepBOR | 0.52* | 265 | 342 | 77 | 126 | 90.9 | 0.12 | 469 | 255 | -214 | 80 | 38.9 |
| Sheep PR | 0.75* | 273 | 420 | 147 | 190 | 87.8 | 0.02 | 400 | 186 | -214 | 153 | 3.7 |

1. Unweighted farm sector portfolio used as $R_m$, $R_f$ = $170/ha,
2. A * indicates the estimate is statistically significant at the five percent level of significance. The standard error of the estimates are presented in Appendix 5-2.

The results in Table 5-5 indicate that a greater number of the Beta coefficients were significant with the non - deflated model than with the deflated model. The difference in the total risk indicated by the two models was not great. The results were also different when considering which activities were compensated for systematic risk. With the non - deflated model process potatoes, white clover and ryegrass / white clover were fully compensated for systematic risk whereas with the deflated model wheat, frozen peas, frozen beans and the two sheep activities were fully compensated. What was more striking, however was that the systematic risk component of the total risk was much higher with the non - deflated model, with the exception of process potatoes and white clover.

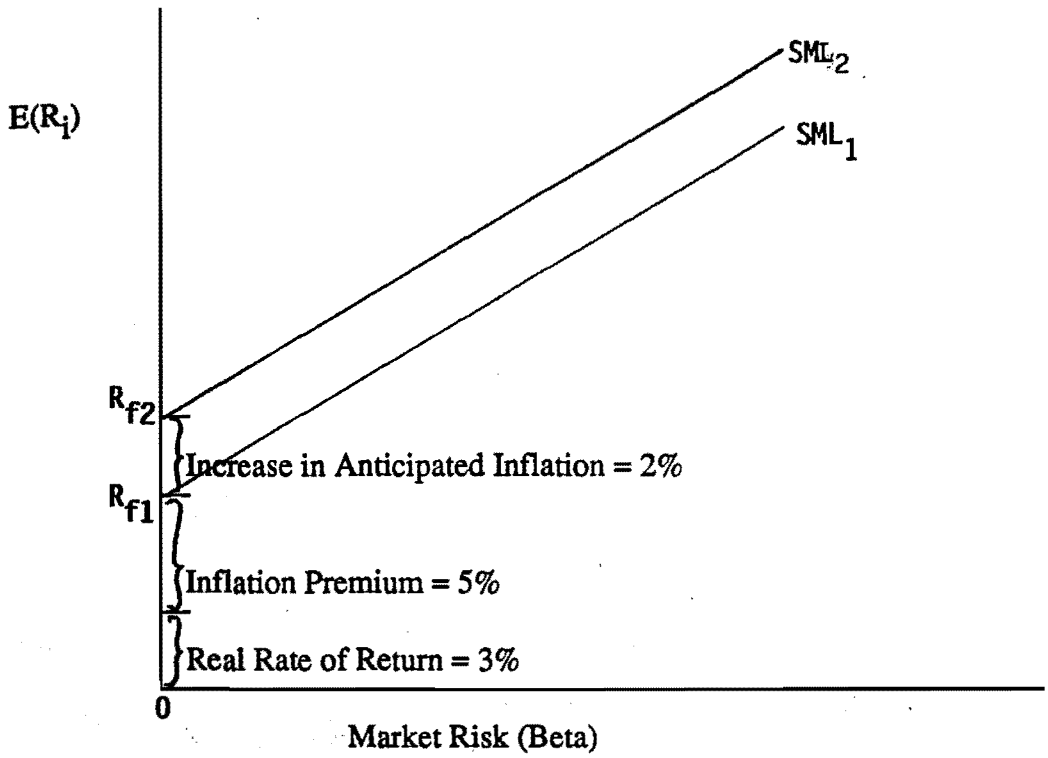
These results clearly support those obtained in the previous studies of the FSCAPM. Collins and Barry, who used deflated data, found much lower levels of systematic risk than did Turvey and Driver, who used non - deflated data. The results indicate that this is the most likely explanation for most of the big difference between the two studies rather than the farm sector portfolio used or the way the returns are measured, as cited by Turvey and Driver (1987).

The impact of inflation is an intricate issue and has not been well developed in CAPM analysis. Agricultural economists tend to deflate data for most problems, and it could be argued that analysing the 'real' variation rather than 'nominal' variation is more appropriate. Collins and Barry obviously adhere to this school of thought. However, Turvey and Driver state that inflation is not exactly predictable and can be a source of systematic risk, and therefore the data should not be deflated.

This view tends to be supported by the studies reported in the finance literature. For example, Van Horne (1986) maintains that as long as inflation is predictable, it is not a source of uncertainty, and therefore, the risk of a security can be described by its systematic and non-systematic risks, regardless of whether these risks are measured in real or nominal terms. On the other hand, uncertain inflation means the market does not anticipate changes that occur in the rate of inflation. The indices used in this study (New Zealand Farm Output Price Index and Farm Input Cost Index) tended to fluctuate markedly from period to period (see Appendix 4-3), and it could be argued that these presumably unanticipated changes were a source of uncertainty. In the finance setting, predicting the sensitivity of the return on an individual asset to unanticipated changes in inflation is very difficult, and according to Van Horne, efforts to do so often result in no additional predictive ability of the model. As noted in Section 3.3.3, studies have shown that there is a consistent lack of positive relation between asset returns and inflation (Glutekin, 1983; Solnik, 1983; and Geske and Roll, 1983).

The Risk - free asset is also expressed as a nominal rate and consists of a real rate of return and an inflation premium which is equal to the anticipated rate of inflation. As the expected rate of inflation increases, a premium must be added to the real rate of return to compensate investors for the loss of purchasing power that results from inflation (Brigham, 1986). This is illustrated in Figure 5-1.

**Figure 5-1: Security Market Line and the Impact of Inflation**




If the expected rate of inflation rose from 5 to 7 percent, this would cause the risk - free rate, $R_f$, to rise from $R_{f1}$ (8 percent) to $R_{f2}$ (10 percent). An increase in $R_f$ also leads to an increase in the rate of return on all risky assets by the same magnitude, since the inflation premium is built into the required rate of return of both riskless and risky assets. For example, the rate of return on an average stock $R_m$, increases from 12 to 14 percent, other risky securities' returns would also rise by 2 percent.

If the issue is how to derive an optimal plan which minimises risk, it seems to make sense to deflate and thereby exclude any 'common' elements and focus on 'residual' risk, as Collins and Barry did. However, on balance the CAPM literature suggests that one should not deflate for the reasons given above. In addition, if the decision is made to deflate, there is the problem of choosing an appropriate index. An aggregate inflation index may distort the raw data. In this study, it was found that deflating the data rendered many of the betas not significant.

For all these reasons, it is thought preferable to use non - deflated data, although it must be acknowledged that the issue of whether to deflate or not is critical in

FSCAPM analysis. Obviously, more research needs to be done here, and care in use and interpretation needs to be exercised.

### 5.3.4 The Farm Sector Portfolio

The discussion in Section 3.3.3 highlighted the importance of identifying an appropriate portfolio index when adopting CAPM as planning tool in agriculture. In Chapter 4, four farm sector portfolios were developed for the Lincoln University Mixed Cropping Farm. These were

a. Unweighted Index;
b. N.Z. Meat and Wool Boards' Farm Class 8;
c. N.Z. Agriculture; and
d. N.Z. Gross Agricultural Production.

Table 5-6 shows the Beta coefficients, historic mean returns, expected returns, and percent systematic risk for each of these four farm sector portfolios.

A clear observation from Table 5-6 is that the values of the non - deflated Beta coefficients show high levels of consistency for the 'N.Z. Agriculture', 'N.Z. Gross Agric. Production' and 'N.Z. Farm Class 8' farm sector portfolios. However, the values for the 'Unweighted Index' tend to differ from those for other indices. For example, the Beta values for frozen peas ranged from 3.14 to 3.53 across the three former models, whereas, the Beta value for the 'Unweighted Index' was 1.35. Apart from process potatoes and white clover, whose Beta coefficients were not statistically significant, the Beta coefficients for all other activities were a lot higher with the 'N.Z. Agriculture', 'N.Z. Gross Agricultural Production' and 'N.Z. Farm Class 8' farm sector portfolios, than with the 'Unweighted Index'.

**Table 5-6: A Comparison of the four Farm Sector Portfolios[1]**

| Activity | Historic Return | Unweighted Index $R_m$=$504.77/ha,SD=$223/ha | | | | | N.Z.Farm Class 8 $R_m$=$175.78/ha,SD=$83/ha | | | | | N.Z. Agriculture $R_m$=$176.14/ha,SD=$94/ha | | | | | N.Z.Grs.Agric.Production $R_m$=$183.35/ha,SD=$105/ha | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Beta | Expt. Retn. | Error | Systm. Risk | | Beta | Expt. Retn. | Error | Systm. Risk | | Beta | Expt. Retn. | Err- | Systm. Risk | | Beta | Expt. Retn. | Error | Systm. Risk | |
| | $/ha | | $/ha | $/ha | $/h | % | | $/ha | $/ha | $/h | % | | $/ha | $/ha | $/h | % | | $/ha | $/ha | $/ha | % |
| Fzn.Bean | 1303 | 4.12*[2] | 1549 | 246 | 919 | 93 | 8.49* | 219 | -1084 | 704 | 72 | 9.37* | 227 | -1076 | 881 | 90 | 8.29* | 280 | -1023 | 872 | 89 |
| Fzn.Peas | 609 | 1.35* | 621 | 12 | 300 | 81 | 3.53* | 190 | -419 | 293 | 79 | 3.46* | 191 | -418 | 326 | 88 | 3.14* | 212 | -397 | 330 | 89 |
| Grs/Clv. | 776 | 1.28* | 598 | -178 | 285 | 78 | 2.70* | 186 | -590 | 224 | 61 | 2.55* | 186 | -590 | 240 | 66 | 2.50* | 203 | -573 | 263 | 72 |
| Wheat | 456 | 1.09* | 535 | 79 | 243 | 91 | 2.73* | 186 | -270 | 226 | 84 | 2.69* | 186 | -270 | 253 | 94 | 2.38* | 202 | -254 | 250 | 93 |
| Ryegrass | 311 | 0.77* | 428 | 117 | 172 | 69 | 1.30 | 177 | -134 | 108 | 43 | 1.54* | 179 | -132 | 144 | 58 | 1.53* | 190 | -121 | 161 | 65 |
| Sheep PR | 273 | 0.75* | 420 | 147 | 166 | 88 | 2.07* | 182 | -91 | 172 | 91 | 1.93* | 182 | -91 | 182 | 96 | 1.67* | 192 | -81 | 175 | 92 |
| Fld.Peas | 378 | 0.70* | 406 | 28 | 157 | 69 | 1.83* | 181 | -197 | 152 | 67 | 1.83* | 181 | -197 | 172 | 75 | 1.56* | 191 | -187 | 148 | 65 |
| SheepBOR | 265 | 0.52* | 342 | 77 | 115 | 91 | 1.45* | 178 | -87 | 120 | 95 | 1.28* | 178 | -87 | 120 | 95 | 1.15* | 185 | -80 | 121 | 96 |
| F.Barley | 207 | 0.22* | 243 | 36 | 49 | 60 | 0.68* | 174 | -33 | 57 | 70 | 0.58* | 173 | -34 | 55 | 67 | 0.50* | 177 | -30 | 53 | 65 |
| W.Clover | 366 | 0.15 | 219 | -147 | 32 | 17 | 0.49 | 173 | -193 | 40 | 21 | 0.09 | 171 | -195 | 9 | 5 | 0.14 | 172 | -194 | 15 | 8 |
| P.Potato | 607 | 0.07 | 193 | -414 | 15 | 2 | -1.6 | 160 | -447 | 136 | 19 | -1.4 | 162 | -445 | 127 | 18 | -1.3 | 153 | -454 | 130 | 18 |
| TOTAL | 5552 | | 5552 | 0 | | | | 2007 | -3546 | | | | 2017 | -3535 | | | | 2157 | -3394 | | |
| MEAN | 505 | | 505 | 0 | 67 | | | 182 | -322 | 63 | | | 183 | -321 | 68 | | | 196 | -309 | 68 | |

1. Non - deflated models.
2. A * indicates the estimates are statistically significant at the five percent level of significance.

Figure 5-2 plots the return on the farm sector portfolios, $R_{m,t}$, over time for each of the portfolios. It indicates that the range in the returns on the 'Unweighted Index' was greater than the range in the returns for the other indices over this time period and that the variability in the index, $\sigma_m$, was greater over the period. Statistics in Table 5-6 confirm this. The influence of $R_m$ on the Beta coefficient can be explained by the Characteristic Line equation (Equation 3.7).

$$R_i = a_i + B_i R_m + e_i \quad \text{..........Equation 3.7}$$

where $R_i$ = return on the i'th activity;

$a_i$ = intercept term, which is a constant;

$B_i$ = Beta coefficient for activity i;

$R_m$ = return on the farm sector portfolio, M; and

$e_i$ = a random error term.

It can be seen from Equation 3.7 that the greater the range in the $R_m$ for a given range in the $R_i$, the lower the Beta coefficient will be. Figure 5-2 indicates that the range for $R_m$ using the unweighted index was much greater for the unweighted index than for the other three indices; hence the observed difference in the Beta coefficients.

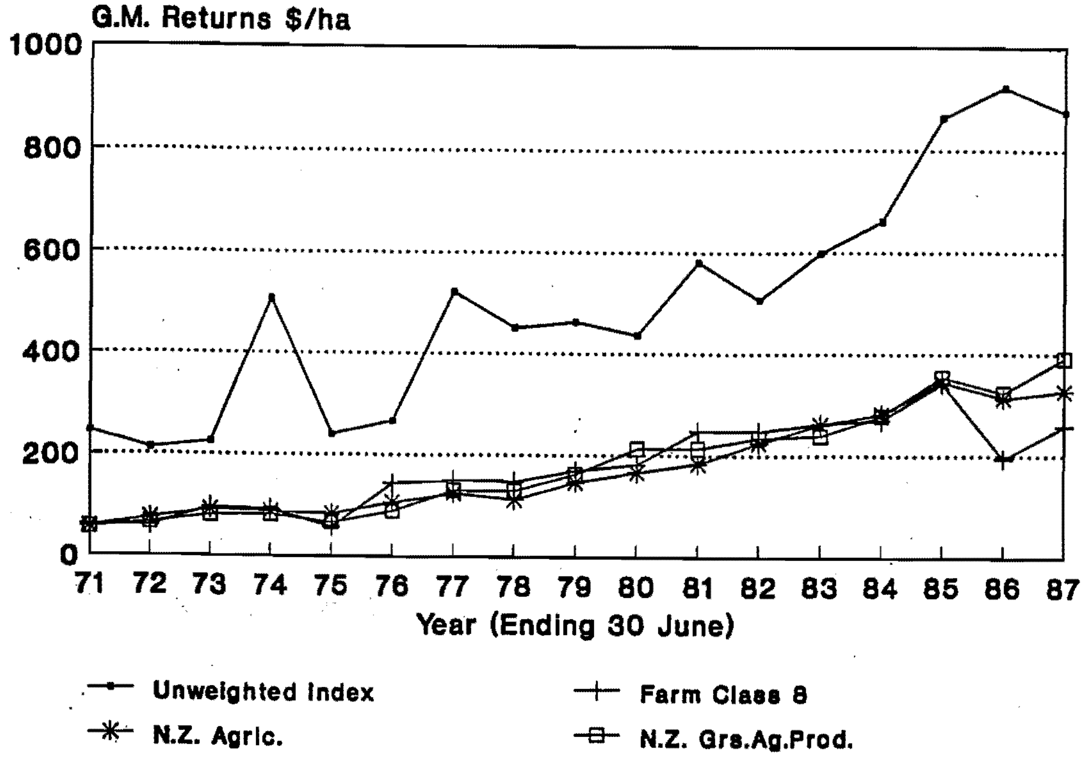
The following Beta coefficient equation (Equation 3.5) explains why a higher value of the standard deviation of returns from the market portfolio, $\sigma_m$, produces a lower Beta coefficient for a given covariance of returns between an activity and the market portfolio.

$$B_i = \frac{COV(R_i R_m)}{\sigma_m^2} \quad \text{..........Equation 3.5}$$

where $COV(R_i R_m)$ = covariance of returns between activity i and the market portfolio; and

$\sigma_m$ = standard deviation of returns from the market portfolio, M.

**Figure 5-2: Annual Returns on Farm Sector Portfolio : A Comparison of the Farm Sector Portfolios (Non - deflated Models)**




The magnitude of the Beta coefficients will influence the expected return on activities. Figure 5-3 presents a comparison of the relationship between the Beta coefficients and expected return for activities under each of the four farm sector portfolios using the Farm Sector Security Market Line. Recall from Section 3.2.1 that the equation for the Security Market Line (Equation 3.6) is

$$E(R_i) = R_f + B_i \,(E(R_m) - R_f) \quad \text{.......... Equation 3.6}$$

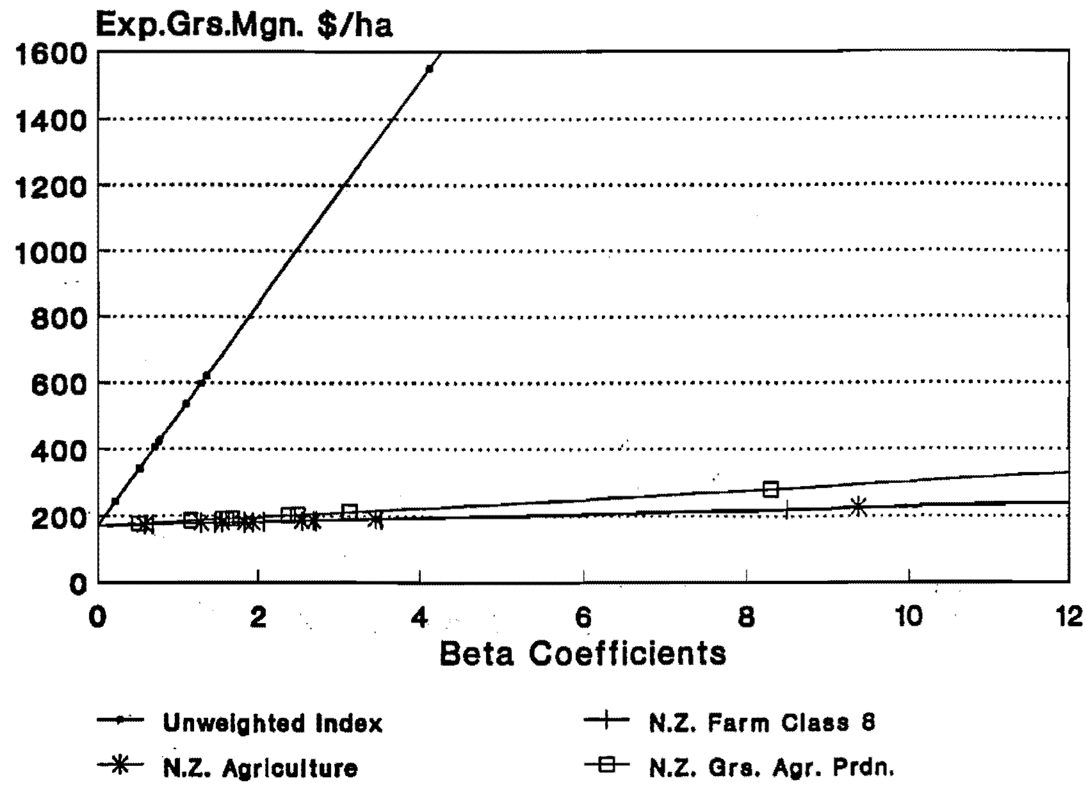
where $E(R_i)$ = expected return on an i'th activity;

$R_f$ = return on holdings of a risk - free asset;

$B_i$ = Beta coefficient for activity i; and,

$E(R_m)$ = expected return on the market portfolio, M.

**Figure 5-3: Farm Sector Security Market Lines : A Comparison of the Farm Sector Portfolios (Non - deflated Models)**




The Security Market Lines (SML) illustrate that there was marked similarity between the outcomes when 'N.Z. Agriculture' and 'N.Z. Farm Class 8' were used as farm sector portfolios. Although not shown in Figure 5-3, the 'N.Z. Gross Agricultural Production' farm sector portfolio produced a SML which was little different from these two portfolios. However, the 'Unweighted Index' produced an SML which was in striking contrast to the above three portfolios. For a given Beta coefficient, the expected return was much higher with the 'Unweighted Index' than with the other three indices.

The percent systematic risk columns in Table 5-6 show very little observable difference between the four farm sector portfolios. Hence, the choice of farm sector portfolio in Equation 3.7 to calculate the Beta coefficient does not appear to be critical when determining the proportion of systematic risk associated with each activity.

However, the 'Error' columns indicate that most of the activities under the 'Unweighted Index' had positive errors implying that the activities were undercompensated for systematic risk, whereas all activities had negative errors with the other three indices, implying that they were more than fully compensated. Undercompensation occurs when the mean historic return for an activity is lower than its expected return. Equation 3.6 illustrates the factors which will encourage a high expected return and hence undercompensation. For example, a high return on the farm sector portfolio, $R_m$, with the 'Unweighted Index' will produce high expected returns on the individual activities (Figure 5-3), and hence will encourage undercompensation. Similarly, for a given $R_m$, equation 3.6 shows that higher Beta coefficient, $B_i$, will produce a higher expected return on an activity. Table 5-6 shows that the Beta coefficients with the 'Unweighted Index' was much lower than the other three indices.

With the 'Unweighted Index', all the farm activities were included in equal proportion, and therefore some activities, which did not make up a high proportion of the New Zealand mixed cropping agriculture but had very high returns will have pushed the returns of the farm sector portfolio beyond what it might have been if an index which was weighted in terms of crop areas was used.

The return on the farm sector portfolio, $R_m$, using 'N.Z. Farm Class 8', 'N.Z. Agriculture' and 'N.Z. Gross Agricultural Production' were much lower, and despite the high betas, the 'Error' terms were negative. There was very little difference in the $R_m$ values among these three portfolios, and therefore the 'Error' terms were quite consistent across these three portfolios.

When using the 'Unweighted Index', eight of the eleven farm activities were undercompensated. However, the other three farm sector portfolios show that all the activities were more than fully compensated. Turvey and Driver (1987) got a similar result when using the 'Unweighted Index', with 22 out of 28 activities being undercompensated.

A closer scrutiny of the data in Table 5-6 (p.100) and Turvey and Driver's data indicates that the sum of the errors over all portfolio activities was zero when the 'Unweighted Index' was used, although this result did not apply when other indices were used. A more careful examination of this index is presented in Appendix 5-7, where it is mathematically proven that when an unweighted index is used, the sum of the error terms for the undercompensated activities must always equal the sum of the error terms for the overcompensated activities. This mathematical feature of the index gives some cause for concern, since it implies that if a very few activities are highly overcompensated for systematic risk and this is not counterbalanced by a very few activities which are massively undercompensated for systematic risk, then you will invariably arrive at the conclusion that most activities are not being compensated for systematic risk.

Turvey and Driver (1987) also realised that the sum of errors over all portfolio activities with 'Unweighted Index' was zero. They concluded that this illustrated that the FSCAPM efficiently redistributes the wealth of the portfolio among its elements based on their systematic risk without disrupting the mean or the risk of the portfolio, thereby enabling a comparison of the different activities in the portfolio. However, this must also imply that any risk analysis is restricted only to those activities included in the construction of the 'Unweighted' farm sector portfolio. In this study, eleven activities were used to construct of the 'Unweighted Index'. This was based on the availability of the activity gross margin data and on what has previously been grown on this property. However, a market portfolio in the context of stock market analysis represents the total economy; it is a weighted average of all quoted equities (Dobbins and Witt, 1983, p3). Such a large diversified portfolio is considered to be free of any diversifiable risk (Turvey and Driver, 1987, p389). Thus a market portfolio for a mixed cropping farm should consist of all risky activities suited to such farms and they should be weighted to represent their proportionate area. For practical purposes, this portfolio is approximated by some other portfolio, which is considered to be indicative of the performance of mixed cropping agriculture.

In the case of stock market portfolio analysis, Roll (1977) demonstrated that choice of incorrect index as proxy for the market can lead to wrong estimates of the systematic risk of individual assets and portfolios and hence result in an inappropriate estimate of the Security Market Line. In this study, the 'Unweighted Index' had Beta coefficients very different from the other indices considered, which gives cause for concern, since a misestimated Beta coefficient will result in a poor estimate of the SML and will not be helpful in selecting risk efficient farm portfolio. With a limited sized farm sector portfolio such as the 'Unweighted Index', activity Beta coefficients cannot be defined in terms of the systematic risk associated with raising that activity in an efficient well diversified market portfolio, but a limited sized farm sector portfolio may indicate the systematic risk within that limited sized portfolio only (Turvey, 1985). That is, the activity Beta coefficients reflect the systematic risk relative to the farm sector portfolio or the market index used in the model, and a different index portfolio or an index portfolio comprised of different activities would provide different Beta values (Turvey, Driver and Baker, 1988).

Table 5-7 illustrates that the magnitude and direction of compensation appears to be quite sensitive to the number of activities in the portfolio when using an unweighted index. Potatoes (Table 5-6, p100) had a low Beta coefficient and a relatively high historic mean return with high overcompensation, although its Beta coefficient was not significant. When the potato activity was removed from the portfolio, the Beta coefficients do not alter much, but the frozen peas activity changed from being marginally undercompensated to being marginally overcompensated, (Table 5-7). Thus the redistribution of wealth as stated by Turvey and Driver (1987) is among the base activities, and changes in the compensation structure occur within that set of activities only. Turvey and Driver were conscious of this and they tried to add as many activities as possible to the portfolio, in order to construct a widely diversified index, although it is arguable whether they achieved this. In addition, there is a temptation to include activities which may not be suitable for a particular farm or farm type, in order to increase the range of activities. The results in Table 5-7 show that Turvey and Driver's concern was justified. Thus it would seem prudent to search for a more appropriate index.

**Table 5-7: Sensitivity of the Unweighted Index to Portfolio Size[1]**

| Activity i | Beta $B_i$ | | Histrc. Mean $R_i$ \$/ha | Expected Return $E(R_i)$ | | Error $E(R_i) - R_i$ | |
|---|---|---|---|---|---|---|---|
| | With Pot. | No Pot. | | With Pot. \$/ha | No Potato \$/ha | With Pot. \$/ha | No Potato \$/ha |
| Wheat | 1.09 | 0.94 | 456.34 | 534.92 | 476.03 | 78.58 | 19.69 |
| F.Barley | 0.22 | 0.22 | 207.36 | 243.03 | 240.71 | 35.66 | 33.35 |
| Fld.Peas | 0.70 | 0.70 | 377.92 | 405.62 | 395.74 | 27.70 | 17.83 |
| Frz.Peas | 1.35 | 1.31 | 608.99 | 620.67 | 594.34 | 11.69 | -14.64 |
| Frz.Bean | 4.12 | 3.66 | 1303.88 | 1549.02 | 1359.06 | 245.15 | 55.19 |
| P.Potato | 0.07 | | 607.43 | 192.81 | | -414.62 | |
| Ryegrass | 0.77 | 0.67 | 311.09 | 427.61 | 386.74 | 116.51 | 75.65 |
| W.Clover | 0.15 | 0.20 | 365.73 | 218.73 | 235.55 | -147.00 | -130.18 |
| Rgrs/Clv | 1.28 | 1.20 | 775.70 | 598.01 | 558.66 | -177.69 | -217.04 |
| SheepBOR | 0.52 | 0.45 | 265.37 | 342.38 | 317.24 | 77.01 | 51.87 |
| SheepPR | 0.75 | 0.65 | 272.63 | 419.68 | 380.93 | 147.04 | 108.29 |
| Total | | | 5552.48 | 5552.48 | 4945.00 | 0.00 | 0.00 |
| $R_m$, \$/ha | | | | 504.77 | 449.55 | | |

1. Non - deflated, Gross Margin Model, $R_f$ = \$170.00/ha

The above results however, depend not only on the number of activities in the portfolio, but also on the type of activities. Generally, activities that have very low Beta coefficients with high historic mean returns will exhibit high overcompensation for a given index. On the other hand, extreme undercompensation is more likely to occur when activities have low historic mean returns and high Beta coefficients, for a given $R_m$. Turvey and Driver may have arrived at a different conclusion had they not included the 'Swine finish' activity in their portfolio, since this had a very low Beta coefficient, and the values of the error terms for the other activities will change when an 'extreme' activity is deleted from the portfolio.

As can be seen from Table 5-6 (p. 100), the higher returns on the farm sector portfolio, $R_m$, when the 'Unweighted Index' is used, increases the expected returns on the activities and therefore the activities have a greater chance of being undercompensated than in the case of a more diversified index with a lower $R_m$, such as 'Farm Class 8'. For example, the return on the farm sector portfolio, $R_m$, for 'Farm Class 8' was only $175.78 per hectare, compared to $504.77 for the 'Unweighted Index'. The sensitivity of the error term to different $R_m$ values is presented in Table 5-8, where the value of $R_m$ for the 'N.Z. Farm Class 8' was raised from its original value of $175.78 per hectare to $504.77 per hectare, and then to $703.14 per hectare.

A comparison of results in Table 5-6 and Table 5-8 shows that when the value of the farm sector portfolio ($R_m$) was increased the Beta coefficients decreased, the number of activities that were undercompensated increased and the total error coefficient changed from -$3545.90 in Table 5-6, to -$927.53 and -$532.88 in Table 5-9. However, the systematic and non - systematic risk coefficients remained unchanged, as this calculation is determined by the correlation coefficients, rather than the market index.

Above discussions show that the choice of the farm sector portfolio is crucial in FSCAPM analysis. The 'Unweighted Index' which has been used in studies to date does not seem appropriate and an alternative well diversified portfolio which is appropriately weighted is required. The 'Farm Class 8', 'N.Z. Agriculture', and 'N.Z Gross Agricultural Production' were introduced in an attempt to obtain a widely diversified portfolio, analogous to the stock market index, and the results indicated that there was very little difference between these three indices. The problem of using aggregate data (highlighted in Section 4.2.1) would suggest that 'Farm Class 8' may have some limitations. However, it is a well diversified index, which is easy to calculate.

**Table 5-8: Sensitivity of the FSCAPM to alternative values of the Farm Sector Portfolio[1]**

**Farm Class 8, $R_m$ = \$504.77 per hectare[2]**

| Asset i | Beta $B_i$ | Histrc. Mean $R_i$ \$/ha | Corrl. Coeff. $r_{im}$ | Expct. Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systm. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 0.95 | 456.34 | 0.844 | 488.02 | 31.68 | 268.17 | 41.95 | 226.22 |
| F.Barley | 0.24 | 207.36 | 0.697 | 249.47 | 42.11 | 81.05 | 24.52 | 56.53 |
| Fld.Peas | 0.64 | 377.92 | 0.665 | 383.47 | 5.55 | 228.22 | 76.38 | 151.85 |
| Frz.Peas | 1.23 | 608.99 | 0.789 | 581.85 | -27.14 | 371.48 | 78.52 | 292.96 |
| Frz.Bean | 2.96 | 1303.88 | 0.715 | 1160.03 | -143.84 | 984.40 | 280.15 | 704.24 |
| P.Potato | -0.57 | 607.43 | 0.190 | -20.66 | -628.09 | 712.58 | 576.95 | 135.63 |
| Ryegrass | 0.45 | 311.09 | 0.430 | 321.26 | 10.17 | 250.06 | 142.47 | 107.59 |
| W.Clover | 0.17 | 365.73 | 0.211 | 226.68 | -139.05 | 190.84 | 150.52 | 40.31 |
| Rgrs/Clv | 0.94 | 775.70 | 0.613 | 484.68 | -291.01 | 365.04 | 141.20 | 223.85 |
| SheepBOR | 0.50 | 265.37 | 0.950 | 338.80 | 73.43 | 126.43 | 6.36 | 120.07 |
| SheepPR | 0.72 | 272.63 | 0.905 | 411.30 | 138.66 | 189.63 | 17.99 | 171.64 |
| Total | | 5552.44 | | 4624.90 | -927.53 | 3767.9 | 1537.0 | 2230.9 |

**Farm Class 8, $R_m$ = \$703.14 per hectare[3]**

| Asset i | Beta $B_i$ | Histrc. Mean $R_i$ \$/ha | Corrl. Coeff. $r_{im}$ | Expct. Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systm. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 0.68 | 456.34 | 0.844 | 533.58 | 77.24 | 268.17 | 41.95 | 226.22 |
| F.Barley | 0.17 | 207.36 | 0.697 | 260.86 | 53.50 | 81.05 | 24.52 | 56.53 |
| Fld.Peas | 0.46 | 377.92 | 0.665 | 414.05 | 36.13 | 228.22 | 76.38 | 151.85 |
| Frz.Peas | 0.88 | 608.99 | 0.789 | 640.85 | 31.86 | 371.48 | 78.52 | 292.96 |
| Frz.Bean | 2.12 | 1303.88 | 0.715 | 1301.86 | -2.01 | 984.40 | 280.15 | 704.24 |
| P.Potato | -0.41 | 607.43 | 0.190 | -47.98 | -655.41 | 712.58 | 576.95 | 135.63 |
| Ryegrass | 0.32 | 311.09 | 0.430 | 342.93 | 31.83 | 250.06 | 142.47 | 107.59 |
| W.Clover | 0.12 | 365.73 | 0.211 | 234.79 | -130.93 | 190.84 | 150.52 | 40.31 |
| Rgrs/Clv | 0.68 | 775.70 | 0.613 | 529.76 | -245.93 | 365.04 | 141.20 | 223.85 |
| SheepBOR | 0.36 | 265.37 | 0.950 | 362.98 | 97.61 | 126.43 | 6.36 | 120.07 |
| SheepPR | 0.52 | 272.63 | 0.905 | 445.87 | 173.23 | 189.63 | 17.99 | 171.64 |
| Total | | 5552.44 | | 5019.55 | -532.88 | 3767.9 | 1537.0 | 2230.9 |

1. Gross Margin, Non - deflated model, $R_f$ = \$170.00 per hectare.
2. Each $R_{m,t}$ value for 'Farm Class 8' was multiplied by 2.8715 to get a $R_m$ value of \$504.77 per hectare, to make the value equal to the $R_m$ value obtained with the 'Unweighted Index'.
3. Each $R_{m,t}$ value for 'Farm Class 8' was multiplied by 4 to get a $R_m$ value of \$703.14 per hectare, to make the value higher than the $R_m$ value obtained with the 'Unweighted Index'.

### 5.3.5 Sensitivity to Risk - Free Rate

Since the risk - free asset is not required when the characteristic line is used to calculate the Beta coefficients, it does not influence the Beta coefficient. However, when calculating the expected returns, using the FSCAPM equation (Equation 3.6), the estimation of the return on the risk - free asset is necessary. The results in Table 5-9 below, show that although the expected returns for the activities alter with changes in the value of the risk-free rate, the expected returns appear not to be very sensitive to the risk-free rate. As was stated in Chapter 4, the consultants' estimates of the rental value of land for this mixed cropping farm ranged from $150 to $190 per hectare. The median value of $170 per hectare was used throughout this study. Thus, the sensitivity test in Table 5-9 used $150, $170 and $190 per hectare as the risk - free rate.

**Table 5-9: Sensitivity of FSCAPM to Alternative Values of Risk - Free Asset ($R_m$ = Farm Class 8, Non - deflated, Grs. Margin Models[1])**

| Activity | Historic Return $R_i$ $/ha | Beta | Expected Returns $E(R_i)$, Gr.Mgn.,$/ha | | | Error, $/ha $E(R_i) - R_i$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | Risk-free Rate $/ha | | | Risk- free Rate $/ha | | |
| | | | 150 | 170 | 190 | 150 | 170 | 190 |
| Wheat | 456 | 2.73*[2] | 220 | 186 | 151 | -236 | -270 | -305 |
| F.Barley | 207 | 0.68* | 168 | 174 | 180 | -39 | -33 | -27 |
| Fld.Peas | 378 | 1.83* | 197 | 181 | 164 | -181 | -197 | -214 |
| Fzn.Peas | 609 | 3.53* | 241 | 190 | 140 | -368 | -419 | -469 |
| Fzn.Bean | 1303 | 8.49* | 369 | 219 | 69 | -934 | -1084 | -1234 |
| P.Potato | 607 | -1.64 | 108 | 161 | 213 | -499 | -446 | -394 |
| Ryegrass | 311 | 1.30 | 183 | 178 | 172 | -128 | -133 | -139 |
| W.Clover | 366 | 0.49 | 163 | 173 | 183 | -203 | -193 | -183 |
| Grs/Clv. | 776 | 2.70* | 220 | 186 | 152 | -556 | -590 | -624 |
| SheepBOR | 265 | 1.45* | 187 | 178 | 169 | -78 | -87 | -96 |
| SheepPR | 273 | 2.07* | 203 | 182 | 161 | -70 | -91 | -112 |

1. Sensitivity for Deflated G.M. models is presented in Appendix 5-8.
2. A * indicates the estimate is statistically significant at the five percent level of significance.

With a constant return on the market index, as in Table 5-9, it can be demonstrated using the FSCAPM equation (Equation 3.6) that the expected return on an activity is influenced by its Beta - risk coefficient and the risk - free asset. The results in Table 5-9 indicate that when the Beta coefficient is greater than one, an increase in the risk - free rate decreases the expected return. However, when the Beta coefficient is less than one, an increase in the risk - free rate increases the expected return. For example, with wheat (Beta = 2.73) an increase in the risk - free rate from $170 to $190 (11.8 percent) decreases the expected return from $186 to $151 per hectare, which is a 19 percent decrease. However, with feed barley (Beta = 0.68) the same increase in the risk - free rate increases the expected return from $174 to $180 per hectare, a 3 percent increase. It can be observed from Table 5-9 that the greater the Beta coefficient the greater is the change in the expected return for an activity.

Recall from Section 5.3.4 that when 'N.Z. Farm Class 8' was used as the farm sector portfolio, all the activities had negative error coefficients, i.e. all the activities were fully compensated for systematic risk. Results in Table 5-9 show that when the risk - free rates were altered, a small change in the activity error coefficients occured, but they all remained negative. Hence, the results from this model do not appear to be unduly sensitive to changes in the risk - free rate.

### 5.3.6 Summary

The results have shown that the Beta coefficients for non - deflated models were, in general, statistically significant and positive. These positive coefficients indicate that systematic risk was present. The same result was observed for the deflated models, although very few of these estimates were significant.

Turvey and Driver's gross revenue, non - deflated approach was compared to Collins and Barry's gross margin, deflated approach, using the Lincoln University Mixed Cropping Farm data. The results using the Turvey and Driver approach showed that the ratio of systematic to non - systematic risk was very high. Conversely, when the Collins and Barry model was used, the percentage of systematic risk was found to be low, although the results in this study were not found to be as low as of those of Collins and Barry. Therefore the ratio of systematic to non - systematic risk was very much dependent on whether the returns were deflated or not, and on how the returns were measured. The Beta coefficients were also sensitive to these two approaches.

This study examined the impact of inflation, how the returns are to be measured, and the sensitivity of the FSCAPM to alternative farm sector portfolios and to the risk - free rate. The gross revenue approach indicated a higher percentage of systematic risk for the activities, than did the gross margin approach. It was suggested that where reliable input data are available the gross margin approach is theoretically more appropriate, as it can account for the variability in input costs.

The Beta coefficients and the amount of systematic risk present in the system very much depended on whether the returns were deflated or not. Although deflating is common in agricultural economic studies, arguments can be advanced from the finance literature which supports the use the non - deflated data, and this later approach is used in this study. However, since the issue is quite critical, it is recommended that more research needs to be done here.

The 'Unweighted Index' used in previous studies as the farm sector portfolio was of some concern to the researchers. This study justified this concern. The unweighted index did not include all the risky mixed cropping activities and the proportion of each activity in the farm sector portfolio did not reflect the proportion of that activity in comparison to other mixed cropping activities. It was therefore felt that this index was more likely to lead to wrong estimates of the Beta coefficients, and affect the selection of risk efficient farm portfolio. Some very high return activities which did not make up a high proportion of mixed cropping agriculture influenced the return of the farm sector portfolio, $R_m$, a great deal, when the 'Unweighted Index' was used. These high $R_m$

values appear to have reduced the Beta coefficients, and led to the conclusion that many of the activities were undercompensated for systematic risk, when other farm sector portfolios with much lower $R_m$ values showed that all the activities were fully compensated.

It was mathematically proven that when an unweighted index is used, the error terms always sum to zero. When 'N.Z. Farm Class 8', 'N.Z. Agriculture', and 'N.Z. Gross Agricultural Production' were introduced to get a widely diversified and a more representative farm sector portfolio, very little difference was found between them. Although the 'N.Z. Farm Class 8' was calculated from aggregate data and was not specifically based on the resources of the Lincoln University Mixed Cropping Farm, it was preferred over the other indices available as the appropriate farm sector portfolio for this property, although it was not ideal. The value of the risk - free asset did not seem to influence the results from the model a great deal.

In the following section the risk - return relationship, the percentage of systematic risk and the levels of compensation for this systematic risk will be calculated and discussed in more depth for the Lincoln University Mixed Cropping Farm using the preferred model, which is the non - deflated, gross margin, N.Z. Farm Class 8 variant of Farm Sector Capital Asset Pricing Model.

## 5.4 Risk Analysis for the Lincoln University Mixed Cropping Farm Using the Preferred Farm Sector Capital Asset Pricing Model

Activity Beta coefficients and expected gross margin returns per hectare for the Lincoln University Mixed Cropping Farm using the preferred model are shown in Table 5-10.

**Table 5-10: Risk - Return Measures for the Lincoln University Mixed Cropping Farm Using the FSCAPM[1]**

**Model = Non - deflated, Gross Margin, $R_m$ = Farm Class 8, $R_f$ = \$170/ha**

| Asset<br>i | Beta<br>$B_i$ | Histor. Mean<br>$R_i$<br>\$/ha | Corr. Coef.<br>$r_{im}$ | Exptd. Return<br>$E(R_i)$<br>\$/ha | Error<br>$E(R_i)$-$R_i$<br>\$/ha | Total Risk<br>$\sigma_i$<br>\$/ha | Nonsyst. Risk<br>$\sigma_i(1-r_{im})$<br>\$/ha | Systm. Risk<br>$r_{im}\sigma_i$<br>\$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.73*[2] | 456.34 | 0.844 | 185.77 | -270.58 | 268.17 | 41.95 | 226.22 |
| F.Barley | 0.68* | 207.36 | 0.697 | 173.94 | -33.42 | 81.05 | 24.52 | 56.53 |
| Fld.Peas | 1.83* | 377.92 | 0.665 | 180.58 | -197.34 | 228.22 | 76.38 | 151.85 |
| Frz.Peas | 3.53* | 608.99 | 0.789 | 190.42 | -418.57 | 371.48 | 78.52 | 292.96 |
| Frz.Bean | 8.49* | 1303.88 | 0.715 | 219.08 | -1084.79 | 984.40 | 280.15 | 704.24 |
| P.Potato | -1.64 | 607.43 | 0.190 | 160.55 | -446.88 | 712.58 | 576.95 | 135.63 |
| Ryegrass | 1.30 | 311.09 | 0.430 | 177.50 | -133.59 | 250.06 | 142.47 | 107.59 |
| W.Clover | 0.49 | 365.73 | 0.211 | 172.81 | -192.92 | 190.84 | 150.52 | 40.31 |
| Rgrs/Clv | 2.70* | 775.70 | 0.613 | 185.60 | -590.10 | 365.04 | 141.20 | 223.85 |
| SheepBOR | 1.45* | 265.37 | 0.950 | 178.37 | -87.00 | 126.43 | 6.36 | 120.07 |
| SheepPR | 2.07* | 272.63 | 0.905 | 181.96 | -90.67 | 189.63 | 17.99 | 171.64 |

1. Gross Margin, non - deflated, N.Z. Farm Class 8 variant of FSCAPM used. $R_f$ = \$170/ha.
2. A * indicates the estimate was statistically significant at the five percent level of confidence.

The estimated Beta coefficients range from a low of 0.68 for feed barley activity to a high of 8.49 for frozen beans. The Beta coefficients for three activities were statistically not significant. Most activities have Beta coefficients greater than one. This implies that each extra one percent rise in the returns on the market index results in a greater than one percent rise in the returns on the activity. This however, also implies that these high Beta activities have standard deviations greater than one times the standard deviation of the market portfolio.

The relationship between an activity's total risk, $\sigma_i$, the total risk of the farm sector portfolio, $\sigma_m$, and the correlation coefficient, $r_{im}$, in generating Beta coefficients is shown in Table 5-10.

The standard deviations of activity gross margins are given in the total risk column in Table 5-10. This is broken down further into their systematic risk ($r_{im}\sigma_i$) and nonsystematic risk ($(1-r_{im})\sigma_i$) components. Most activities are highly correlated with the returns on the market portfolio; for instance, the mean $r_{im}$ value for those activities with significant Beta coefficients is 0.77. All of these significant Beta risk activities have $r_{im}$ values greater than 0.61. Hence, all these activities show a high degree of systematic risk relative to non-systematic risk. For instance, the standard deviation of returns for wheat is \$268.17 per hectare. With a $r_{im}$ value of 0.844 the diversifiable portion of this risk is only \$41.95 per hectare. This implies that diversification strategies may not be effective, because wheat is so highly correlated with the farm sector portfolio. These results are similar to those which Turvey and Driver (1987) observed for Ontario farm activities.

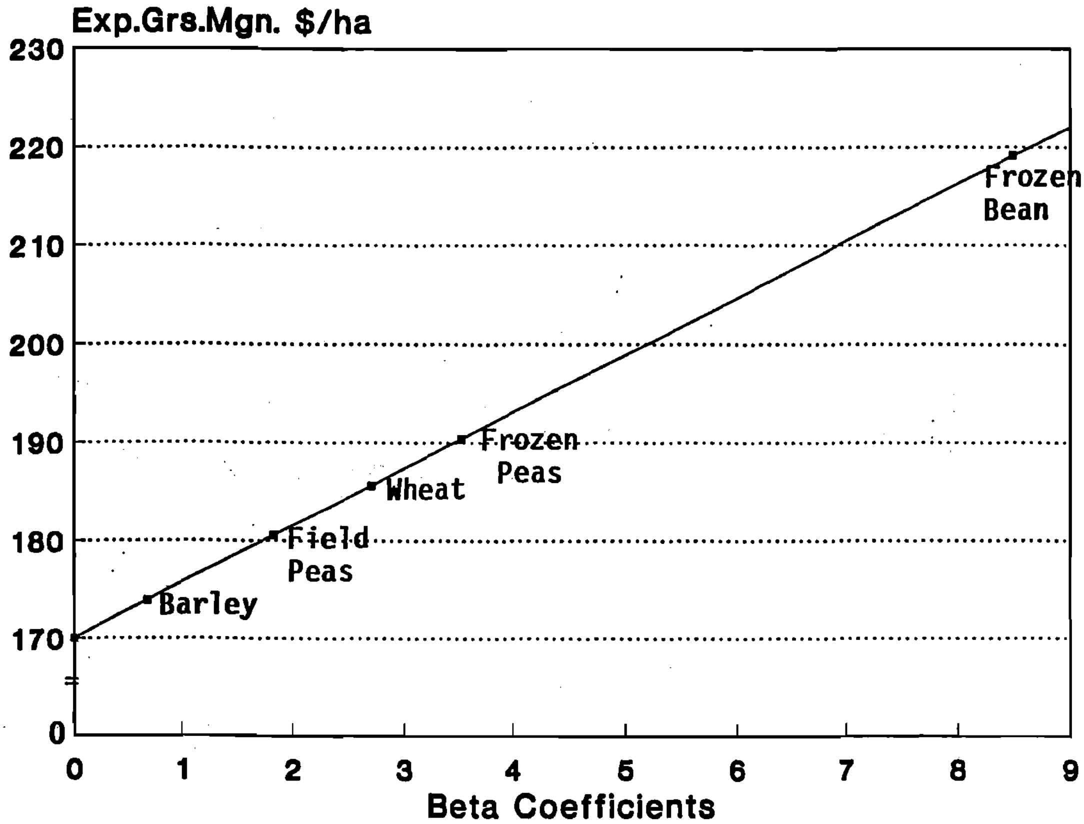
The risk - free asset, $R_f$, is the rental value of land. It is assumed that the farmer could rent out his land for a certain payment of \$170.00 per hectare. The return on the farm sector portfolio, $R_m$, is the mean gross margin per hectare on the farm sector portfolio over the 17 year time horizon (\$175.78 per hectare). The return on the $i^{th}$ farm activity, $R_i$, is the mean return over the entire time period. The equation for the Security Market Line, which generated the expected activity returns to systematic risk, $E(R_i)$, according to Equation 3.6, then becomes

$$E(R_i) = \$170.00 + B_i\ (\$175.78 - \$170.00)$$

The 'Error' column in Table 5-10 shows that all the activities had negative error terms, i.e. $R_i$ was greater the $E(R_i)$. This implies that all the activities were being fully compensated relative to the amount of systematic risk in the system.

The Security Market Line for the Lincoln University Mixed Cropping Farm is shown in Figure 5-4.

**Figure 5-4: Farm - Sector Security Market Line for the Lincoln University Mixed Cropping Farm ($R_m$ = Farm Class 8, Non-deflated Model)**

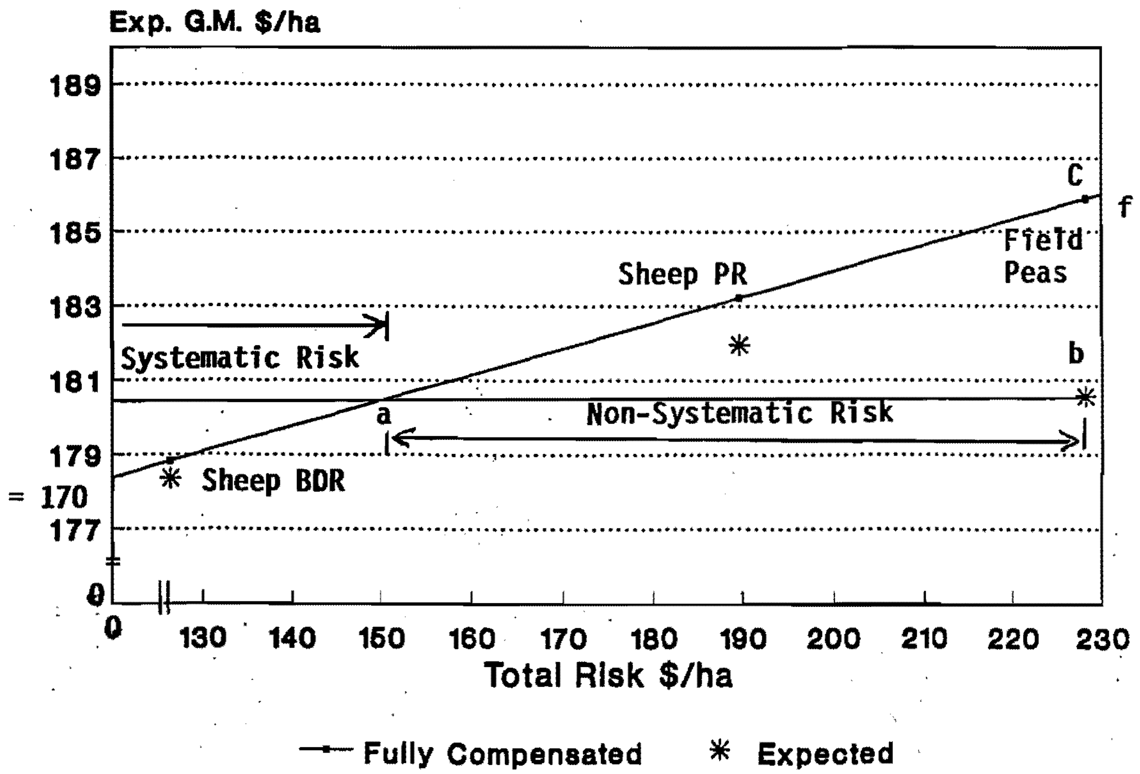



The Security Market Line in Figure 5-4 has Beta coefficients for process potato, ryegrass and white clover activities set at zero, since their Beta coefficients were not significant (see Table 5-10). Thus, their expected gross margin ($E(R_i)$) is equal to $170.00 per hectare. The Beta coefficients for process potato and white clover were also not significant at the ten percent level of confidence. The five percent level of confidence was used throughout this thesis. The graph in Appendix 5-9, where the actual Beta coefficients for the non - significant activities were used, show that the line is not different from that in Figure 5-4.

The Security Market Line in Figure 5-4 illustrates the relationship between expected return and Beta risk coefficients. That is, as Beta increases so does expected return. Process crop activities such as frozen beans, B = 8.49, and frozen peas, B = 3.53, have higher values of $E(R_i)$ than wheat, B = 2.73, or feed barley, B = 0.68. The associated gross margin return for frozen beans, which is 8.49 times as risky as the farm sector portfolio, would expect a gross margin return of $219.08, whereas feed barley, which is only 0.68 times as risky as the farm sector portfolio, expects a return of only $173.94 per hectare.

Figure 5-5 illustrates the systematic and non - systematic components of an activity's total risk and how this is related to the Capital Market Line.

**Figure 5-5: The Farm Sector Capital Market Line for the Lincoln University Mixed Cropping Farm (Farm Class 8, Non - deflated Model)**




Recall from Section 3.2.1 that the CML indicates the expected return - standard deviation of returns tradeoff. The graph represented by the line F - f in Figure 5-5 plots the expected returns if all of the risk was systematic. The total risk associated with the field peas activity is $228.22 (point b) and its systematic risk is $151.85 (point a). The distance along the line segment from X = 0 to point a is the systematic risk of the field peas activity and the line segment ab is the non - systematic risk. The sum of the two segments is equal to the activity's total risk. However, if this farm sector portfolio was in equilibrium then all of the total risk would be systematic. Hence, the expected return to the field peas activity would be $185.90 which corresponds with an activity Beta coefficient of 2.75. This is represented by point c in Figure 5-5.

The expected return for accepting the level of systematic risk indicated above is $180.58. This amount contrasts with the actual observed returns to the field peas activity of $377.92 (see Table 5-10). The dollar difference between the actual return and the expected return is $197.34 per hectare. This indicates that the activity was more than fully compensated for the level of systematic risk it had. Table 5-10 indicates that this result was general with all the activities analysed.

This section on the application of the FSCAPM has shown that the Lincoln University Mixed Cropping Farm activities generally have Beta coefficients greater than one. This implies that each extra one percent rise in the returns on the market index results in a greater than one percent rise in the returns on the activity. The analysis has also shown that most of the activities have a high degree of systematic risk relative to non - systematic risk. This suggests that the diversification strategies may not be effective. However, only non - deflated data were used, and diversification opportunities may be suggested by a deflated data set. The analysis also revealed that all the farm activities were fully compensated for systematic risk, when 'Farm Class 8' was used as the market portfolio. This was expected, since this farm would easily fall in the top ten percent of the New Zealand mixed cropping farms. It has a good resource base, is highly mechanised, partly irrigated and has very skilled and knowledgeable management and staff. However, as was pointed out in Section 5.3.4 that this conclusion could alter if a different market index was used.

The Beta coefficients could be used for portfolio planning by farmers. Since these coefficients are a relative measure of the riskiness of a farm activity with respect to the riskiness of some diversified portfolio, activity Beta coefficients provide important risk information. A farm manager can first evaluate a list of Beta coefficients, standard deviations and revenues such as those presented in Table 5-10. This table provides all of the relevant risk - return information needed to make enterprise choices. Once a decision has been made with respect to which enterprises are to be included in the farm portfolio, proportional areas can than be determined. These proportions would be based on the amount of systematic risk the farmer wants in his portfolio and on the compensatory revenues for holding this risk. Ultimately, the selection would be based on the farmer's attitude toward risk as well as on the feasibility of the portfolio, given available resources.

However, it should be noted that this model was developed specifically for the Lincoln University Mixed Cropping Farm. Although 'Farm Class 8' could be used as a farm sector portfolio for any New Zealand mixed cropping farm, the return on individual farm activities and the risk - free rate were specific to this farm unit.

# Chapter 6

# Summary and Implications of Study

## 6.1 Summary

The primary aim of this study was to examine the feasibility and desirability of using capital asset pricing theory to assist farmers in making short term tactical decisions, especially in the context of New Zealand mixed cropping agriculture. There were three specific objectives. The first of these was to review the development of the literature on the appropriate choice of a set of farm activities in a risky environment, with a view to evaluating the claim that the concept of systematic risk, and the single - index models which emanate from it, offers additional insights over more traditional approaches. The second objective was to evaluate the feasibility of using a specific single - index model known as the Capital Asset Pricing Model for the analysis and evaluation of systematic risk in tactical farm planning, and the final objective was to apply this concept to an appropriate New Zealand farming situation in order to evaluate whether the use of this technique is likely to be feasible in practice.

A conceptual framework for the analysis of agricultural risks was developed. The concept of Bernoullian Utility was discussed, and the various utility measurement techniques were reviewed. It was noted that the mean - variance efficiency criterion was able to discriminate between the allocation of resources for a unique or fixed resource base, and therefore, was appropriate for this study.

Farm management approaches to planning under a risky and uncertain environment were reviewed. These included systems simulation, quadratic risk programming, a linear programming - risk simulator, minimisation of total absolute deviations, the focus - loss model, and stochastic programming. It was concluded that it was appropriate to evaluate a single - index portfolio model known as the Capital Asset Pricing Model (CAPM) further. This model is able to incorporate the concepts of systematic and non - systematic risk, and can be used to determine whether on - farm diversification activity is appropriate or not, and whether activities are being fully compensated for systematic, or non - diversifiable, risk. In addition, the computational requirements of the model are much less complex than those for more sophisticated models.

This model was discussed in greater depth, and the agricultural adaptation of it, the Farm - Sector Capital Asset Pricing Model (FSCAPM) was also reviewed. Variations of the FSCAPM were then generated, using four different farm sector portfolios (or market indices), two alternative measures of return on activities, three different levels of risk - free rate, and both deflated and non - deflated data. These models were developed for a Canterbury mixed cropping farm situation.

These empirical models were then evaluated. The stability and the statistical reliability of the Beta coefficients generated by the various models were tested. The approaches to FSCAPM taken in the previous studies were reviewed and compared on this common data base. The alternative measures of activity returns, the impact of deflating data, the use of alternative farm sector portfolios and sensitivity to risk - free rates were evaluated. Finally, the preferred model was used for risk analysis on the Lincoln University Mixed Cropping Farm data.

It was concluded that the model had potential for assisting farmers with tactical diversification decisions, although some concerns about its use emerged. These centred on the stability of the model and conclusions emanating from it.

## 6.2 Principal Findings and Implications of Study

Several observations emerged from the study. These findings and their implications are as follows:

1) The Beta coefficients with non - deflated models were statistically significant. The principal implication of this was that it was possible to construct a FSCAPM with non - deflated data, using the principles of the capital asset pricing model (CAPM), and to separate the systematic component from a farm activity's total risk. Unfortunately, this was not possible with the deflated data, since many of the Beta coefficients were not statistically significant.

2) The Beta coefficients, and the systematic risk coefficients were very dependent on whether the returns were deflated or not, with the two approaches yielding contradictory results. The non -deflated models showed a high degree of systematic risk, implying that off - farm diversification may be a more appropriate strategy than on - farm diversification. On the other hand, the deflated models showed that both systematic and non - systematic risks were present, implying that both on - farm and off - farm diversification may be appropriate. Hence, the CAPM predictions on whether on - farm or off - farm diversification is appropriate hinge very much on whether data is deflated or not. Studies reported in the finance literature support the view that the data should not be deflated, although agricultural economists traditionally deflate their data. This study showed that this was a critical issue.

3) The gross margin approach yielded different results to the gross revenue approach, although these differences were not marked. It was concluded that the gross margin approach, unlike the gross revenue approach, was able to account for the variability in input costs in the analysis. The 'rate of return' approach was ruled out due to lack of data, and the more complicated calculations involved.

4) It was observed that the farm sector portfolio 'New Zealand Agriculture', which is analogous to the stock market index, generated Beta coefficients and systematic risk coefficients that were very similar to those derived by using New Zealand Gross Agricultural Production, which is analogous to a GNP proxy, and the New Zealand Meat and Wool Boards' Economic Service's Farm Class 8, which was a proxy thought to be appropriate for mixed cropping agriculture. However, the 'Unweighted Index' which was used in the previous studies using the FSCAPM, yielded very different results. The returns on the 'Unweighted Market Index' was a lot higher than they were with the other indices, and the variability in returns was also much greater. This gave higher expected returns, and much lower Beta coefficients with the 'Unweighted Index'. Thus, the results this index generated regarding the levels of compensation for systematic risk were different to those from the other indices. It was mathematically proven that when the compensation structure is calculated with an unweighted index, the 'Error' terms always sum to zero, which can lead to bias in the results if there are outlier activities in the portfolio. For these reasons, and due to the simple calculations involved and the easy availability of data, the 'Farm Class 8' was preferred as a farm sector portfolio (the market index) for N.Z. mixed cropping agriculture. It may thus be possible to use other N.Z. Meat and Wool Boards' Economic Service Farm Classes as farm sector portfolios when analysing other farm types in New Zealand. However, one reservation with this alternative index is that it uses aggregate rather than case farm data.

5) The CAPM analysis using 'Farm Class 8' as the market portfolio showed that the farm activities on the Lincoln University Mixed Cropping Farm were being more than fully compensated relative to the amount of systematic risk in the system. This reflects the well developed state of this farm, good soil type, and highly skilled and knowledgeable management and staff. Turvey and Driver (1987) may have arrived at a similar conclusion for their data had they not used an unweighted market index.

The Lincoln University Mixed Cropping Farm activities displayed high levels of systematic risk, implying that off - farm diversification may be more appropriate than on - farm diversification.

## 6.3 Limitations of the Study and Inferences For Further Research

A number of limitations emerged from this study. These have implications for the application of the CAPM to the agricultural situation, and for further research. These limitations and their implications are as follows:

1) The Beta coefficients and the systematic risk coefficients were very sensitive to whether the activity returns were deflated or not. Hence, the choice of an on - farm or off - farm diversification strategy was very much dependent on whether the returns were deflated. In this study, the deflated models did not perform well, as many of the Beta coefficients they generated were not significant. However, this may be due to the crude inflation indices used. Although the use of non - deflated models was preferred in this study, it would seem prudent to conduct further research on this issue, since it obviously has a critical influence on the model results.

2) An attempt was made in this study to develop a suitable proxy for New Zealand mixed cropping agriculture to use as a farm sector portfolio (market index) in the FSCAPM analysis. Three of the proxies, 'N.Z. Agriculture', 'N.Z. Gross Agricultural Production' and 'Farm Class 8' were based on aggregate statistics, while the 'Unweighted Index' used actual field data. However, the 'Unweighted Index' proved unsatisfactory, as it only contained a subset of all the possible mixed cropping farm activities and gave dubious results regarding the compensation structure for the different farm activities.

Although 'N.Z. Agriculture', 'N.Z. Gross Agricultural Production' and 'Farm Class 8' gave very similar results, and appeared to be an obvious improvement over the unweighted index which had been used in previous studies, these indices are based on aggregate data which may reduce the variability of the index below that which would apply in an on - farm situation. Since, the choice of a suitable proxy for this index is crucial to the successful adaptation of CAPM to agriculture, it would seem advisable to conduct further research on this with a view to determining whether it is possible to construct an on - farm weighted index, and then to test whether the results from a model using such an index which differ significantly from those using an index based on aggregate data.

3) No comparison of the Beta coefficients and the systematic risk coefficients generated using the 'gross margin' approach and the 'rate of return' approach was possible, due to lack of data. Such a comparison would have tested the reliability of the coefficients generated in this study, since the 'rate of return' approach is theoretically preferred. If the CAPM is to be used to evaluate diversification of a more strategic nature, then it would be necessary to use the 'rate of return' approach since different activities may require different resource bases. If the CAPM is to be used in this way, then some attempt must be made to address the problems associated with using the 'rate of return' approach.

4) It was difficult to obtain published rental values of land to represent the risk-free rate which could be used for all mixed cropping farms. Reliable published data is not possible to obtain as the land rent depends on a number of factors, including the location, the farm's state of development, and the world market prices for agricultural produce. Therefore consultants' estimates were used in this study. Although the model was not very sensitive to the value of the risk - free asset, any future use of this model will always require some estimation of this value for specific farm units under study.

5) Although the practical results obtained were very encouraging, it cannot be recommended that an information package on Beta coefficients be presented en masse to farmers, since the Beta coefficients developed for one particular farm may not be appropriate for another with a different resource base. That is, the Beta coefficients may

vary from farm to farm. Greater understanding of the behaviour of the CAPM in an agricultural understanding would be gained if Beta coefficients could be generated for different farms of a similar farm type. This would allow the volatility of the CAPM with respect to individual farm returns to be gauged. Research of this nature would indicate the extent to which the application of CAPM would have to be farm specific, or whether a representative farm could be used for this purpose.

## 6.4 Research Contributions of this Study

The CAPM allows an activity's total risk to be partitioned into two parts, the systematic (non - diversifiable) risk, and non - systematic (diversifiable) risk. These concepts provide fresh insights into the nature of risk, and the CAPM model provides a new approach to risk modelling in agriculture. Only two previous studies have attempted to apply the CAPM to the farm sector. The approaches used in these studies were not identical and contradictory results were obtained.

This study makes valuable contribution to this limited research on how the CAPM framework can be applied to an agricultural setting. It focusses on the calculations of the Beta coefficients and the elements of the FSCAPM, and in doing so, explains the differences which were observed between these previous studies. This study showed that caution in the application of CAPM is warranted due to the sensitivity of FSCAPM to its elements, including the measure of activity returns, deflating or otherwise of data, and a farm base market index. In addition to this advance to the development of FSCAPM, this research makes an applied contribution, since a study of this type has not been reported in New Zealand before.

Although the study indicates that caution is appropriate, nevertheless the CAPM framework shows great promise. It can provide useful information on risk attributes for individual farm activities, which farmers can then use subjectively for farm portfolio selection and for on - farm versus off - farm diversification decisions.

# References


Anderson, J.A.; Dillon, J.L., and Hardaker, B. (1977) Agricultural Decision Analysis. Iowa : Iowa State University Press.

Barnard, C.S. and Nix, J.S. (1979) Farm Planning and Control. Second Edition. Cambridge : Cambridge University Press.

Barr, G.D. and Knight, R.F. (1988) Some Geometrical Characteristics of the Risk - Return Plane. Journal of Business Finance and Accounting 15(3) : 437-445.

Barry, P.J. (1980) Capital Asset Pricing and Farm Real Estate. American Journal of Agricultural Economics 62(3) : 549-553.

Ben-Horim, M. and Levy, H. (1980) Total Risk, Diversifiable Risk and Nondiversifiable Risk : A Pedagogic Note. Journal of Financial and Quantitative Analysis 15(2) : 289-297.

Bilbrough, A. (1989) Personal Communication.

Black, F.; Jensen, M.C.; and Scholes, M. (1972) The Capital Asset Pricing Model: Some Empirical Tests. In: Studies in the Theory of Capital Markets, ed. Jensen, M.C. New York : Praeger.

Blume, M.E. and Friend, I. (1973) A New Look at the Capital Asset Pricing Model. The Journal of Finance 28(1) : 19-23.

Boehlje, M.D. and Eidman, V.R. (1984) Farm Management. New York : John Wiley and Sons.

Brealey, R. and Myers, S. (1984) Principles of Corporate Finance. Second Edition. Auckland, N.Z. : McGraw-Hill.

Brigham, E.F. (1986) Fundamentals of Financial Management. Fourth Edition. New York : Dryden Press.

Cawood, R. (1989) Personal Communication.

Collins, R.A. and Barry, P.J. (1986) Risk Analysis and Single - Index Portfolio Models: An Application to Farm Planning. American Journal of Agricultural Economics 68(1) : 152-161.

Copeland, T.E. and Weston, J.F. (1988) Financial Theory and Corporate Policy. Third Edition. New York : Addison - Wesley.

Croft, L. (1989) Personal Communication.

Crowder, R. (1989) Personal Communication.

Debrah, S. and Hall, H.H. (1989) Data Aggregation and Farm Risk Analysis. Agricultural Systems 31 : 239-245.

Dent, J.B. and Blackie, M.J. (1979) Systems Simulation in Agriculture. London : Applied Science Publishers.

Dillon, J.L. (1979) Bernoullian Decision Theory: Outline and Problems. p. 23-37. In: Risk, Uncertainty and Agricultural Development, eds. J.A. Roumasset, J. Boussard and I. Singh. New York : Agricultural Development Council.

Dobbins, R. and Witt, S.F. (1983) Portfolio Theory & Investment Management. Oxford : Martin Robertson & Co.

Driver, H.C. and Stackhouse, S.J.B. (1976) Organisational Responses to Uncertainty. Canadian Journal of Agricultural Economics 24(1) : 1-19.

Eisgruber, L.M. and Schuman, L.S. (1963) The Usefulness of Aggregate Data in the Analysis of Farm Income Variability and Resource Allocation. Journal of Farm Economics 45 : 587-591.

Elton, E.J. and Gruber, M.J. (1987) Modern Portfolio Theory And Investment Analysis. Third Edition. New York : John Wiley & Sons.

Fama, E.; and MacBeth, J. (1973) Risk, Return and Equilibrium : Empirical Tests. Journal of Political Economy 81(3) : 607-636.

Farrell, Jr., J.L. (1983) Guide to Portfolio Management. New York : McGraw - Hill.

Genet, R. (1989) Personal Communication.

Geske, R. and Roll, R. (1983) The Fiscal and Monetary Linkage Between Stock Returns and Inflation. The Journal of Finance 38(1) : 1- 29.

Gultekin, N.B. (1983) Stock Market Returns and Inflation: Evidence from Other Countries. The Journal of Finance 38(1) : 49-65.

Hazell, P.B.R. (1971) Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty. American Journal of Agricultural Economics 53(1) : 53-62.

Hazell, P.B.R. and Norton, R.D. (1986) Mathematical Programming For Economic Analysis In Agriculture. New York : Macmillan.

Heady, E.O. (1952) Economics of Agricultural Production and Resource Use. New York : Prentice - Hall.

Hill, G. (1989) Personal Communication.

Jensen, M.C. (1972) Capital Markets: Theory and Evidence. Bell Journal of Economics and Management Science 3(2) : 357-398.

Johnson, R. (1987) Government and the Farmer. In : <u>Rural New Zealand - What Next?</u> eds. Wallace, L.T. and Lattimore, R. (Agribusiness and Economics Research Unit, Lincoln College. Discussion Paper No. 109).

Johnson, S.R. (1967) A Re-examination of the Farm Diversification Problem. <u>Journal of Farm Economics</u> 49(3) : 610-621.

Kelly, M. (1989) Personal Communication.

King, R.F. and Robison, L.J. (1984) Risk Efficiency Models. p.68-81. In: <u>Risk Management in Agriculture</u>, ed P.J. Barry. Iowa : Iowa State University Press.

Levy, H. and Sarnat, M. (1972) <u>Investment and Portfolio Analysis</u>. New York : Wiley.

Lilley, M. (1989) Personal Communication.

Lin, W.; Dean, G.W. and Moore, C.V. (1974) An Empirical Test of Utility versus Profit Maximisation in Agricultural Production. <u>American Journal of Agricultural Economics</u> 56(3) : 497-508.

Lincoln College. <u>Lincoln College Farms Accounts</u>. [Published annually].

Lincoln College. <u>Lincoln College Farm Bulletin</u>. [Published annually].

Lincoln College. <u>Lincoln College Farms Programme</u>. [Published annually].

Lincoln College. Department of Farm Management and Rural Valuation. <u>Farm Budget Manual</u>. [Published annually until 1984].

Lincoln College. Department of Farm Management and Rural Valuation. <u>Financial Budget Manual</u>. [Published annually from 1985].

Lintner, J. (1965) The Valuation of Risk Assets and Selection of Risky Investments in Stock Portfolios and Capital Budgets. <u>Review of Economics and Statistics</u> 47 : 13-37.

Lockhart, J.C. (1989) Results of a Survey of Planning and Financial Management on Three Farm Types in New Zealand. Paper presented at the Annual Conference of the N.Z. Branch of the Australian Agricultural Economics Society, Flock House, Bulls, July 1989.

MAF Corp (April 1988) <u>Situation and Outlook for New Zealand Agriculture</u>. Wellington : MAF Corp.

MAF Technology Rural Policy Unit (June 1988) <u>MAF Farm Monitoring Report : National Report</u>. Wellington : MAF Tech.

MAF Technology Rural Policy Unit (December 1988) MAF Farm Monitoring Report : National Report. Wellington : MAF Tech.

MAF Technology Rural Policy Unit (June 1988) MAF Farm Monitoring Report : South Central. Wellington : MAF Tech.

Malcolm, L.R. (1988) A Record of Fifty Years of Academic Work in Farm Management in Australia: An Idiosyncratic View. Paper presented to the 32nd Annual Conference of the Australian Agricultural Economics Society, La Trobe University, Melbourne, February, 1988.

Mapp, Jr., H.P. and Helmers, G.A. (1984) Methods of Risk Analysis for Farm Firms. p.116-128. In: Risk Management in Agriculture, ed. P.J. Barry. Iowa : Iowa State University Press.

Markowitz, H.M. (1952) Portfolio Selection. Journal of Finance 12 : 77-91.

Markowitz, H.M. (1959) Portfolio Selection: Efficient Diversification of Investments. New York : John Wiley.

Moffit, R.G. An Economic Survey of New Zealand Town Milk Producers. (Agribusiness and Economics Research Unit Research Report. Lincoln College). [Published annually].

Moorhead, E. (1989) Personal Communication.

New Zealand Dairy Board. Annual Report. Wellington : Government Printer. [Published annually].

New Zealand Dairy Board Livestock Improvement Division. 63rd Livestock Improvement Report No.63.

New Zealand Department of Statistics. Agricultural Statistics. Wellington : Government Printer. [Published annually].

New Zealand Department of Statistics. Monthly Abstract of Statistics. Wellington : Government Printer. [Published Annually].

New Zealand Department of Statistics. New Zealand Official Yearbook. Wellington : Government Printer. [Published annually].

New Zealand Meat and Wool Boards' Economic Service. Annual Review of the N.Z. Sheep and Beef Industry. Wellington : Government Printer. [Published annually].

New Zealand Meat and Wool Boards' Economic Service. The New Zealand Sheep and Beef Farm Survey. Wellington : Government Printer. [Published annually].

Pittaway, S.F. (1989) Personal Communication.

Rayner, T. (1987) Regulation. p.20.1-20.10. In: Rural New Zealand - What Next?, eds. Wallace, L.T. and Lattimore, R. (Agribusiness and Economics Research Unit. Lincoln College. Discussion Paper no. 109).

Rao, R.K.S. (1987) Financial Management : Concepts and Applications. New York : MacMillan.

Robison, L.J.; Barry, P.J.; Kliebenstein, J.B. and Patrick, G. (1984) Risk Attitudes: Concepts and Measurement Approaches. p.11-30. In: Risk Management In Agriculture, ed. Barry, P.J. Iowa : Iowa State University Press.

Roll, R. (1977) A Critique of the Asset Pricing Theory's Tests : Part 1 - On Past and Potential Testability of the Theory. Journal of Financial Economics 4(2) : 129-176.

Ross, B. (1987) Development of the Agricultural Industry. p.10.1-10.7. In: Rural New Zealand - What Next?, eds. Wallace, L.T. and Lattimore, R. (Agribusiness and Economics Research Unit, Lincoln College. Discussion Paper No. 109).

Selley, R., (1984) Decision Rules in Risk Analysis. p.53-67. In: Risk Management In Agriculture, ed. Barry, P.J. Iowa : Iowa State University Press.

Sharpe, W.F. (1964) Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk. Journal of Finance 19(3) : 425-442.

Sharpe, W.F. (1970) Portfolio Theory and Capital Markets. New York : McGraw - Hill.

Smith, J. (1989) Personal Communication.

Solnik, B. (1983) The Relation Between Stock Prices and Inflationary Expectations: The International Evidence. The Journal of Finance 38(1) : 35-48.

Sonka, S.T. and Patrick, G.F., (1984) Risk Management and Decision Making In Agricultural Firms. p.95-115. In: Risk Management in Agriculture, ed. Barry, P.J. Iowa : Iowa State University Press.

Tobin, J. (1958) Liquidity Preference as Behaviour Towards Risk. Review of Economic Studies 25 : 65-86.

Turvey, C.G. (1985) Evaluating the Contribution of Systematic Risk to E - V efficient Portfolio Selection in Agriculture, MSc thesis. University of Guelph, Guelph, Ontario.

Turvey, C.G. and Driver, H.C. (1987) Systematic and Nonsystematic Risks in Agriculture. Canadian Journal of Agricultural Economics 35 : 387-401.

Turvey, C.G.; Driver, H.C. and Baker, T.G. (1988) Systematic and Nonsystematic Risk in Farm Portfolio Selection. American Journal of Agricultural Economics 70(4) : 831-836.

Van Horne, J.C. (1986) **Financial Management and Policy**. Seventh Edition. New Jersey : Prentice - Hall.

Whatman, A.C.W. (1989) Personal Communication.

Wright, V., (1983) Some Bounds to the Relevance of Decision Theory. **Australian Journal of Agricultural Economics** 27(3) : 221-230.

# Appendices

## Appendix 4-1

**Lincoln University Mixed Cropping Farm Accounts, Past Trend**

| Year end 30/6 | Total Farming Assets $ | Net Farming Profit $ | Gross L/stock Revenue $ | Gross Cropping Revenue $ | Gross Sundry Revenue $ | Gross Revenue $ | Gross Expend-iture $ |
|---|---|---|---|---|---|---|---|
| 1978 | 399733 | 30140 | 3075 | 102976 | 10159 | 116210 | 86070 |
| 1979 | 848660 | 26041 | 4967 | 103752 | 13786 | 122505 | 96464 |
| 1980 | 952965 | 69844 | 4050 | 145911 | 37026 | 186987 | 117143 |
| 1981 | 984306 | 69568 | 3901 | 166811 | 17006 | 187718 | 118150 |
| 1982 | 991270 | 62347 | | 206713 | 30848 | 237561 | 175214 |
| 1983 | 1003182 | 50790 | | 154644 | 53675 | 208319 | 157529 |
| 1984 | 1376496 | 17816 | -2467 | 207275 | 37094 | 241902 | 224086 |
| 1985 | 1329255 | 5470 | 10022 | 197216 | 21262 | 228500 | 223030 |
| 1986 | 1456710 | 23720 | 3074 | 218053 | 32642 | 253769 | 230049 |
| 1987 | 1453685 | 42006 | 24621 | 170931 | 14402 | 209954 | 167948 |
| Past 10yr Avg. | 1079627 | 39774 | 5124 | 163676 | 30542 | 199342 | 159568 |
| 1988 | 1988608 | 40609 | 35015 | 228935 | 22611 | 286561 | 245952 |

Reference: Lincoln College Farm Accounts. [Published Annually].

# Appendix 4-2

## Lincoln University Mixed Cropping Farm Activity Gross Margins

### CROP: Feed Barley Gross Margins

| YEAR(End30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 5.85 | 5.05 | 3.92 | 3.70 | 4.10 | 3.90 | 3.80 | 3.20 | 5.80 |
| PRICE ($/t) | 140.00 | 150.00 | 170.00 | 165.00 | 150.00 | 150.00 | 165.00 | 132.50 | 87.00 |
| GRS.IN.($/ha) | 819.00 | 757.50 | 666.40 | 610.50 | 615.00 | 585.00 | 627.00 | 424.00 | 504.60 |
| CULT.$,hr=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| SEED ($/ha) | 57.00 | 77.40 | 61.80 | 54.00 | 48.00 | 48.00 | 47.76 | 39.60 | 26.40 |
| -price,$/t | 475.00 | 645.00 | 515.00 | 450.00 | 400.00 | 400.00 | 398.00 | 330.00 | 220.00 |
| FERTLZ ($/ha) | 22.63 | 25.25 | 18.75 | 17.00 | 15.63 | 15.63 | 15.11 | 11.93 | 7.99 |
| -super, $/t | 181.00 | 202.00 | 150.00 | 136.00 | 125.00 | 125.00 | 120.85 | 95.40 | 63.95 |
| WD/P/DS($/ha) | 82.00 | 66.91 | 48.62 | 40.94 | 42.49 | 42.49 | 44.38 | 43.63 | 34.88 |
| -MCPA, $/l | 5.50 | 5.05 | 6.00 | 5.18 | 4.91 | 4.91 | 5.48 | 4.83 | 3.91 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| -Bayleton,$/l | 75.00 | 72.47 | 40.60 | 33.60 | 42.00 | 42.00 | 46.95 | 48.95 | 37.10 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| HARVEST($/ha) | 296.60 | 244.93 | 167.74 | 140.23 | 144.32 | 137.28 | 113.05 | 84.64 | 127.89 |
| - $/t | 50.70 | 48.50 | 42.79 | 37.90 | 35.20 | 35.20 | 29.75 | 26.45 | 22.05 |
| FREIGHT($/ha) | 68.45 | 51.46 | 42.73 | 31.75 | 24.60 | 23.40 | 20.90 | 16.00 | 23.20 |
| - $/t | 11.70 | 10.19 | 10.90 | 8.58 | 6.00 | 6.00 | 5.50 | 5.00 | 4.00 |
| T.D.CST($/ha) | 590.74 | 522.17 | 398.78 | 343.17 | 321.38 | 313.14 | 278.92 | 230.57 | 247.91 |
| G.MRGIN($/ha) | 228.00 | 235.00 | 268.00 | 267.00 | 294.00 | 272.00 | 348.00 | 193.00 | 257.00 |

### CROP: Feed Barley Gross Margins (Continued)

| YEAR(End30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 2.90 | 4.10 | 5.04 | 4.16 | 3.20 | 3.59 | 2.98 | 3.09 | 4.10 |
| PRICE ($/t) | 87.00 | 83.00 | 83.00 | 75.00 | 92.00 | 56.00 | 35.26 | 39.60 | 35.20 |
| GRS.IN.($/ha) | 252.30 | 340.30 | 418.32 | 312.00 | 294.40 | 201.04 | 105.07 | 122.36 | 144.32 |
| CULT.$,hr=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| SEED ($/ha) | 24.00 | 22.20 | 20.88 | 20.52 | 11.45 | 11.45 | 9.79 | 9.50 | 9.13 |
| -price,$/t | 200.00 | 185.00 | 174.00 | 171.00 | 95.40 | 95.40 | 81.60 | 79.20 | 76.12 |
| FERTLZ ($/ha) | 4.79 | 5.73 | 5.10 | 3.26 | 3.26 | 3.26 | 2.18 | 2.18 | 2.39 |
| -super, $/t | 38.30 | 45.80 | 40.80 | 26.10 | 26.10 | 26.10 | 17.45 | 17.45 | 19.15 |
| WD/P/DS($/ha) | 11.11 | 11.40 | 9.21 | 6.88 | 6.09 | 3.78 | 2.60 | 2.25 | 2.25 |
| -MCPA, $/l | 3.17 | 3.11 | 2.67 | 1.96 | 1.78 | 1.11 | 0.74 | 0.69 | 0.69 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| -Bayleton,$/l | | | | | | | | | |
| ~application | | | | | | | | | |
| HARVEST($/ha) | 53.71 | 75.93 | 79.63 | 51.25 | 36.80 | 31.66 | 26.22 | 22.65 | 25.54 |
| - $/t | 18.52 | 18.52 | 15.80 | 12.32 | 11.50 | 8.82 | 8.80 | 7.33 | 6.23 |
| FREIGHT($/ha) | 10.15 | 9.84 | 11.09 | 7.90 | 5.76 | 5.39 | 4.47 | 4.64 | 5.54 |
| - $/t | 3.50 | 2.40 | 2.20 | 1.90 | 1.80 | 1.50 | 1.50 | 1.50 | 1.35 |
| T.D.CST($/ha) | 123.15 | 144.11 | 142.86 | 104.77 | 73.01 | 62.58 | 51.27 | 46.96 | 50.22 |
| G.MRGIN($/ha) | 129.00 | 196.00 | 275.00 | 207.00 | 221.00 | 138.00 | 54.00 | 75.00 | 94.00 |

Reference:
1. Yields, Lincoln University records (See Table 4-1 Notes).
2. Costs and prices, Lincoln College Financial Budget Manuals. [Published Annually]. (See Table 4-1 Notes).

## Appendix 4-2 (Continued)

## CROP: White Clover Gross Margins

| YEAR(End30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD kg/ha | 312.88 | 294.94 | 277.00 | 236.00 | 335.00 | 234.00 | 315.00 | 454.00 | 345.00 |
| PRICE $/kg | 2.40 | 2.80 | 3.00 | 1.80 | 2.90 | 2.90 | 3.30 | 2.30 | 1.60 |
| GRS.IN.($/ha) | 750.90 | 825.80 | 831.00 | 424.80 | 971.50 | 678.60 | 1039.5 | 1044.2 | 552.00 |
| SEED ($/ha) | 11.10 | 12.00 | 15.30 | 7.50 | 13.50 | 13.50 | 12.00 | 8.70 | 6.90 |
| -price,$/kg | 3.70 | 4.00 | 5.10 | 2.50 | 4.50 | 4.50 | 4.00 | 2.90 | 2.30 |
| CULT.$,hr=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| FERTLZ ($/ha) | 22.63 | 25.25 | 18.75 | 17.00 | 15.63 | 15.63 | 15.11 | 11.93 | 7.99 |
| -super, $/t | 181.00 | 202.00 | 150.00 | 136.00 | 125.00 | 125.00 | 120.85 | 95.40 | 63.95 |
| WD/P/DS($/ha) | 187.60 | 157.12 | 141.42 | 128.50 | 104.88 | 104.88 | 90.58 | 89.28 | 78.68 |
| -Cabtmx, $/kg | 30.70 | 26.20 | 24.40 | 21.65 | 17.09 | 17.09 | 15.25 | 15.25 | 13.28 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| -Nexion,$/l | 18.40 | 18.40 | 16.75 | 16.65 | 14.88 | 14.88 | 12.56 | 11.81 | 10.48 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| -MCPB, $/l | | | | | | | | | |
| ~application | | | | | | | | | |
| HARVEST($/ha) | 139.00 | 133.00 | 117.31 | 103.80 | 96.40 | 96.40 | 81.70 | 72.25 | 60.20 |
| FREIGHT($/ha) | 7.15 | 5.61 | 5.26 | 3.96 | 4.07 | 2.84 | 3.60 | 4.54 | 2.66 |
| - $/t | 15.97 | 13.29 | 13.29 | 11.73 | 8.50 | 8.50 | 8.00 | 7.00 | 5.40 |
| S/Drsng($/ha) | 147.65 | 124.42 | 114.87 | 91.12 | 114.97 | 80.31 | 108.11 | 116.86 | 82.39 |
| - $/kg | 0.330 | 0.295 | 0.290 | 0.270 | 0.240 | 0.240 | 0.240 | 0.180 | 0.167 |
| T.D.CST($/ha) | 579.19 | 513.63 | 472.06 | 411.13 | 395.79 | 359.90 | 348.83 | 338.34 | 266.37 |
| G.MRGIN($/ha) | 172.00 | 312.00 | 359.00 | 14.00 | 576.00 | 319.00 | 691.00 | 706.00 | 286.00 |

## CROP: White Clover Gross Margins (Continued)

| YEAR(End30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD kg/ha | 533.00 | 282.00 | 499.00 | 397.00 | 250.00 | 497.00 | 296.00 | 202.00 | 296.00 |
| PRICE $/kg | 1.35 | 2.00 | 1.32 | 1.10 | 0.93 | 1.45 | 0.99 | 1.03 | 1.03 |
| GRS.IN. $/ha) | 719.60 | 564.00 | 658.70 | 436.70 | 232.50 | 720.70 | 293.00 | 208.10 | 304.90 |
| SEED ($/ha) | 5.55 | 6.00 | 5.25 | 4.50 | 4.50 | 5.94 | 3.15 | 3.00 | 3.00 |
| -price, $/kg | 1.85 | 2.00 | 1.75 | 1.50 | 1.50 | 1.98 | 1.05 | 1.00 | 1.00 |
| CULT.$,hr=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| FERTLZ ($/ha) | 4.79 | 5.73 | 5.10 | 3.26 | 3.26 | 3.26 | 2.18 | 2.18 | 2.39 |
| -super, $/t | 38.30 | 45.80 | 40.80 | 26.10 | 26.10 | 26.10 | 17.45 | 17.45 | 19.15 |
| WD/P/DS($/ha) | 71.98 | 35.77 | 30.96 | 25.09 | 19.74 | 16.72 | 4.13 | 3.68 | 3.68 |
| -Cabtmx,$/kg | 12.55 | | | | | | | | |
| ~application | 1.60 | | | | | | | | |
| -Nexion, $/l | 9.29 | 9.41 | 8.66 | 6.80 | 5.11 | 5.11 | | | |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | | | |
| -MCPB, $/l | | 3.66 | 3.21 | 2.71 | 2.29 | 1.60 | 1.07 | 1.00 | 1.00 |
| ~application | | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| HARVEST($/ha) | 50.80 | 50.80 | 46.25 | 37.05 | 32.00 | 19.80 | 19.80 | 19.80 | 17.30 |
| FREIGHT($/ha) | 3.58 | 1.53 | 2.43 | 1.70 | 1.00 | 1.63 | 0.97 | 0.63 | 0.92 |
| - $/t | 4.70 | 3.80 | 3.40 | 3.00 | 2.80 | 2.30 | 2.30 | 2.17 | 2.17 |
| S/Drsng($/ha) | 115.85 | 52.83 | 85.63 | 51.09 | 32.18 | 58.99 | 33.10 | 22.53 | 33.02 |
| - $/kg | 0.152 | 0.131 | 0.120 | 0.090 | 0.090 | 0.083 | 0.078 | 0.078 | 0.078 |
| T.D.CST($/ha) | 271.94 | 171.66 | 192.56 | 137.65 | 102.32 | 113.39 | 69.33 | 57.56 | 65.67 |
| G.MRGIN($/ha) | 448.00 | 392.00 | 466.00 | 299.00 | 130.00 | 607.00 | 224.00 | 150.00 | 239.00 |

## Appendix 4-2 (Continued)

### CROP: Field Peas Gross Margins

| YEAR(End30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 2.70 | 3.60 | 2.80 | 3.20 | 4.30 | 3.60 | 2.50 | 3.70 | 3.00 |
| PRICE ($/t) | 400.00 | 350.00 | 280.00 | 260.00 | 280.00 | 280.00 | 290.00 | 180.00 | 140.00 |
| PEA INC($/ha) | 1080.0 | 1260.0 | 784.00 | 832.00 | 1204.0 | 1008.0 | 725.00 | 666.00 | 420.00 |
| P/vine $/bale | 1.20 | 2.00 | 1.20 | 1.25 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| P/vine ($/ha) | 72.00 | 120.00 | 72.00 | 75.00 | 45.00 | 45.00 | 45.00 | 45.00 | 45.00 |
| T.G.INC($/ha) | 1152.0 | 1380.0 | 856.0 | 907.0 | 1249.0 | 1053.0 | 770.0 | 711.0 | 465.0 |
| CULT.$,hr=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| SEED ($/ha) | 203.00 | 189.66 | 156.60 | 95.70 | 107.30 | 107.30 | 130.50 | 84.10 | 69.60 |
| -price, $/t | 700.00 | 654.00 | 540.00 | 330.00 | 370.00 | 370.00 | 450.00 | 290.00 | 240.00 |
| FERTLZ ($/ha) | 47.25 | 48.39 | 40.25 | 35.83 | 33.45 | 33.45 | 32.35 | 27.53 | 20.46 |
| -mo super,$/t | 189.00 | 193.54 | 161.00 | 143.30 | 133.80 | 133.80 | 129.40 | 110.10 | 81.85 |
| WD/P/DS($/ha) | 39.45 | 33.21 | 28.51 | 22.78 | 22.21 | 22.21 | 22.29 | 20.64 | 17.63 |
| -MCPB, $/l | 7.27 | 7.27 | 6.67 | 5.28 | 5.38 | 5.38 | 5.73 | 5.23 | 4.38 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| HARVEST($/ha) | 148.50 | 189.50 | 130.03 | 131.20 | 164.26 | 137.52 | 80.75 | 106.19 | 71.70 |
| - $/t | 55.00 | 52.64 | 46.44 | 41.00 | 38.20 | 38.20 | 32.30 | 28.70 | 23.90 |
| FREIGHT($/ha) | 43.12 | 47.84 | 37.21 | 37.54 | 36.55 | 30.60 | 20.00 | 25.90 | 16.20 |
| - $/t | 15.97 | 13.29 | 13.29 | 11.73 | 8.50 | 8.50 | 8.00 | 7.00 | 5.40 |
| T.D.CST($/ha) | 545.39 | 564.83 | 451.74 | 382.30 | 410.11 | 377.42 | 323.62 | 299.13 | 223.13 |
| G.MRGIN($/ha) | 607.00 | 815.00 | 404.00 | 525.00 | 839.00 | 676.00 | 446.00 | 412.00 | 242.00 |

### CROP: Field Peas Gross Margins (Continued)

| YEAR(End30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 2.30 | 1.77 | 1.65 | 2.64 | 4.56 | 4.10 | 3.50 | 3.00 | 2.56 |
| PRICE ($/t) | 160.00 | 145.00 | 190.00 | 93.50 | 114.00 | 147.00 | 66.13 | 66.00 | 58.67 |
| PEA INC($/ha) | 368.00 | 256.70 | 313.50 | 246.80 | 519.80 | 602.70 | 231.50 | 198.00 | 150.20 |
| P/vine $/bale | 0.60 | 0.60 | 0.40 | 0.35 | 0.30 | 0.20 | 0.20 | 0.20 | 0.18 |
| P/vine ($/ha) | 36.00 | 36.00 | 24.00 | 21.00 | 18.00 | 12.00 | 12.00 | 12.00 | 10.80 |
| T.G.INC($/ha) | 404.00 | 292.70 | 337.50 | 267.80 | 537.80 | 614.70 | 243.50 | 210.00 | 161.00 |
| CULT.$,hr=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| SEED ($/ha) | 79.75 | 79.75 | 44.95 | 44.95 | 44.66 | 37.29 | 11.72 | 10.10 | 9.28 |
| -price, $/t | 275.00 | 275.00 | 155.00 | 155.00 | 154.00 | 128.60 | 40.40 | 34.83 | 32.00 |
| FERTLZ ($/ha) | 10.81 | 12.29 | 10.88 | 7.01 | 7.01 | 7.01 | 5.25 | 5.25 | 5.64 |
| -mo super,$/t | 43.25 | 49.15 | 43.50 | 28.05 | 28.05 | 28.05 | 21.00 | 21.00 | 22.55 |
| WD/P/DS($/ha) | 14.10 | 14.88 | 12.44 | 10.49 | 8.77 | 6.05 | 4.13 | 3.68 | 3.68 |
| -MCPB, $/l | 3.57 | 3.66 | 3.21 | 2.71 | 2.29 | 1.60 | 1.07 | 1.00 | 1.00 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| HARVEST($/ha) | 46.46 | 35.75 | 28.05 | 35.90 | 58.82 | 34.65 | 30.10 | 25.29 | 18.76 |
| - $/t | 20.20 | 20.20 | 17.00 | 13.60 | 12.90 | 8.45 | 8.60 | 8.43 | 7.33 |
| FREIGHT($/ha) | 10.81 | 6.73 | 5.61 | 7.92 | 12.77 | 9.43 | 8.05 | 6.51 | 5.56 |
| - $/t | 4.70 | 3.80 | 3.40 | 3.00 | 2.80 | 2.30 | 2.30 | 2.17 | 2.17 |
| T.D.CST($/ha) | 181.32 | 168.41 | 118.87 | 121.22 | 141.68 | 101.47 | 65.24 | 56.58 | 48.28 |
| G.MRGIN($/ha) | 223.00 | 124.00 | 219.00 | 147.00 | 396.00 | 513.00 | 178.00 | 153.00 | 113.00 |

## Appendix 4-2 (Continued)

## CROP: Ryegrass Gross Margins

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR(End30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
| YIELD, kg/ha | 879.00 | 1039.00 | 663.00 | 1130.00 | 983.00 | 786.00 | 503.00 | 250.00 | 869.00 |
| PRICE, $/kg | 1.20 | 1.40 | 1.50 | 0.90 | 0.90 | 0.90 | 1.25 | 1.35 | 0.85 |
| SEED IN($/ha) | 1054.80 | 1454.60 | 994.50 | 1017.00 | 884.70 | 707.40 | 628.80 | 337.50 | 738.70 |
| STRAW $/bale | 1.20 | 2.00 | 1.20 | 1.25 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| STRAW ($/ha) | 120.00 | 200.00 | 120.00 | 125.00 | 75.00 | 75.00 | 75.00 | 75.00 | 75.00 |
| T.G.INC($/ha) | 1174.80 | 1654.60 | 1114.50 | 1142.00 | 959.70 | 782.40 | 703.80 | 412.50 | 813.70 |
| CULT.$,hr=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| SEED ($/ha) | 59.40 | 54.56 | 59.40 | 24.20 | 81.40 | 81.40 | 49.50 | 66.00 | 48.40 |
| -price, $/kg | 2.70 | 2.48 | 2.70 | 1.10 | 3.70 | 3.70 | 2.25 | 3.00 | 2.20 |
| FERTLZ ($/ha) | 96.63 | 94.44 | 103.30 | 90.45 | 98.88 | 98.88 | 95.58 | 87.96 | 57.94 |
| -urea, $/t | 400.00 | 374.00 | 457.00 | 397.00 | 450.00 | 450.00 | 435.00 | 411.00 | 270.00 |
| -super, $/t | 181.00 | 202.00 | 150.00 | 136.00 | 125.00 | 125.00 | 120.85 | 95.40 | 63.95 |
| WD/P/DS($/ha) | 123.50 | 150.92 | 148.57 | 126.34 | 99.59 | 99.59 | 80.15 | 71.55 | 61.28 |
| -MCPA, $/l | 5.50 | 5.05 | 6.00 | 5.18 | 4.91 | 4.91 | 5.48 | 4.83 | 3.91 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| -MCPB, $/l | | | | | | | | | |
| ~application | | | | | | | | | |
| -Avenge, $/l | 15.80 | 24.05 | 24.05 | 20.44 | 15.62 | 15.62 | 11.85 | 10.48 | 8.99 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| HARVEST($/ha) | 178.60 | 172.95 | 160.60 | 148.10 | 141.10 | 141.10 | 123.20 | 109.45 | 89.20 |
| ~heading $/ha | 122.00 | 116.35 | 104.00 | 93.50 | 86.90 | 86.90 | 73.70 | 67.45 | 56.20 |
| ~Windrow $/ha | 56.60 | 56.60 | 56.60 | 54.60 | 54.20 | 54.20 | 49.50 | 42.00 | 33.00 |
| FREIGHT($/ha) | 16.51 | 16.25 | 10.37 | 15.59 | 9.83 | 7.86 | 4.73 | 2.06 | 5.52 |
| - $/t | 15.97 | 13.29 | 13.29 | 11.73 | 8.50 | 8.50 | 8.00 | 7.00 | 5.40 |
| SD/DRESS $/ha | 155.12 | 146.68 | 93.60 | 136.93 | 99.46 | 79.52 | 50.89 | 19.12 | 57.25 |
| ~rate c/kg | 0.15 | 0.12 | 0.12 | 0.103 | 0.086 | 0.086 | 0.086 | 0.065 | 0.056 |
| T.D.CST($/ha) | 693.83 | 692.03 | 634.98 | 600.86 | 576.59 | 554.69 | 441.79 | 390.92 | 347.14 |
| G.MRGIN($/ha) | 481.00 | 963.00 | 480.00 | 541.00 | 383.00 | 228.00 | 262.00 | 22.00 | 467.00 |

## Appendix 4-2 (Continued)

### CROP: Ryegrass Gross Margins (Continued)

| YEAR(End30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD, kg/ha | 485.00 | 1063.0 | 820.00 | 627.00 | 437.00 | 844.00 | 763.00 | 789.00 | 612.00 |
| PRICE, $/kg | 0.62 | 0.70 | 0.52 | 0.36 | 0.27 | 0.78 | 0.35 | 0.22 | 0.17 |
| SEED IN ($/ha) | 300.70 | 744.10 | 426.40 | 225.70 | 118.00 | 658.30 | 267.10 | 173.60 | 104.00 |
| STRAW $/bale | 0.60 | 0.60 | 0.40 | 0.35 | 0.30 | 0.20 | 0.20 | 0.20 | 0.18 |
| STRAW ($/ha) | 60.00 | 60.00 | 40.00 | 35.00 | 30.00 | 20.00 | 20.00 | 20.00 | 18.00 |
| T.G.INC ($/ha) | 360.70 | 804.10 | 466.40 | 260.70 | 148.00 | 678.30 | 287.10 | 193.60 | 122.00 |
| CULT.$,hrs=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| SEED ($/ha) | 18.70 | 15.40 | 22.00 | 13.20 | 13.20 | 24.20 | 11.00 | 5.50 | 5.50 |
| -price, $/kg | 0.85 | 0.70 | 1.00 | 0.60 | 0.60 | 1.10 | 0.50 | 0.25 | 0.25 |
| FERTLZ ($/ha) | 47.95 | 40.61 | 40.21 | 46.79 | 45.08 | 25.80 | 16.35 | 16.05 | 18.01 |
| -urea, $/t | 233.30 | 188.55 | 189.80 | 235.30 | 226.05 | 121.80 | 76.60 | 74.95 | 84.40 |
| -super, $/t | 38.30 | 45.80 | 40.80 | 26.10 | 26.10 | 26.10 | 17.45 | 17.45 | 19.15 |
| WD/P/DS ($/ha) | 50.66 | 26.28 | 21.65 | 17.37 | 14.86 | 9.83 | 6.73 | 5.93 | 5.93 |
| -MCPA, $/l | 3.17 | 3.11 | 2.67 | 1.96 | 1.78 | 1.11 | 0.74 | 0.69 | 0.69 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| -MCPB, $/l | | 3.66 | 3.21 | 2.71 | 2.29 | 1.60 | 1.07 | 1.00 | 1.00 |
| ~application | | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| -Avenge, $/l | 7.59 | | | | | | | | |
| ~application | 1.60 | | | | | | | | |
| HARVEST ($/ha) | 76.35 | 73.70 | 63.00 | 51.88 | 41.85 | 24.70 | 23.50 | 23.50 | 21.02 |
| ~heading $/ha | 47.50 | 47.50 | 43.25 | 34.58 | 29.50 | 17.30 | 17.30 | 17.30 | 14.82 |
| ~Windrow $/ha | 28.85 | 26.20 | 19.75 | 17.30 | 12.35 | 7.40 | 6.20 | 6.20 | 6.20 |
| FREIGHT ($/ha) | 2.68 | 4.75 | 3.28 | 2.21 | 1.44 | 2.28 | 2.06 | 2.01 | 1.56 |
| - $/t | 4.70 | 3.80 | 3.40 | 3.00 | 2.80 | 2.30 | 2.30 | 2.17 | 2.17 |
| SD/DRESS $/ha | 29.10 | 55.03 | 38.59 | 23.97 | 16.71 | 29.59 | 25.67 | 26.55 | 20.59 |
| ~S.D.rate c/kg | 0.051 | 0.044 | 0.04 | 0.0325 | 0.0325 | 0.0298 | 0.0286 | 0.0286 | 0.0286 |
| T.D.CST ($/ha) | 244.83 | 234.77 | 205.68 | 170.38 | 142.79 | 123.44 | 91.31 | 85.28 | 77.98 |
| G.MRGIN ($/ha) | 116.00 | 569.00 | 261.00 | 90.00 | 5.00 | 555.00 | 196.00 | 108.00 | 44.00 |

## Appendix 4-2 (Continued)

### CROP: Frozen Peas Gross Margins

| YEAR(End 30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 5.43 | 6.33 | 6.00 | 4.40 | 5.20 | 6.50 | 5.40 | 5.80 | 6.00 |
| PRICE ($/t) | 253.00 | 234.00 | 272.00 | 237.00 | 204.00 | 204.00 | 204.00 | 173.00 | 157.00 |
| T.G.INC ($/ha) | 1373.8 | 1481.2 | 1632.0 | 1042.8 | 1060.8 | 1326.0 | 1101.6 | 1003.4 | 942.00 |
| CULT.$,hrs=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| SEED ($/ha) | 259.26 | 240.70 | 204.45 | 174.00 | 124.70 | 124.70 | 84.39 | 84.39 | 69.60 |
| -price, $/t | 894.00 | 830.00 | 705.00 | 600.00 | 430.00 | 430.00 | 291.00 | 291.00 | 240.00 |
| FERTLZ ($/ha) | 47.25 | 48.39 | 40.25 | 35.83 | 33.45 | 33.45 | 32.35 | 27.53 | 20.46 |
| -mo super, $/t | 189.00 | 193.54 | 161.00 | 143.30 | 133.80 | 133.80 | 129.40 | 110.10 | 81.85 |
| WD/P/DS ($/ha) | 39.45 | 33.21 | 28.51 | 22.78 | 22.21 | 22.21 | 22.29 | 20.64 | 17.63 |
| -MCPB, $/l | 7.27 | 7.27 | 6.67 | 5.28 | 5.38 | 5.38 | 5.73 | 5.23 | 4.38 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| T.D.CST ($/ha) | 410.03 | 378.52 | 332.35 | 291.86 | 226.70 | 226.70 | 176.76 | 167.33 | 135.23 |
| G.MRGIN ($/ha) | 964.00 | 1103.0 | 1300.0 | 751.00 | 834.00 | 1099.0 | 925.00 | 836.00 | 807.00 |

### CROP: Frozen Peas Gross Margins (Continued)

| YEAR(End 30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 4.60 | 4.40 | 4.76 | 3.25 | 4.32 | 2.46 | 4.51 | 3.42 | 3.75 |
| PRICE ($/t) | 150.00 | 142.00 | 130.00 | 109.00 | 97.27 | 64.85 | 62.26 | 61.28 | 56.00 |
| T.G.INC ($/ha) | 690.00 | 624.80 | 618.80 | 354.30 | 420.20 | 159.50 | 280.80 | 209.60 | 210.00 |
| CULT.$,hrs=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| SEED ($/ha) | 71.05 | 92.80 | 89.90 | 85.26 | 46.40 | 71.11 | 53.30 | 53.16 | 53.16 |
| -price, $/t | 245.00 | 320.00 | 310.00 | 294.00 | 160.00 | 245.20 | 183.80 | 183.30 | 183.30 |
| FERTLZ ($/ha) | 10.81 | 12.29 | 10.88 | 7.01 | 7.01 | 7.01 | 5.25 | 5.25 | 5.64 |
| -mo super, $/t | 43.25 | 49.15 | 43.50 | 28.05 | 28.05 | 28.05 | 21.00 | 21.00 | 22.55 |
| WD/P/DS ($/ha) | 14.10 | 14.88 | 12.44 | 10.49 | 8.77 | 6.05 | 4.13 | 3.68 | 3.68 |
| -MCPB, $/l | 3.57 | 3.66 | 3.21 | 2.71 | 2.29 | 1.60 | 1.07 | 1.00 | 1.00 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| T.D.CST ($/ha) | 115.35 | 138.98 | 130.16 | 117.71 | 71.83 | 91.21 | 68.68 | 67.83 | 67.84 |
| G.MRGIN ($/ha) | 575.00 | 486.00 | 489.00 | 237.00 | 348.00 | 68.00 | 212.00 | 142.00 | 142.00 |

## Appendix 4-2 (Continued)

### CROP: Wheat Gross Margins

| YEAR(End30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 5.74 | 5.07 | 5.29 | 4.72 | 5.40 | 5.50 | 3.10 | 4.80 | 5.10 |
| PRICE ($/t) | 240.00 | 274.00 | 270.00 | 260.00 | 204.00 | 204.00 | 203.00 | 183.00 | 140.00 |
| GRS.IN.($/ha) | 1376.4 | 1389.2 | 1428.3 | 1227.2 | 1101.6 | 1122.0 | 629.30 | 878.40 | 714.00 |
| CULT.$,hr=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| SEED ($/ha) | 84.00 | 94.20 | 80.16 | 57.84 | 51.60 | 51.60 | 44.88 | 30.08 | 28.62 |
| -price, $/t | 700.00 | 785.00 | 668.00 | 482.00 | 430.00 | 430.00 | 374.00 | 250.70 | 238.50 |
| FERTLZ ($/ha) | 50.00 | 46.75 | 57.13 | 49.63 | 56.25 | 56.25 | 54.38 | 51.38 | 33.75 |
| -urea, $/t | 400.00 | 374.00 | 457.00 | 397.00 | 450.00 | 450.00 | 435.00 | 411.00 | 270.00 |
| WD/P/DS($/ha) | 82.00 | 66.91 | 48.62 | 40.94 | 42.49 | 42.49 | 44.38 | 43.63 | 34.88 |
| -MCPA, $/l | 5.50 | 5.05 | 6.00 | 5.18 | 4.91 | 4.91 | 5.48 | 4.83 | 3.91 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| -Bayleton,$/l | 75.00 | 72.47 | 40.60 | 33.60 | 42.00 | 42.00 | 46.95 | 48.95 | 37.10 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| HARVEST($/ha) | 242.37 | 204.93 | 188.64 | 149.15 | 158.22 | 161.15 | 76.88 | 105.84 | 93.84 |
| - $/t | 42.26 | 40.42 | 35.66 | 31.60 | 29.30 | 29.30 | 24.80 | 22.05 | 18.40 |
| FREIGHT($/ha) | 67.10 | 51.66 | 57.66 | 40.50 | 32.40 | 33.00 | 17.05 | 24.00 | 20.40 |
| - $/t | 11.70 | 10.19 | 10.90 | 8.58 | 6.00 | 6.00 | 5.50 | 5.00 | 4.00 |
| T.D.CST($/ha) | 589.54 | 520.68 | 491.35 | 397.31 | 387.30 | 390.83 | 275.29 | 289.71 | 239.03 |
| G.MRGIN($/ha) | 787.00 | 869.00 | 937.00 | 830.00 | 714.00 | 731.00 | 354.00 | 589.00 | 475.00 |

### CROP: Wheat Gross Margins (Continued)

| YEAR(End30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 4.30 | 3.90 | 5.33 | 5.10 | 3.21 | 3.36 | 3.85 | 3.17 | 3.39 |
| PRICE ($/t) | 127.50 | 120.00 | 110.00 | 102.88 | 91.86 | 59.71 | 56.99 | 55.00 | 53.17 |
| GRS.IN.($/ha) | 548.30 | 468.00 | 586.30 | 524.70 | 294.90 | 200.60 | 219.40 | 174.40 | 180.20 |
| CULT.$,hr=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| SEED ($/ha) | 27.60 | 25.49 | 22.13 | 19.03 | 13.37 | 11.16 | 10.03 | 10.25 | 10.16 |
| -price, $/t | 230.00 | 212.45 | 184.40 | 158.57 | 111.40 | 93.00 | 83.60 | 85.43 | 84.70 |
| FERTLZ ($/ha) | 29.16 | 23.57 | 23.73 | 29.41 | 28.26 | 15.23 | 9.58 | 9.37 | 10.55 |
| -urea, $/t | 233.30 | 188.55 | 189.80 | 235.30 | 226.05 | 121.80 | 76.60 | 74.95 | 84.40 |
| WD/P/DS($/ha) | 11.11 | 11.40 | 9.21 | 6.88 | 6.09 | 3.78 | 2.60 | 2.25 | 2.25 |
| -MCPA, $/l | 3.17 | 3.11 | 2.67 | 1.96 | 1.78 | 1.11 | 0.74 | 0.69 | 0.69 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| -Bayleton,$/l | | | | | | | | | |
| ~application | | | | | | | | | |
| HARVEST($/ha) | 66.35 | 60.18 | 70.89 | 52.48 | 30.66 | 24.86 | 28.49 | 23.24 | 21.12 |
| - $/t | 15.43 | 15.43 | 13.30 | 10.29 | 9.55 | 7.40 | 7.40 | 7.33 | 6.23 |
| FREIGHT($/ha) | 15.05 | 9.36 | 11.73 | 9.69 | 5.78 | 5.04 | 5.78 | 4.76 | 4.58 |
| - $/t | 3.50 | 2.40 | 2.20 | 1.90 | 1.80 | 1.50 | 1.50 | 1.50 | 1.35 |
| T.D.CST($/ha) | 168.66 | 149.01 | 154.63 | 132.44 | 93.80 | 67.11 | 62.47 | 55.61 | 54.02 |
| G.MRGIN($/ha) | 380.00 | 319.00 | 432.00 | 392.00 | 201.00 | 134.00 | 157.00 | 119.00 | 126.00 |

## Appendix 4-2 (Continued)

### CROP: Frozen Bean Gross Margins

| YEAR(End30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 11.13 | 14.57 | 15.22 | 12.87 | 9.33 | 13.97 | 11.50 | 12.24 | 9.16 |
| PRICE ($/t) | 234.81 | 234.78 | 266.00 | 224.44 | 185.49 | 186.74 | 185.63 | 163.55 | 115.61 |
| GRS.IN.($/ha) | 2613.4 | 3420.8 | 4048.5 | 2888.6 | 1730.6 | 2608.8 | 2134.8 | 2001.8 | 1059.0 |
| CULT.$,hr=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| SEED ($/ha) | 440.00 | 400.00 | 350.00 | 250.00 | 236.00 | 236.00 | 236.00 | 236.00 | 236.00 |
| -price, $/kg | 4.40 | 4.00 | 3.50 | 2.50 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 |
| FERTLZ ($/ha) | 47.25 | 48.39 | 40.25 | 35.83 | 33.45 | 33.45 | 32.35 | 27.53 | 20.46 |
| -mo super,$/t | 189.00 | 193.54 | 161.00 | 143.30 | 133.80 | 133.80 | 129.40 | 110.10 | 81.85 |
| WD/P/DS($/ha) | 39.45 | 33.21 | 28.51 | 22.78 | 22.21 | 22.21 | 22.29 | 20.64 | 17.63 |
| -MCPB, $/l | 7.27 | 7.27 | 6.67 | 5.28 | 5.38 | 5.38 | 5.73 | 5.23 | 4.38 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| T.D.CST($/ha) | 590.77 | 537.82 | 477.90 | 367.86 | 338.00 | 338.00 | 328.37 | 318.94 | 301.63 |
| G.MRGIN($/ha) | 2023.0 | 2883.0 | 3571.0 | 2521.0 | 1393.0 | 2271.0 | 1806.0 | 1683.0 | 757.00 |

### CROP: Frozen Bean Gross Margins (Continued)

| YEAR(End30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 11.29 | 10.01 | 9.67 | 2.65 | 9.53 | 10.90 | 3.70 | 5.10 | 6.50 |
| PRICE ($/t) | 107.70 | 101.56 | 110.35 | 83.06 | 82.09 | 116.06 | 85.00 | 85.00 | 80.00 |
| GRS.IN.($/ha) | 1215.9 | 1016.6 | 1067.1 | 220.10 | 782.30 | 1265.0 | 314.50 | 433.50 | 520.00 |
| CULT.$,hr=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| SEED ($/ha) | 210.00 | 200.00 | 180.00 | 160.00 | 140.00 | 120.00 | 100.00 | 100.00 | 90.00 |
| -price, $/kg | 2.10 | 2.00 | 1.80 | 1.60 | 1.40 | 1.20 | 1.00 | 1.00 | 0.90 |
| FERTLZ ($/ha) | 10.81 | 12.29 | 10.88 | 7.01 | 7.01 | 7.01 | 5.25 | 5.25 | 5.64 |
| -mo super,$/t | 43.25 | 49.15 | 43.50 | 28.05 | 28.05 | 28.05 | 21.00 | 21.00 | 22.55 |
| WD/P/DS($/ha) | 14.10 | 14.88 | 12.44 | 10.49 | 8.77 | 6.05 | 4.13 | 3.68 | 3.68 |
| -MCPB, $/l | 3.57 | 3.66 | 3.21 | 2.71 | 2.29 | 1.60 | 1.07 | 1.00 | 1.00 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| T.D.CST($/ha) | 254.30 | 246.18 | 220.26 | 192.45 | 165.43 | 140.11 | 115.37 | 114.67 | 104.68 |
| G.MRGIN($/ha) | 962.00 | 770.00 | 847.00 | 28.00 | 617.00 | 1125.0 | 199.00 | 319.00 | 415.00 |

## Appendix 4-2 (Continued

## CROP: Process Potatoes Gross Margins

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR(End30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
| YIELD (t/ha) | 42.40 | 19.20 | 35.20 | 51.20 | 31.20 | 21.60 | 8.00 | 46.40 | 27.20 |
| PRICE ($/t) | 130.50 | 133.10 | 126.40 | 112.00 | 93.00 | 83.00 | 78.00 | 67.50 | 60.00 |
| GRS.IN.($/ha) | 5533.2 | 2555.5 | 4449.3 | 5734.4 | 2901.6 | 1792.8 | 624.00 | 3132.0 | 1632.0 |
| CULT.$, hr=10 | 183.07 | 160.67 | 168.99 | 169.30 | 132.40 | 132.40 | 107.81 | 99.39 | 78.69 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| SEED $/ha | 822.50 | 822.50 | 822.50 | 822.50 | 875.00 | 875.00 | 875.00 | 819.00 | 402.50 |
| -price, $/t | 235.00 | 235.00 | 235.00 | 235.00 | 250.00 | 250.00 | 250.00 | 234.00 | 115.00 |
| CUT/DIP, $/ha | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | 10.50 | 4.17 |
| -cut/dip, $/t | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 3.00 | 1.19 |
| PLANTING,$/ha | 162.00 | 150.00 | 141.00 | 129.00 | 126.00 | 126.00 | 126.00 | 75.00 | 75.00 |
| -plntng, $/hr | 54.00 | 50.00 | 47.00 | 43.00 | 42.00 | 42.00 | 42.00 | 25.00 | 25.00 |
| FERTLZ ($/ha) | 72.90 | 62.10 | 77.00 | 52.90 | 57.80 | 57.80 | 99.40 | 79.40 | 71.90 |
| -Nphoska, $/t | 583.00 | 497.00 | 616.00 | 423.00 | 462.00 | 462.00 | | | |
| -Pot.fert,$/t | | | | | | | 159.10 | 127.00 | 115.00 |
| ROGUING($/Ha) | 50.00 | 46.00 | 44.00 | 40.00 | 39.00 | 39.00 | 39.00 | 28.00 | 28.00 |
| WD/P/DS($/ha) | 374.44 | 329.40 | 286.69 | 257.62 | 220.76 | 220.76 | 192.09 | 146.59 | 133.91 |
| disyston$/kg | 5.93 | 5.20 | 4.73 | 4.30 | 3.17 | 3.17 | 2.75 | 2.60 | 2.40 |
| application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| metasystx$/L | 24.92 | 20.00 | 17.00 | 14.76 | 11.80 | 11.80 | 13.00 | 13.50 | 17.80 |
| application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| reglone, $/L | 16.93 | 16.12 | 16.12 | 13.08 | 12.65 | 12.65 | 12.20 | 11.44 | 9.40 |
| application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| metrabusin | 113.60 | 114.12 | 94.50 | 85.75 | 66.00 | 66.00 | 61.95 | 61.25 | 56.95 |
| application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| blight ctrl. | 23.06 | 23.06 | 21.84 | 21.84 | 25.00 | 25.00 | 19.27 | | |
| application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | | |
| DIGGING($/ha) | 1780.8 | 806.4 | 1478.4 | 1638.4 | 873.60 | 604.80 | 208.00 | 1020.8 | 482.80 |
| -digging, $/t | 42.00 | 42.00 | 42.00 | 32.00 | 28.00 | 28.00 | 26.00 | 22.00 | 17.75 |
| FREIGHT($/Ha) | 678.40 | 259.20 | 475.20 | 614.40 | 273.94 | 189.65 | 64.00 | 324.80 | 152.32 |
| -frght.8k,$/t | 16.00 | 13.50 | 13.50 | 12.00 | 8.78 | 8.78 | 8.00 | 7.00 | 5.60 |
| T.D.CST($/ha) | 4141.6 | 2653.8 | 3511.3 | 3741.6 | 2615.9 | 2262.9 | 1728.8 | 2603.5 | 1429.3 |
| G.MRGIN($/ha) | 1392.0 | -98.00 | 938.00 | 1993.0 | 286.00 | -470.0 | -1105 | 529.00 | 203.00 |

## Appendix 4-2 (Continued)

### CROP: Process Potatoes Gross Margins (Continued)

| YEAR(End30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| YIELD (t/ha) | 48.80 | 31.20 | 48.00 | 42.40 | 29.60 | 48.80 | 29.60 | 42.40 | 48.00 |
| PRICE ($/t) | 57.00 | 55.00 | 55.00 | 45.00 | 42.00 | 35.20 | 35.20 | 35.20 | 35.20 |
| GRS.IN.($/ha) | 2781.6 | 1716.0 | 2640.0 | 1908.0 | 1243.2 | 1717.8 | 1041.9 | 1492.5 | 1689.6 |
| CULT.$, hr=10 | 55.40 | 54.31 | 48.44 | 42.72 | 27.57 | 20.12 | 17.14 | 16.41 | 15.33 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| SEED $/ha | 350.00 | 385.00 | 385.00 | 455.00 | 455.00 | 315.00 | 210.00 | 210.00 | 245.00 |
| -price, $/t | 100.00 | 110.00 | 110.00 | 130.00 | 130.00 | 90.00 | 60.00 | 60.00 | 70.00 |
| CUT/DIP, $/ha | 3.12 | 1.89 | 1.44 | 0.70 | 0.70 | 0.70 | 5.25 | 8.75 | 8.75 |
| -cut/dip, $/t | 0.89 | 0.54 | 0.41 | 0.20 | 0.20 | 0.20 | 1.50 | 2.50 | 2.50 |
| PLANTING,$/ha | 63.00 | 48.00 | 18.00 | 18.00 | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 |
| -plntng, $/hr | 21.00 | 16.00 | 6.00 | 6.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| FERTLZ ($/ha) | 35.80 | 40.30 | 6.90 | 41.90 | 19.40 | 19.40 | 19.40 | 17.10 | 17.10 |
| -Nphoska, $/t | | | | | | | | | |
| -Pot.fert,$/t | 57.35 | 64.40 | 59.10 | 67.10 | 31.08 | 31.08 | 31.08 | 27.30 | 27.35 |
| ROGUING($/Ha) | 23.00 | 20.00 | 18.00 | 18.00 | 15.00 | 12.00 | 12.00 | 5.00 | 5.00 |
| WD/P/DS($/ha) | 133.51 | 56.37 | 41.94 | 31.25 | 26.94 | 26.34 | 20.41 | 15.06 | 15.06 |
| disyston$/kg | 3.27 | 2.30 | 1.50 | 1.00 | 0.91 | 0.91 | 0.91 | 0.68 | 0.68 |
| application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| metasystx$/L | 7.41 | | | | | | | | |
| application | 1.60 | | | | | | | | |
| reglone, $/L | 8.11 | 5.91 | 5.68 | 4.75 | 3.93 | 3.93 | 2.00 | 1.50 | 1.50 |
| application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| metrabusin | 52.25 | | | | | | | | |
| application | 1.60 | | | | | | | | |
| blight ctrl. | | | | | | | | | |
| application | | | | | | | | | |
| DIGGING($/ha) | 732.00 | 280.80 | 432.00 | 381.60 | 266.40 | 292.80 | 177.60 | 254.40 | 192.00 |
| -digging, $/t | 15.00 | 9.00 | 9.00 | 9.00 | 9.00 | 6.00 | 6.00 | 6.00 | 4.00 |
| FREIGHT($/Ha) | 209.84 | 92.35 | 127.68 | 97.52 | 63.94 | 85.89 | 49.73 | 68.69 | 70.56 |
| -frght.8k,$/t | 4.30 | 2.96 | 2.66 | 2.30 | 2.16 | 1.76 | 1.68 | 1.62 | 1.47 |
| T.D.CST($/ha) | 1605.7 | 979.00 | 1109.4 | 1086.7 | 890.00 | 787.30 | 526.60 | 610.40 | 583.80 |
| G.MRGIN($/ha) | 1176.0 | 737.00 | 1531.0 | 821.00 | 353.00 | 930.00 | 515.00 | 882.00 | 1106.0 |

## Appendix 4-2 (Continued)

### Livestock: Corriedale Ewe Flock Gross Margins, Breeding Own Replacements

| YEAR(End 30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| Lambing % | 100.00 | 100.00 | 103.00 | 105.00 | 100.00 | 101.00 | 102.00 | 107.00 | 109.00 |
| Pm.Wth.Lmbs.$@ | 20.15 | 22.40 | 19.46 | 28.35 | 20.37 | 20.37 | 20.44 | 15.82 | 12.04 |
| " Inc. $ | 8060.0 | 8960.0 | 8018.0 | 11907 | 8148.0 | 8229.0 | 8340.0 | 6771.0 | 5249.0 |
| Str.MS Lmbs.$@ | 11.00 | 14.00 | 15.00 | 14.00 | 13.00 | 13.00 | 13.00 | 12.00 | 14.00 |
| " Inc. $ | 2200.0 | 2800.0 | 3090.0 | 2940.0 | 2600.0 | 2626.0 | 2652.0 | 2568.0 | 3052.0 |
| C.Hgt/2ths $@ | 25.00 | 26.67 | 21.23 | 38.54 | 27.00 | 27.00 | 29.40 | 18.90 | 14.07 |
| " Inc. $ | 3005.0 | 3206.0 | 2552.0 | 4632.0 | 3245.0 | 3245.0 | 3534.0 | 2272.0 | 1691.0 |
| Ewes 5yrs. $@ | 18.00 | 8.50 | 6.25 | 17.50 | 8.25 | 8.25 | 6.25 | 11.25 | 9.83 |
| " Inc. $ | 2700.0 | 1275.0 | 937.50 | 2625.0 | 1237.5 | 1237.5 | 937.50 | 1687.5 | 1474.5 |
| Cl.Wks Ews. $@ | 4.23 | 13.23 | 6.75 | 14.31 | 6.50 | 6.50 | 6.50 | 3.30 | 1.60 |
| " Inc. $ | 212.00 | 662.00 | 338.00 | 716.00 | 325.00 | 325.00 | 325.00 | 165.00 | 80.00 |
| Wool $/kg. d | 4.39 | 4.09 | 3.39 | 4.36 | 3.43 | 2.79 | 2.94 | 2.61 | 2.64 |
| " Inc. $ | 24672 | 22986 | 19052 | 24503 | 19277 | 15680 | 16523 | 14668 | 14837 |
| GRS INC /farm | 40848 | 39888 | 33986 | 45391 | 33862 | 30265 | 31081 | 26800 | 25078 |
| Shearing,$/frm | 1936.1 | 1786.7 | 1766.9 | 1614.1 | 1574.3 | 1574.3 | 1299.2 | 1147.2 | 896.00 |
| ~shring $/100 | 90.50 | 82.50 | 82.50 | 75.00 | 75.00 | 75.00 | 60.00 | 54.00 | 40.00 |
| ~T.Crh.E.$/100 | 32.00 | 30.00 | 30.00 | 25.00 | 23.00 | 23.00 | 20.00 | 15.00 | 15.00 |
| ~M.Crh.E.$/100 | 38.00 | 36.00 | 34.00 | 34.00 | 32.00 | 32.00 | 28.00 | 26.00 | 20.00 |
| WL.SHD.EX.$/fm | 451.50 | 447.80 | 426.50 | 399.00 | 373.90 | 363.90 | 302.60 | 241.40 | 180.10 |
| ~exp. $/ewe | 0.35 | 0.35 | 0.340 | 0.320 | 0.310 | 0.300 | 0.250 | 0.200 | 0.150 |
| ~exp. $/hgt | 0.27 | 0.26 | 0.230 | 0.210 | 0.170 | 0.170 | 0.140 | 0.110 | 0.080 |
| A.HEALTH $/Fm | 1702.4 | 1262.0 | 1538.0 | 1461.2 | 1338.5 | 1339.8 | 1136.7 | 1023.7 | 838.46 |
| ~dnch.ewe $/ds | 0.26 | 0.20 | 0.200 | 0.160 | 0.130 | 0.130 | 0.120 | 0.127 | 0.100 |
| ~2xDnch.LB.$/d | 0.11 | 0.08 | 0.080 | 0.080 | 0.065 | 0.065 | 0.057 | 0.053 | 0.043 |
| ~vaccn. $/ds | 0.28 | 0.27 | 0.120 | 0.120 | 0.146 | 0.146 | 0.118 | 0.098 | 0.077 |
| ~tg.ft.dck.$/F | 400.00 | 350.00 | 500.00 | 475.00 | 475.00 | 475.00 | 410.00 | 350.00 | 300.00 |
| ~dipping $/hd | 0.29 | 0.12 | 0.340 | 0.330 | 0.270 | 0.270 | 0.220 | 0.200 | 0.160 |
| CTGE,10k,$/fm | 866.40 | 738.80 | 743.80 | 658.00 | 461.00 | 463.00 | 402.70 | 375.30 | 304.60 |
| ~Prm.Lmb. $/hd | 0.596 | 0.523 | 0.523 | 0.461 | 0.320 | 0.320 | 0.260 | 0.260 | 0.210 |
| " $ total | 238.40 | 209.20 | 215.48 | 193.62 | 128.00 | 129.28 | 106.08 | 111.28 | 91.56 |
| ~Str.Lmb. $/hd | 0.597 | 0.483 | 0.483 | 0.438 | 0.360 | 0.360 | 0.300 | 0.250 | 0.200 |
| " $ total | 119.40 | 96.60 | 99.50 | 91.98 | 72.00 | 72.72 | 61.20 | 53.50 | 43.60 |
| ~C.H.2t,5yE.$@ | 0.685 | 0.584 | 0.584 | 0.503 | 0.350 | 0.350 | 0.320 | 0.280 | 0.230 |
| " $ total | 184.95 | 157.68 | 157.68 | 135.81 | 94.50 | 94.50 | 86.40 | 75.60 | 62.10 |
| ~Wk.Ewes. $/hd | 0.768 | 0.646 | 0.646 | 0.545 | 0.380 | 0.380 | 0.310 | 0.310 | 0.250 |
| " $ total | 38.40 | 32.30 | 32.30 | 27.25 | 19.00 | 19.00 | 15.50 | 15.50 | 12.50 |
| ~wool,10k, $/b | 4.06 | 3.46 | 3.40 | 2.98 | 2.10 | 2.10 | 1.90 | 1.70 | 1.35 |
| " $ total | 285.22 | 243.07 | 238.85 | 209.35 | 147.53 | 147.53 | 133.48 | 119.43 | 94.84 |
| SLNG.CHS.$/Fm | 657.00 | 630.90 | 573.00 | 777.20 | 576.40 | 581.00 | 534.80 | 455.30 | 380.00 |
| ~Yrd.Fees.$/hd | 0.43 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.26 | 0.26 | 0.26 |
| ~Commission. % | 5.50 | 4.75 | 4.75 | 4.75 | 4.75 | 4.75 | 4.75 | 4.75 | 4.75 |
| Ram Prch. $/Fm | 950.00 | 1250.0 | 1000.0 | 900.00 | 750.00 | 750.00 | 500.00 | 500.00 | 400.00 |
| ~Ram Prch.$/hd | 190.00 | 250.00 | 200.00 | 180.00 | 150.00 | 150.00 | 100.00 | 100.00 | 80.00 |
| T.D.Cst.$/farm | 6563.4 | 6116.2 | 6048.1 | 5809.4 | 5074.2 | 5072.1 | 4176.1 | 3742.9 | 2999.2 |
| T.G.Mgn.$/farm | 34285 | 33772 | 27938 | 39581 | 28788 | 25193 | 26905 | 23057 | 22079 |
| GM/SU (1279su) | 26.81 | 26.40 | 21.84 | 30.95 | 22.51 | 19.70 | 21.04 | 18.03 | 17.26 |
| GM/Ha,@17su/ha | 456.00 | 449.00 | 371.00 | 526.00 | 383.00 | 335.00 | 358.00 | 306.00 | 293.00 |
| GRev,$/ha@17su | 543.00 | 530.00 | 452.00 | 603.00 | 450.00 | 402.00 | 413.00 | 356.00 | 333.00 |

## Appendix 4-2 (Continued)

### Livestock: Corriedale Ewe Flock G.Ms., Breeding Own Replacements (Continued)

| YEAR(End 30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| Lambing % | 107.00 | 105.00 | 117.00 | 110.00 | 107.00 | 104.00 | 116.00 | 99.00 | 105.00 |
| Pm.Wth.Lmbs.$@ | 10.29 | 9.14 | 11.20 | 7.31 | 5.18 | 7.94 | 6.02 | 3.84 | 4.81 |
| " Inc. $ | 4404.0 | 3839.0 | 5242.0 | 3216.0 | 2217.0 | 3303.0 | 2793.0 | 1521.0 | 2020.0 |
| Str.MS Lmbs.$@ | 11.00 | 9.00 | 11.00 | 7.00 | 4.50 | 6.00 | 5.00 | 4.00 | 4.00 |
| " Inc. $ | 2354.0 | 1890.0 | 2574.0 | 1540.0 | 963.0 | 1248.0 | 1160.0 | 792.00 | 840.00 |
| C.Hgt/2ths $@ | 14.07 | 12.39 | 15.38 | 9.62 | 6.18 | 10.78 | 7.00 | 4.50 | 6.00 |
| " Inc. $ | 1691.0 | 1489.0 | 1849.0 | 1156.0 | 743.0 | 1296.0 | 841.00 | 541.00 | 721.00 |
| Ewes 5yrs. $@ | 9.60 | 8.00 | 8.38 | 5.38 | 3.00 | 9.98 | 8.30 | 2.80 | 2.50 |
| " Inc. $ | 1440.0 | 1200.0 | 1257.0 | 807.00 | 450.00 | 1497.0 | 1245.0 | 420.00 | 375.00 |
| Cl.Wks Ewes.$@ | 1.60 | 1.60 | 2.70 | 3.50 | 3.80 | 4.30 | 3.60 | 3.00 | 2.70 |
| " Inc. $ | 80.00 | 80.00 | 135.00 | 175.00 | 190.00 | 215.00 | 180.00 | 150.00 | 135.00 |
| Wool $/kg, d | 2.17 | 1.93 | 2.17 | 1.40 | 0.90 | 1.54 | 1.57 | 0.61 | 0.56 |
| " Inc. $ | 12195 | 10847 | 12195 | 7868.0 | 5058.0 | 8655.0 | 8823.0 | 3428.0 | 3147.0 |
| GRS INC $/farm | 21203 | 18620 | 21547 | 13965 | 9160.0 | 15709 | 14258 | 6682.0 | 6866.0 |
| Shearing,$/frm | 782.80 | 696.90 | 696.90 | 606.10 | 530.20 | 445.60 | 398.30 | 356.00 | 346.10 |
| ~shring $/100 | 35.00 | 32.00 | 32.00 | 29.00 | 26.00 | 22.00 | 20.00 | 18.00 | 18.00 |
| ~T.Crh.E.$/100 | 13.00 | 11.00 | 11.00 | 9.00 | 7.50 | 6.00 | 5.50 | 5.00 | 5.00 |
| ~M.Crh.E.$/100 | 17.50 | 15.00 | 15.00 | 12.00 | 10.00 | 8.50 | 7.00 | 6.00 | 5.00 |
| WL.SHD.EX.$/fm | 150.10 | 110.10 | 110.10 | 96.30 | 85.30 | 85.30 | 83.90 | 82.60 | 68.80 |
| ~exp. $/ewe | 0.120 | 0.080 | 0.080 | 0.070 | 0.062 | 0.062 | 0.061 | 0.060 | 0.050 |
| ~exp. $/hgt | 0.080 | 0.080 | 0.080 | 0.070 | 0.062 | 0.062 | 0.061 | 0.060 | 0.050 |
| A.HEALTH $/Frm | 790.42 | 585.94 | 575.94 | 516.60 | 453.60 | 435.60 | 384.40 | 326.80 | 331.60 |
| ~dnch.ewe $/ds | 0.100 | 0.097 | 0.097 | 0.080 | 0.070 | 0.070 | 0.060 | 0.056 | 0.056 |
| ~2xDnch.LB.$/d | 0.043 | 0.039 | 0.035 | 0.050 | 0.050 | 0.050 | 0.040 | 0.040 | 0.040 |
| ~vaccn. $/ds | 0.065 | 0.064 | 0.064 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 |
| ~tg.ft.dck.$/F | 300.00 | 110.00 | 100.00 | 80.00 | 60.00 | 60.00 | 45.00 | 35.00 | 35.00 |
| ~dipping $/hd | 0.140 | 0.140 | 0.140 | 0.110 | 0.090 | 0.080 | 0.070 | 0.050 | 0.050 |
| CTGE,10k, $/fm | 264.90 | 201.00 | 190.20 | 159.30 | 146.40 | 116.40 | 122.40 | 108.60 | 102.90 |
| ~Prm.Lmb. $/hd | 0.180 | 0.145 | 0.130 | 0.110 | 0.105 | 0.085 | 0.085 | 0.075 | 0.075 |
| " $ total | 77.04 | 60.90 | 60.84 | 48.40 | 44.94 | 35.36 | 39.44 | 29.70 | 31.50 |
| ~Str.Lmb. $/hd | 0.180 | 0.135 | 0.120 | 0.105 | 0.095 | 0.080 | 0.080 | 0.080 | 0.068 |
| " $ total | 38.52 | 28.35 | 28.08 | 23.10 | 20.33 | 16.64 | 18.56 | 15.84 | 14.28 |
| ~C.H.2t,5yE.$@ | 0.200 | 0.150 | 0.140 | 0.120 | 0.110 | 0.090 | 0.090 | 0.085 | 0.085 |
| " $ total | 54.00 | 40.50 | 37.80 | 32.40 | 29.70 | 24.30 | 24.30 | 22.95 | 22.95 |
| ~Wk.Ewes $/hd | 0.220 | 0.160 | 0.145 | 0.125 | 0.115 | 0.100 | 0.100 | 0.100 | 0.080 |
| " $ total | 11.00 | 8.00 | 7.25 | 6.25 | 5.75 | 5.00 | 5.00 | 5.00 | 4.00 |
| ~wool,10k, $/b | 1.20 | 0.90 | 0.80 | 0.70 | 0.65 | 0.50 | 0.50 | 0.50 | 0.43 |
| " $ total | 84.30 | 63.23 | 56.20 | 49.18 | 45.66 | 35.13 | 35.13 | 35.13 | 30.21 |
| SLNG.CHGS.$/Fm | 271.10 | 180.40 | 233.50 | 162.80 | 123.00 | 161.40 | 144.20 | 81.90 | 88.70 |
| ~Yrd.Fees $/hd | 0.12 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.05 | 0.05 |
| ~Commission % | 4.75 | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 | 3.00 |
| Ram Prch. $/Fm | 400.00 | 250.00 | 400.00 | 375.00 | 350.00 | 350.00 | 300.00 | 250.00 | 250.00 |
| ~Ram Prch.$/hd | 80.00 | 50.00 | 80.00 | 75.00 | 70.00 | 70.00 | 60.00 | 50.00 | 50.00 |
| T.D.Cst.$/farm | 2659.2 | 2024.3 | 2206.6 | 1916.1 | 1688.5 | 1594.3 | 1433.3 | 1205.8 | 1188.1 |
| T.G.Mgn.$/farm | 18544 | 16596 | 19340 | 12049 | 7471.0 | 14115 | 12825 | 5476.0 | 5677.0 |
| GM/SU (1279su) | 14.50 | 12.98 | 15.12 | 9.42 | 5.84 | 11.04 | 10.03 | 4.28 | 4.44 |
| GM/Ha,@17su/ha | 246.00 | 221.00 | 257.00 | 160.00 | 99.00 | 188.00 | 170.00 | 73.00 | 75.00 |
| GRev,$/ha@17su | 282.00 | 247.00 | 286.00 | 186.00 | 122.00 | 209.00 | 190.00 | 89.00 | 91.00 |

## Appendix 4-2 (Continued)

**Livestock: Corriedale 2 Yr. Flock Gross Margins,**
**Replacement by Purchase of 5 yr old ewes annually.**

| YEAR(End 30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| Lambing % | 110.00 | 110.00 | 113.30 | 115.50 | 110.00 | 111.10 | 112.20 | 117.70 | 119.90 |
| Pm.MS Lmb,$/hd | 20.15 | 22.40 | 19.46 | 28.35 | 20.37 | 20.37 | 20.44 | 15.82 | 12.04 |
| " $ total | 22165 | 24640 | 22048 | 32744 | 22407 | 22631 | 22934 | 18620 | 14436 |
| Cl.Wks Ewes $@ | 4.23 | 13.23 | 6.75 | 14.31 | 6.50 | 6.50 | 6.50 | 3.30 | 1.60 |
| " $ total | 2229 | 6972 | 3557 | 7541 | 3426 | 3426 | 3426 | 1739 | 843.00 |
| Wool $/kg, d | 4.39 | 4.09 | 3.39 | 4.36 | 3.43 | 2.79 | 2.94 | 2.61 | 2.64 |
| " $ total | 16858 | 15706 | 13018 | 16742 | 13171 | 10714 | 11290 | 10022 | 10138 |
| GRS INC $/farm | 41252 | 47318 | 38623 | 57028 | 39004 | 36770 | 37649 | 30382 | 25417 |
| Replc.Ews.$/Fm | 11900 | 9520 | 7735 | 8330 | 8330 | 8330 | 10710 | 11305 | 13685 |
| ~replc.ews. $@ | 20.00 | 16.00 | 13.00 | 14.00 | 14.00 | 14.00 | 18.00 | 19.00 | 23.00 |
| Shearing,$/frm | 1369.3 | 1264.8 | 1245.5 | 1152.6 | 1124.9 | 1124.9 | 929.80 | 832.00 | 639.70 |
| ~shring $/100 | 90.50 | 82.50 | 82.50 | 75.00 | 75.00 | 75.00 | 60.00 | 54.00 | 40.00 |
| ~T.Crh.E.$/100 | 32.00 | 30.00 | 30.00 | 25.00 | 23.00 | 23.00 | 20.00 | 15.00 | 15.00 |
| ~M.Crh.E.$/100 | 38.00 | 36.00 | 34.00 | 34.00 | 32.00 | 32.00 | 28.00 | 26.00 | 20.00 |
| WL.SHD.EX.$/fm | 350.00 | 350.00 | 340.00 | 320.00 | 310.00 | 300.00 | 250.00 | 200.00 | 150.00 |
| ~exp. $/ewe | 0.35 | 0.35 | 0.340 | 0.320 | 0.310 | 0.300 | 0.250 | 0.200 | 0.150 |
| A.HEALTH $/Fm | 1064.3 | 839.71 | 882.20 | 867.94 | 797.20 | 798.63 | 654.53 | 600.48 | 490.79 |
| ~dnch.ewe $/ds | 0.26 | 0.20 | 0.200 | 0.160 | 0.130 | 0.130 | 0.120 | 0.127 | 0.100 |
| ~2xDnch.LB.$/d | 0.11 | 0.08 | 0.080 | 0.080 | 0.065 | 0.065 | 0.057 | 0.053 | 0.043 |
| ~vaccn. $/ds | 0.28 | 0.27 | 0.120 | 0.120 | 0.146 | 0.146 | 0.118 | 0.098 | 0.077 |
| ~tg.ft.dck.$/F | 180.00 | 160.00 | 250.00 | 275.00 | 275.00 | 275.00 | 205.00 | 175.00 | 150.00 |
| ~dipping $/hd | 0.29 | 0.12 | 0.340 | 0.330 | 0.270 | 0.270 | 0.220 | 0.200 | 0.160 |
| CTGE,10k, $/fm | 1725.7 | 1432.4 | 1448.4 | 1239.2 | 862.76 | 866.28 | 735.93 | 716.43 | 581.20 |
| ~Prm.Lmb. $/hd | 0.596 | 0.523 | 0.523 | 0.461 | 0.320 | 0.320 | 0.260 | 0.260 | 0.210 |
| ~Wk.Ewes $/hd | 0.768 | 0.646 | 0.646 | 0.545 | 0.380 | 0.380 | 0.310 | 0.310 | 0.250 |
| ~repl.ewes $@ | 0.98 | 0.75 | 0.750 | 0.603 | 0.450 | 0.450 | 0.407 | 0.357 | 0.286 |
| ~wool,10k, $/b | 4.06 | 3.46 | 3.40 | 2.98 | 2.10 | 2.10 | 1.90 | 1.70 | 1.35 |
| Ram Prch. $/Fm | 760.00 | 1000.0 | 800.00 | 720.00 | 600.00 | 600.00 | 400.00 | 400.00 | 320.00 |
| ~Ram Prch.$/hd | 190.00 | 250.00 | 200.00 | 180.00 | 150.00 | 150.00 | 100.00 | 100.00 | 80.00 |
| T.D.Cst.$/farm | 17169 | 14407 | 12451 | 12630 | 12025 | 12020 | 13680 | 14054 | 15867 |
| T.G.Mgn.$/farm | 24082 | 32911 | 26172 | 44398 | 26979 | 24750 | 23969 | 16328 | 9550 |
| GM/SU (1013su) | 23.77 | 32.49 | 25.84 | 43.83 | 26.63 | 24.43 | 23.66 | 16.12 | 9.43 |
| GM/Ha,@17su/ha | 404.00 | 552.00 | 439.00 | 745.00 | 453.00 | 415.00 | 402.00 | 274.00 | 160.00 |
| GRev,$/ha@17su | 692.00 | 794.00 | 648.00 | 957.00 | 655.00 | 617.00 | 632.00 | 510.00 | 427.00 |

## Appendix 4-2 (Continued)

**Livestock: Corriedale 2 Yr.Flock Gross Margins (Continued), Replacement by Purchase of 5 yr old ewes annually.**

| YEAR(End 30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| Lambing % | 117.70 | 115.50 | 128.70 | 121.00 | 117.70 | 114.40 | 127.60 | 108.90 | 115.50 |
| Pm.MS Lmb,$/hd | 10.29 | 9.14 | 11.20 | 7.31 | 5.18 | 7.94 | 6.02 | 3.84 | 4.81 |
| " $ total | 12111 | 10557 | 14414 | 8845.0 | 6097.0 | 9083.0 | 7682.0 | 4182.0 | 5556.0 |
| Cl.Wks Ewes $@ | 1.60 | 1.60 | 2.70 | 3.50 | 3.80 | 4.30 | 3.60 | 3.00 | 2.70 |
| " $ Total | 843.00 | 843.00 | 1423.0 | 1845.0 | 2003.0 | 2266.0 | 1897.0 | 1581.0 | 1423.0 |
| Wool $/kg, d | 2.17 | 1.93 | 2.17 | 1.40 | 0.90 | 1.54 | 1.57 | 0.61 | 0.56 |
| " $ total | 8333.0 | 7411.0 | 8333.0 | 5376.0 | 3456.0 | 5914.0 | 6029.0 | 2342.0 | 2150.0 |
| GRS INC $/farm | 21287 | 18811 | 24170 | 16066 | 11555 | 17263 | 15608 | 8105.0 | 9129.0 |
| Replc.Ews.$/Fm | 8330.0 | 8330.0 | 10115 | 5950.0 | 2975.0 | 7438.0 | 5950.0 | 4760.0 | 4760.0 |
| ~replc.ewes $@ | 14.00 | 14.00 | 17.00 | 10.00 | 5.00 | 12.50 | 10.00 | 8.00 | 8.00 |
| Shearing,$/frm | 559.20 | 497.90 | 497.90 | 431.80 | 377.50 | 318.30 | 282.50 | 251.60 | 242.00 |
| ~shring $/100 | 35.00 | 32.00 | 32.00 | 29.00 | 26.00 | 22.00 | 20.00 | 18.00 | 18.00 |
| ~T.Crh.E.$/100 | 13.00 | 11.00 | 11.00 | 9.00 | 7.50 | 6.00 | 5.50 | 5.00 | 5.00 |
| ~M.Crh.E.$/100 | 17.50 | 15.00 | 15.00 | 12.00 | 10.00 | 8.50 | 7.00 | 6.00 | 5.00 |
| WL.SHD.EX.$/fm | 120.00 | 80.00 | 80.00 | 70.00 | 62.00 | 62.00 | 61.00 | 60.00 | 50.00 |
| ~exp. $/ewe | 0.120 | 0.080 | 0.080 | 0.070 | 0.062 | 0.062 | 0.061 | 0.060 | 0.050 |
| A.HEALTH $/Fm | 468.96 | 393.97 | 393.97 | 372.08 | 330.77 | 323.29 | 287.14 | 249.96 | 255.24 |
| ~dnch.ewe $/ds | 0.100 | 0.097 | 0.097 | 0.080 | 0.070 | 0.070 | 0.060 | 0.056 | 0.056 |
| ~2xDnch.LB.$/d | 0.043 | 0.039 | 0.035 | 0.050 | 0.050 | 0.050 | 0.040 | 0.040 | 0.040 |
| ~vaccn. $/ds | 0.065 | 0.064 | 0.064 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 |
| ~tg.ft.dck.$/F | 150.00 | 90.00 | 90.00 | 70.00 | 50.00 | 50.00 | 40.00 | 30.00 | 30.00 |
| ~dipping $/hd | 0.140 | 0.140 | 0.140 | 0.110 | 0.090 | 0.080 | 0.070 | 0.050 | 0.050 |
| CTGE,10k, $/fm | 496.85 | 391.46 | 368.86 | 312.53 | 286.64 | 233.25 | 240.92 | 211.77 | 202.93 |
| ~Prm.Lmb. $/hd | 0.180 | 0.145 | 0.130 | 0.110 | 0.105 | 0.085 | 0.085 | 0.075 | 0.075 |
| ~Wk.Ewes. $/hd | 0.220 | 0.160 | 0.145 | 0.125 | 0.115 | 0.100 | 0.100 | 0.100 | 0.080 |
| ~repl.ewes $@ | 0.243 | 0.204 | 0.183 | 0.167 | 0.150 | 0.123 | 0.117 | 0.113 | 0.110 |
| ~wool,10k, $/b | 1.20 | 0.90 | 0.80 | 0.70 | 0.65 | 0.50 | 0.50 | 0.50 | 0.43 |
| Ram Prch. $/Fm | 320.00 | 200.00 | 320.00 | 300.00 | 280.00 | 280.00 | 240.00 | 200.00 | 200.00 |
| ~Ram Prch.$/hd | 80.00 | 50.00 | 80.00 | 75.00 | 70.00 | 70.00 | 60.00 | 50.00 | 50.00 |
| T.D.Cst.$/farm | 10295 | 9893.0 | 1776.0 | 7436.0 | 4312.0 | 8654.0 | 7062.0 | 5733.0 | 5710.0 |
| T.G.Mgn.$/farm | 10992 | 8918.0 | 2394.0 | 8629.0 | 7244.0 | 8609.0 | 8546.0 | 2372.0 | 3419.0 |
| GM/SU (1013su) | 10.85 | 8.80 | 12.24 | 8.52 | 7.15 | 8.50 | 8.44 | 2.34 | 3.37 |
| GM/Ha,@17su/ha | 184.00 | 150.00 | 208.00 | 145.00 | 122.00 | 144.00 | 143.00 | 40.00 | 57.00 |
| GRev,$/ha@17su | 357.00 | 316.00 | 406.00 | 270.00 | 194.00 | 290.00 | 262.00 | 136.00 | 153.00 |

## Appendix 4-2 (Continued)

### CROP: Ryegrass / White Clover Gross Margins

| YEAR(End 30/6) | 88/87 | 87/86 | 86/85 | 85/84 | 84/83 | 83/82 | 82/81 | 81/80 | 80/79 |
|---|---|---|---|---|---|---|---|---|---|
| GRS.YLD, kg/ha | 879.00 | 1039 | 663.00 | 1130 | 983.00 | 786.00 | 503.00 | 250.00 | 869.00 |
| GRS.PRC, $/kg | 1.20 | 1.40 | 1.50 | 0.90 | 0.90 | 0.90 | 1.25 | 1.35 | 0.85 |
| G.SD.IN ($/ha) | 1054.8 | 1454.6 | 994.50 | 1017.0 | 884.70 | 707.40 | 628.80 | 337.50 | 738.70 |
| STRAW $/bale | 1.20 | 2.00 | 1.20 | 1.25 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| STRAW ($/ha) | 120.00 | 200.00 | 120.00 | 125.00 | 75.00 | 75.00 | 75.00 | 75.00 | 75.00 |
| G.T.G.I ($/ha) | 1174.8 | 1654.6 | 1114.5 | 1142.0 | 959.70 | 782.40 | 703.80 | 412.50 | 813.70 |
| CLV.YLD kg/ha | 312.88 | 294.94 | 277.00 | 236.00 | 335.00 | 234.00 | 315.00 | 454.00 | 345.00 |
| CLV.PRC $/kg | 2.40 | 2.80 | 3.00 | 1.80 | 2.90 | 2.90 | 3.30 | 2.30 | 1.60 |
| CL.G.IN ($/ha) | 750.90 | 825.80 | 831.00 | 424.80 | 971.50 | 678.60 | 1039.5 | 1044.2 | 552.00 |
| T.G.INC ($/ha) | 1925.7 | 2480.4 | 1945.5 | 1566.8 | 1931.2 | 1461.0 | 1743.2 | 1456.7 | 1365.6 |
| CULT.$,hrs=3.5 | 64.07 | 56.23 | 59.15 | 59.26 | 46.34 | 46.34 | 37.73 | 34.78 | 27.54 |
| - fuel $/hr | 10.76 | 9.44 | 10.50 | 10.53 | 9.13 | 9.13 | 6.90 | 6.05 | 4.21 |
| - r&m $/hr | 7.54 | 6.63 | 6.40 | 6.40 | 4.11 | 4.11 | 3.89 | 3.89 | 3.66 |
| T.SEED ($/ha) | 70.50 | 66.56 | 74.70 | 31.70 | 94.90 | 94.90 | 61.50 | 74.70 | 55.30 |
| GRS.SD ($/ha) | 59.40 | 54.56 | 59.40 | 24.20 | 81.40 | 81.40 | 49.50 | 66.00 | 48.40 |
| -gr.sd.pr,$/kg | 2.70 | 2.48 | 2.70 | 1.10 | 3.70 | 3.70 | 2.25 | 3.00 | 2.20 |
| CLV.SD ($/ha) | 11.10 | 12.00 | 15.30 | 7.50 | 13.50 | 13.50 | 12.00 | 8.70 | 6.90 |
| -cl.sd.pr,$/kg | 3.70 | 4.00 | 5.10 | 2.50 | 4.50 | 4.50 | 4.00 | 2.90 | 2.30 |
| FERTLZ ($/ha) | 119.25 | 119.69 | 122.05 | 107.45 | 114.50 | 114.50 | 110.69 | 99.89 | 65.94 |
| -urea, $/t | 400.00 | 374.00 | 457.00 | 397.00 | 450.00 | 450.00 | 435.00 | 411.00 | 270.00 |
| -super, $/t | 181.00 | 202.00 | 150.00 | 136.00 | 125.00 | 125.00 | 120.85 | 95.40 | 63.95 |
| WD/P/DS ($/ha) | 129.69 | 110.97 | 95.67 | 83.16 | 77.56 | 77.56 | 71.92 | 67.22 | 58.52 |
| -MCPB, $/l | 7.27 | 7.27 | 6.67 | 5.28 | 5.38 | 5.38 | 5.73 | 5.23 | 4.38 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| -MCPB, $/l | 7.27 | 7.27 | 6.67 | 5.28 | 5.38 | 5.38 | 5.73 | 5.23 | 4.38 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| -Nexion, $/l | 18.40 | 18.40 | 16.75 | 16.65 | 14.88 | 14.88 | 12.56 | 11.81 | 10.48 |
| ~application | 14.00 | 7.76 | 5.16 | 4.30 | 3.38 | 3.38 | 2.23 | 2.33 | 2.30 |
| Hvst Grs($/ha) | 178.60 | 172.95 | 160.60 | 148.10 | 141.10 | 141.10 | 123.20 | 109.45 | 89.20 |
| ~heading $/ha | 122.00 | 116.35 | 104.00 | 93.50 | 86.90 | 86.90 | 73.70 | 67.45 | 56.20 |
| ~Windrow $/ha | 56.60 | 56.60 | 56.60 | 54.60 | 54.20 | 54.20 | 49.50 | 42.00 | 33.00 |
| Hvst Clv($/ha) | 139.00 | 133.00 | 117.31 | 103.80 | 96.40 | 96.40 | 81.70 | 72.25 | 60.20 |
| T.Hvest ($/ha) | 317.60 | 305.95 | 277.91 | 251.90 | 237.50 | 237.50 | 204.90 | 181.7 | 149.40 |
| FGHT.grs($/ha) | 16.51 | 16.25 | 10.37 | 15.59 | 9.83 | 7.86 | 4.73 | 2.06 | 5.52 |
| - $/t | 15.97 | 13.29 | 13.29 | 11.73 | 8.50 | 8.50 | 8.00 | 7.00 | 5.40 |
| FGHT.clv($/ha) | 7.15 | 5.61 | 5.26 | 3.96 | 4.07 | 2.84 | 3.60 | 4.54 | 2.66 |
| - $/t | 15.97 | 13.29 | 13.29 | 11.73 | 8.50 | 8.50 | 8.00 | 7.00 | 5.40 |
| T.FRGHT ($/ha) | 23.66 | 21.85 | 15.63 | 19.55 | 13.90 | 10.70 | 8.34 | 6.60 | 8.18 |
| SD/DR.grs $/ha | 155.12 | 146.68 | 93.60 | 136.93 | 99.46 | 79.52 | 50.89 | 19.12 | 57.25 |
| ~S.D.rate c/kg | 0.15 | 0.12 | 0.12 | 0.103 | 0.086 | 0.086 | 0.086 | 0.065 | 0.056 |
| SD/DR.clv $/ha | 147.65 | 124.42 | 114.87 | 91.12 | 114.97 | 80.31 | 108.11 | 116.86 | 82.39 |
| - $/kg | 0.330 | 0.295 | 0.290 | 0.270 | 0.240 | 0.240 | 0.240 | 0.180 | 0.167 |
| T.SD/DR ($/ha) | 302.76 | 271.10 | 208.47 | 228.04 | 214.42 | 159.83 | 158.99 | 135.97 | 139.64 |
| T.D.CST ($/ha) | 1027.5 | 952.40 | 853.60 | 781.10 | 799.10 | 741.30 | 654.10 | 600.90 | 504.50 |
| G.MRGIN ($/ha) | 898.00 | 1528.0 | 1092.0 | 786.00 | 1132.0 | 720.00 | 1089.0 | 856.00 | 861.00 |

## Appendix 4-2 (Continued)

### CROP: Ryegrass / White Clover Gross Margins (Continued)

| YEAR(End 30/6) | 79/78 | 78/77 | 77/76 | 76/75 | 75/74 | 74/73 | 73/72 | 72/71 | 71/70 |
|---|---|---|---|---|---|---|---|---|---|
| GRS.YLD, kg/ha | 485.00 | 1063.0 | 820.00 | 627.00 | 437.00 | 844.00 | 763.00 | 789.00 | 612.00 |
| GRS.PRC, $/kg | 0.62 | 0.70 | 0.52 | 0.36 | 0.27 | 0.78 | 0.35 | 0.22 | 0.17 |
| G.SD.IN ($/ha) | 300.70 | 744.10 | 426.40 | 225.70 | 118.00 | 658.30 | 267.10 | 173.60 | 104.00 |
| STRAW $/bale | 0.60 | 0.60 | 0.40 | 0.35 | 0.30 | 0.20 | 0.20 | 0.20 | 0.18 |
| STRAW ($/ha) | 60.00 | 60.00 | 40.00 | 35.00 | 30.00 | 20.00 | 20.00 | 20.00 | 18.00 |
| G.T.Gr.I($/ha) | 360.70 | 804.10 | 466.40 | 260.70 | 148.00 | 678.30 | 287.10 | 193.60 | 122.00 |
| CLV.YLD kg/ha | 533.00 | 282.00 | 499.00 | 397.00 | 250.00 | 497.00 | 296.00 | 202.00 | 296.00 |
| CLV.PRC $/kg | 1.35 | 2.00 | 1.32 | 1.10 | 0.93 | 1.45 | 0.99 | 1.03 | 1.03 |
| CL.G.IN ($/ha) | 719.60 | 564.00 | 658.70 | 436.70 | 232.50 | 720.70 | 293.00 | 208.10 | 304.90 |
| T.G.INC ($/ha) | 1080.2 | 1368.1 | 1125.0 | 697.42 | 380.49 | 1398.9 | 580.09 | 401.64 | 426.92 |
| CULT.$,hrs=3.5 | 19.39 | 19.01 | 16.95 | 14.95 | 9.65 | 7.04 | 6.00 | 5.74 | 5.36 |
| - fuel $/hr | 2.68 | 2.57 | 2.22 | 2.22 | 1.41 | 1.00 | 0.66 | 0.64 | 0.63 |
| - r&m $/hr | 2.86 | 2.86 | 2.63 | 2.06 | 1.34 | 1.01 | 1.06 | 1.00 | 0.91 |
| T.SEED ($/ha) | 24.25 | 21.40 | 27.25 | 17.70 | 17.70 | 30.14 | 14.15 | 8.50 | 8.50 |
| GRS.SD ($/ha) | 18.70 | 15.40 | 22.00 | 13.20 | 13.20 | 24.20 | 11.00 | 5.50 | 5.50 |
| -gr.pr, $/kg | 0.85 | 0.70 | 1.00 | 0.60 | 0.60 | 1.10 | 0.50 | 0.25 | 0.25 |
| CLV.SD ($/ha) | 5.55 | 6.00 | 5.25 | 4.50 | 4.50 | 5.94 | 3.15 | 3.00 | 3.00 |
| -clv.pr, $/kg | 1.85 | 2.00 | 1.75 | 1.50 | 1.50 | 1.98 | 1.05 | 1.00 | 1.00 |
| FERTLZ ($/ha) | 52.74 | 46.33 | 45.31 | 50.06 | 48.34 | 29.06 | 18.53 | 18.23 | 20.40 |
| -urea, $/t | 233.30 | 188.55 | 189.80 | 235.30 | 226.05 | 121.80 | 76.60 | 74.95 | 84.40 |
| -super, $/t | 38.30 | 45.80 | 40.80 | 26.10 | 26.10 | 26.10 | 17.45 | 17.45 | 19.15 |
| WD/P/DS ($/ha) | 48.37 | 50.65 | 43.39 | 35.57 | 28.50 | 22.77 | 8.25 | 7.36 | 7.36 |
| -MCPB, $/l | 3.57 | 3.66 | 3.21 | 2.17 | 2.29 | 1.60 | 1.07 | 1.00 | 1.00 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| -MCPB, $/l | 3.57 | 3.66 | 3.21 | 2.71 | 2.29 | 1.60 | 1.07 | 1.00 | 1.00 |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | 0.38 | 0.18 | 0.18 |
| -Nexion, $/l | 9.29 | 9.41 | 8.66 | 6.80 | 5.11 | 5.11 | | | |
| ~application | 1.60 | 2.07 | 1.20 | 1.00 | 0.75 | 0.45 | | | |
| Hvst Gr ($/ha) | 76.35 | 73.70 | 63.00 | 51.88 | 41.85 | 24.70 | 23.50 | 23.50 | 21.02 |
| ~heading $/ha | 47.50 | 47.50 | 43.25 | 34.58 | 29.50 | 17.30 | 17.30 | 17.30 | 14.82 |
| ~Windrow $/ha | 28.85 | 26.20 | 19.75 | 17.30 | 12.35 | 7.40 | 6.20 | 6.20 | 6.20 |
| Hvst Cl($/ha) | 50.80 | 50.80 | 46.25 | 37.05 | 32.00 | 19.80 | 19.80 | 19.80 | 17.30 |
| T.Hvest ($/ha) | 127.15 | 124.50 | 109.25 | 88.93 | 73.85 | 44.50 | 43.30 | 43.30 | 38.32 |
| FGHT.grs($/ha) | 2.68 | 4.75 | 3.28 | 2.21 | 1.44 | 2.28 | 2.06 | 2.01 | 1.56 |
| - $/t | 4.70 | 3.80 | 3.40 | 3.00 | 2.80 | 2.30 | 2.30 | 2.17 | 2.17 |
| FGHT.clv($/ha) | 3.58 | 1.53 | 2.43 | 1.70 | 1.00 | 1.63 | 0.97 | 0.63 | 0.92 |
| - $/t | 4.70 | 3.80 | 3.40 | 3.00 | 2.80 | 2.30 | 2.30 | 2.17 | 2.17 |
| T.FRGHT ($/ha) | 6.26 | 6.28 | 5.71 | 3.92 | 2.44 | 3.92 | 3.04 | 2.64 | 2.48 |
| SD/DR.grs $/ha | 29.10 | 55.03 | 38.59 | 23.97 | 16.71 | 29.59 | 25.67 | 26.55 | 20.59 |
| ~S.D.rate c/kg | 0.051 | 0.044 | 0.04 | 0.0325 | 0.0325 | 0.0298 | 0.0286 | 0.0286 | 0.0286 |
| SD/DR.clv $/ha | 115.85 | 52.83 | 85.63 | 51.09 | 32.18 | 58.99 | 33.10 | 22.53 | 33.02 |
| - $/kg | 0.152 | 0.131 | 0.120 | 0.090 | 0.090 | 0.083 | 0.078 | 0.078 | 0.078 |
| T.SD/DR ($/ha) | 144.95 | 107.85 | 124.21 | 75.067 | 48.883 | 88.578 | 58.773 | 49.078 | 53.607 |
| T.D.CST ($/ha) | 423.10 | 376.00 | 372.10 | 286.20 | 229.40 | 226.00 | 152.00 | 134.90 | 136.00 |
| G.MRGIN ($/ha) | 657.00 | 992.00 | 753.00 | 411.00 | 151.00 | 1173.0 | 428.00 | 267.00 | 291.00 |

## Appendix 4-3

**FARM INPUT COST AND OUTPUT PRICE CHANGES**

| YEAR end 30/June | INPUT COST INDEX | OUTPUT PRICE INDEX | YEAR end 30/June | INPUT COST INDEX | OUTPUT PRICE INDEX |
|---|---|---|---|---|---|
| 1970/71 | 171.0 | 187.7 | 1979/80 | 525.2 | 591.9 |
| 1971/72 | 182.8 | 213.7 | 1980/81 | 631.3 | 630.2 |
| 1972/73 | 205.4 | 307.0 | 1981/82 | 743.9 | 736.5 |
| 1973/74 | 231.2 | 299.0 | 1982/83 | 781.5 | 820.2 |
| 1974/75 | 252.4 | 243.5 | 1983/84 | 838.6 | 874.9 |
| 1975/76 | 284.9 | 329.0 | 1984/85 | 973.7 | 1044.5 |
| 1976/77 | 334.3 | 380.6 | 1985/86 | 964.5 | 903.0 |
| 1977/78 | 367.8 | 416.3 | 1986/87 | 1000.0 | 1000.0 |
| 1978/79 | 414.1 | 593.5 | | | |

**Notes :**

1. Reference: New Zealand Department of Statistics. **Monthly Abstract of Statistics**. Wellington : Government Printer [Published Annually].
2. Base = 1000 (June, 1987).
3. The 1986/1987 season is chosen as base, because complete data at the time of this research was unavailable for 1987/1988 season.

# Appendix 4-4

## New Zealand Farm Holdings By Farm Type and Weightings For Different Enterprises.

Ref. : New Zealand Dept. of Statistics. Agricultural Statistics. Wellington : Government Printer. [Published Annually].
: New Zealand Dept.of Statistics. N.Z. Official Yearbook. Wellington : Government Printer. [Published Annually].

Year End 30 June

1970/71 data see 1971/72

| Enterprise | Farm Category | No. of Holdings 1971/72 | % of total 1971/72 | No. of Holdings 1972/73 | % of total 1972/73 |
|---|---|---|---|---|---|
| Dairy-Town Supply | 1 | | | | |
| Dairy-factory Sup. | 2 | 16747 | 26.67 | 15932 | 25.21 |
| Sheep | 3 | 11770 | 18.75 | 13731 | 21.73 |
| Beef | 3 | 5119 | 8.15 | 5852 | 9.26 |
| Pig | 7 | 393 | 0.63 | 531 | 0.84 |
| Cropping | 4 | 1109 | 1.77 | 987 | 1.56 |
| Dairy + Sheep | 2 | 507 | 0.81 | 473 | 0.75 |
| Dairy + Beef | 2 | 1538 | 2.45 | 1305 | 2.07 |
| Dairy + Other | 2 | 504 | 0.80 | 432 | 0.68 |
| Sheep + Dairy | 3 | 178 | 0.28 | 152 | 0.24 |
| Sheep + Beef | 3 | 6443 | 0.26 | 6331 | 10.02 |
| Sheep + Cropping | 3 | 1451 | 2.31 | 1280 | 2.03 |
| Sheep + Other | 3 | 280 | 0.45 | 328 | 0.52 |
| Beef + Dairy | 3 | 224 | 0.36 | 212 | 0.34 |
| Beef + Sheep | 3 | 1864 | 2.97 | 1307 | 2.07 |
| Beef + Other | 3 | 180 | 0.29 | 231 | 0.37 |
| Cropping + Sheep | 3 | 741 | 1.18 | 461 | 0.73 |
| Cropping + Other | 4 | 152 | 0.24 | 183 | 0.29 |
| Pig + Other | 7 | 135 | 0.22 | 124 | 0.20 |
| Stud Horse Brding | 7 | | | | |
| Deer | 7 | | | | |
| Goat | 7 | | | | |
| Sml.Animal Brdng. | 7 | | | | |
| Mixed Livestock | 3 | 6057 | 9.65 | 5215 | 8.25 |
| Genrl.Mixd.Frming. | 7 | 2161 | 3.44 | 1623 | 2.57 |
| Broiler Chicken | 5 | | | 635 | 1.00 |
| Poultry (Other) | 5 | 489 | 0.78 | | |
| Veges.incl.Tomato | 5 | 1275 | 2.03 | 1623 | 2.57 |
| Mushroom Growing | 5 | | | | |
| Pipfruit Orchards | 5 | 1881 | 3.00 | 2054 | 3.25 |
| Citrus Orchards | 5 | | | | |
| Stonefruit Orchard | 5 | | | | |
| Kiwifruit Orchards | 5 | | | | |
| Grape Growing | 5 | | | | |
| Berryfruit Growing | 5 | | | | |
| Other Fruit | 5 | | | | |
| Tobacco & Hop | 5 | 297 | 0.47 | 268 | 0.42 |
| Flower Growing | 5 | | | | |
| Plant Nurseries | 5 | | | | |
| Beekeeping | 5 | | | | |
| Plantations | 6 | 380 | 0.61 | 411 | 0.65 |
| Other Farming | 6 | 914 | 1.46 | 1515 | 2.40 |
| Idle Land & Contr. | 6 | | | | |
| TOTAL | | 62789 | 100 | 63196 | 100 |

Note: Farm types were categorised for groupings (see later this appendix)

## Appendix 4-4 (Continued)

### New Zealand Farm Holdings By Farm Type and Weightings For Different Enterprises (Continued).

1973/74 data see 1975/76

1974/75 data see 1975/76

| Enterprise | Farm Cate-gory | No. of Holdings 1975/76 | % of total 75/76 | No. of Holdings 1976/77 | % of total 76/77 | No. of Holding 1977/78 | % of total 77/78 | No. of Holdings 1978/79 | % of total 78/79 |
|---|---|---|---|---|---|---|---|---|---|
| Dairy-Town Sup. | 1 | | | | | | | | |
| Dairy-fact.Sup. | 2 | 15703 | 23.17 | 15399 | 22.46 | 15159 | 21.84 | 14756 | 20.94 |
| Sheep | 3 | 14513 | 21.41 | 16027 | 23.37 | 17035 | 24.55 | 17497 | 24.84 |
| Beef | 3 | 6868 | 10.13 | 6555 | 9.56 | 6427 | 9.26 | 6474 | 9.19 |
| Pig | 7 | 547 | 0.81 | 585 | 0.85 | 566 | 0.82 | 552 | 0.78 |
| Cropping | 4 | 1431 | 2.11 | 1432 | 2.09 | 1411 | 2.03 | 1447 | 2.05 |
| Dairy + Sheep | 2 | 394 | 0.58 | 398 | 0.58 | 393 | 0.57 | 383 | 0.54 |
| Dairy + Beef | 2 | 697 | 1.03 | 625 | 0.91 | 607 | 0.87 | 675 | 0.96 |
| Dairy + Other | 2 | 398 | 0.59 | 327 | 0.48 | 300 | 0.43 | 268 | 0.38 |
| Sheep + Dairy | 3 | 141 | 0.21 | 122 | 0.18 | 123 | 0.18 | 123 | 0.17 |
| Sheep + Beef | 3 | 5774 | 8.52 | 5424 | 7.91 | 5488 | 7.91 | 5659 | 8.03 |
| Sheep + Cropp. | 3 | 1334 | 1.97 | 1204 | 1.76 | 1195 | 1.72 | 1112 | 1.58 |
| Sheep + Other | 3 | 318 | 0.47 | 373 | 0.54 | 393 | 0.57 | 362 | 0.51 |
| Beef + Dairy | 3 | 166 | 0.24 | 133 | 0.19 | 137 | 0.20 | 160 | 0.23 |
| Beef + Sheep | 3 | 1258 | 1.86 | 1109 | 1.62 | 1025 | 1.48 | 1116 | 1.58 |
| Beef + Other | 3 | 300 | 0.44 | 276 | 0.40 | 272 | 0.39 | 241 | 0.34 |
| Cropping +Sheep | 3 | 751 | 1.11 | 600 | 0.88 | 633 | 0.91 | 499 | 0.71 |
| Cropping +Other | 4 | 219 | 0.32 | 248 | 0.36 | 208 | 0.30 | 171 | 0.24 |
| Pig + Other | 7 | 193 | 0.28 | 187 | 0.27 | 158 | 0.23 | 150 | 0.21 |
| Stud Horse Brd. | 7 | 544 | 0.80 | 629 | 0.92 | 681 | 0.98 | 637 | 0.90 |
| Deer | 7 | 11 | 0.02 | 17 | 0.02 | | | | |
| Goat | 7 | 10 | 0.01 | 19 | 0.03 | | | | |
| Sml.Animal Brd. | 7 | 7 | 0.01 | 4 | 0.01 | | | | |
| Mixed L/stock | 3 | 3746 | 5.53 | 3726 | 5.43 | 3470 | 5.00 | 3901 | 5.54 |
| Gen.Mxd.Frming. | 7 | 1384 | 2.04 | 1485 | 2.17 | 1376 | 1.98 | 1336 | 1.90 |
| Broiler Chicken | 5 | | 0.00 | 613 | 0.89 | | | | |
| Poultry (Other) | 5 | 649 | 0.96 | | 0.00 | 596 | 0.86 | 540 | 0.77 |
| Vegs.inc.Tomato | 5 | 1584 | 2.34 | 1623 | 2.37 | 1709 | 2.46 | 1621 | 2.30 |
| Mushroom | 5 | 9 | 0.01 | 9 | 0.01 | | | | |
| Pipfruit Orchd. | 5 | | 0.00 | 2149 | 3.13 | | | | |
| Citrus Orchards | 5 | | 0.00 | | 0.00 | | | | |
| Stonefruit Orc. | 5 | | 0.00 | | 0.00 | | | | |
| Kiwifruit Orch. | 5 | 2106 | 3.11 | | 0.00 | 2221 | 3.20 | 2384 | 3.38 |
| Grape Growing | 5 | | 0.00 | | 0.00 | | | | |
| Berryfruit | 5 | | 0.00 | | 0.00 | | | | |
| Other Fruit | 5 | | 0.00 | | 0.00 | | | | |
| Tobacco & Hop | 5 | 263 | 0.39 | 250 | 0.36 | 223 | 0.32 | 212 | 0.30 |
| Flower Growing | 5 | | 0.00 | | 0.00 | | | | |
| Plant Nurseries | 5 | 347 | 0.51 | 370 | 0.54 | 365 | 0.53 | 396 | 0.56 |
| Beekeeping | 5 | 24 | 0.04 | 28 | 0.04 | | | | |
| Plantations | 6 | 506 | 0.75 | 552 | 0.81 | 590 | 0.85 | 645 | 0.92 |
| Other Farming | 6 | 522 | 0.77 | 626 | 0.91 | 929 | 1.34 | 1143 | 1.62 |
| Idle Land &Con. | 6 | 5058 | 7.46 | 5447 | 7.94 | 5711 | 8.23 | 5992 | 8.51 |
| TOTAL | | 67775 | 100 | 68571 | 100 | 69401 | 100 | 70452 | 100 |

## Appendix 4-4 (Continued)

### New Zealand Farm Holdings By Farm Type and Weightings For Different Enterprises (Continued).

| Enterprise | Farm Cate-gory | No. of Holdings 1979/80 | % of total 79/80 | No. of Holdings 1980/81 | % of total 80/81 | No. of Holdings 1981/82 | % of total 81/82 | No. of Holdings 1982/83 | % of total 82/83 |
|---|---|---|---|---|---|---|---|---|---|
| Dairy-Town Sup. | 1 | 1264 | 1.77 | 1396 | 1.93 | 1383 | 1.87 | 1221 | 1.61 |
| Dairy-fact.Sup. | 2 | 13053 | 18.25 | 12453 | 17.17 | 12604 | 17.05 | 13087 | 17.28 |
| Sheep | 3 | 18934 | 26.48 | 20047 | 27.65 | 20786 | 28.12 | 20509 | 27.08 |
| Beef | 3 | 6605 | 9.24 | 6541 | 9.02 | 6354 | 8.60 | 6242 | 8.24 |
| Pig | 7 | 503 | 0.70 | 497 | 0.69 | 456 | 0.62 | 460 | 0.61 |
| Cropping | 4 | 1262 | 1.76 | 1126 | 1.55 | 1268 | 1.72 | 1308 | 1.73 |
| Dairy + Sheep | 2 | 346 | 0.48 | 350 | 0.48 | 348 | 0.47 | 351 | 0.46 |
| Dairy + Beef | 2 | 709 | 0.99 | 652 | 0.90 | 576 | 0.78 | 617 | 0.81 |
| Dairy + Other | 2 | 247 | 0.35 | 462 | 0.64 | 446 | 0.60 | 435 | 0.57 |
| Sheep + Dairy | 3 | 107 | 0.15 | 135 | 0.19 | 143 | 0.19 | 170 | 0.22 |
| Sheep + Beef | 3 | 5502 | 7.69 | 5804 | 8.00 | 5818 | 7.87 | 5721 | 7.55 |
| Sheep + Croppn. | 3 | 1041 | 1.46 | 1244 | 1.72 | 1151 | 1.56 | 1123 | 1.48 |
| Sheep + Other | 3 | 347 | 0.49 | 629 | 0.87 | 634 | 0.86 | 606 | 0.80 |
| Beef + Dairy | 3 | 127 | 0.18 | 105 | 0.14 | 91 | 0.12 | 140 | 0.18 |
| Beef + Sheep | 3 | 1095 | 1.53 | 1251 | 1.73 | 1269 | 1.72 | 1494 | 1.97 |
| Beef + Other | 3 | 258 | 0.36 | 336 | 0.46 | 327 | 0.44 | 265 | 0.35 |
| Cropping +Sheep | 3 | 478 | 0.67 | 709 | 0.98 | 709 | 0.96 | 701 | 0.93 |
| Cropping +Other | 4 | 144 | 0.20 | 205 | 0.28 | 214 | 0.29 | 187 | 0.25 |
| Pig + Other | 7 | 126 | 0.18 | 184 | 0.25 | 190 | 0.26 | 165 | 0.22 |
| Stud Horse Brd. | 7 | 477 | 0.67 | 559 | 0.77 | 739 | 1.00 | 777 | 1.03 |
| Deer | 7 | | | 261 | 0.36 | | | 466 | 0.62 |
| Goat | 7 | | | 103 | 0.14 | | | | |
| Sml.Animal Brd. | 7 | | | 21 | 0.03 | | | | |
| Mixed Livestock | 3 | 3963 | 5.54 | 5319 | 7.34 | 2353 | 3.18 | 2480 | 3.27 |
| Gen.Mxd.Frming. | 7 | 1333 | 1.86 | | | | | | |
| Broiler Chicken | 5 | 78 | 0.11 | 86 | 0.12 | 87 | 0.12 | | |
| Poultry (Other) | 5 | 406 | 0.57 | 372 | 0.51 | 348 | 0.47 | | |
| Vegs.inc.Tomato | 5 | 1525 | 2.13 | 1486 | 2.05 | 1593 | 2.15 | 1737 | 2.29 |
| Mushroom | 5 | | | 8 | 0.01 | | | | |
| Pipfruit Orch. | 5 | | | 3066 | 4.23 | | | | |
| Citrus Orchards | 5 | | | | | | | | |
| Stonefruit Orc. | 5 | | | | | | | | |
| Kiwifruit Orch. | 5 | 2587 | 3.62 | | | 2001 | 2.71 | 3584 | 4.73 |
| Grape Growing | 5 | | | | | | | | |
| Berryfruit | 5 | | | | | | | | |
| Other Fruit | 5 | | | | | | | | |
| Tobacco & Hop | 5 | 192 | 0.27 | 179 | 0.25 | 107 | 0.14 | | |
| Flower Growing | 5 | | | 107 | 0.15 | | | | |
| Plant Nurseries | 5 | 434 | 0.61 | 509 | 0.70 | 431 | 0.58 | 414 | 0.55 |
| Beekeeping | 5 | | | 33 | 0.05 | | | | |
| Plantations | 6 | 698 | 0.98 | 764 | 1.05 | 795 | 1.08 | 791 | 1.04 |
| Other Farming | 6 | 1503 | 2.10 | 267 | 0.37 | 5656 | 7.65 | 5265 | 6.95 |
| Idle Land &Con. | 6 | 6161 | 8.62 | 5249 | 7.24 | 5048 | 6.83 | 5429 | 7.17 |
| TOTAL | | 71505 | 100 | 72515 | 100 | 73925 | 100 | 75745 | 100 |

## Appendix 4-4 (Continued)

### New Zealand Farm Holdings By Farm Type and Weightings For Different Enterprises (Continued).

| Enterprise | Farm Cate-gory | No. of Holdings 1983/84 | % of total 83/84 | No. of Holdings 1984/85 | % of total 84/85 | No. of Holdings 1985/86 | % of total | No. of Holdings 1986/87 | % of total 86/87 |
|---|---|---|---|---|---|---|---|---|---|
| Dairy-Town Sup. | 1 | 1141 | 1.49 | 1114 | 1.41 | 1026 | 1.29 | | |
| Dairy-fact.Sup. | 2 | 13361 | 17.44 | 13325 | 16.91 | 13332 | 16.70 | 15618 | 19.33 |
| Sheep | 3 | 19917 | 25.99 | 18752 | 23.79 | 17831 | 22.34 | 36755 | 45.49 |
| Beef | 3 | 6482 | 8.46 | 7158 | 9.08 | 7864 | 9.85 | | |
| Pig | 7 | 404 | 0.53 | 414 | 0.53 | 380 | 0.48 | 502 | 0.62 |
| Cropping | 4 | 1407 | 1.84 | 1450 | 1.84 | 1468 | 1.84 | 1969 | 2.44 |
| Dairy + Sheep | 2 | 347 | 0.45 | 305 | 0.39 | 308 | 0.39 | | |
| Dairy + Beef | 2 | 633 | 0.83 | 734 | 0.93 | 786 | 0.98 | | |
| Dairy + Other | 2 | 452 | 0.59 | 500 | 0.63 | 567 | 0.71 | | |
| Sheep + Dairy | 3 | 211 | 0.28 | 198 | 0.25 | 203 | 0.25 | | |
| Sheep + Beef | 3 | 5625 | 7.34 | 5853 | 7.43 | 5828 | 7.30 | | |
| Sheep +Cropping | 3 | 1179 | 1.54 | 1115 | 1.41 | 1026 | 1.29 | | |
| Sheep + Other | 3 | 628 | 0.82 | 746 | 0.95 | 850 | 1.06 | | |
| Beef + Dairy | 3 | 205 | 0.27 | 180 | 0.23 | 269 | 0.34 | | |
| Beef + Sheep | 3 | 1562 | 2.04 | 1745 | 2.21 | 2184 | 2.74 | | |
| Beef + Other | 3 | 291 | 0.38 | 410 | 0.52 | 562 | 0.70 | | |
| Cropping +Sheep | 3 | 747 | 0.97 | 757 | 0.96 | 744 | 0.93 | | |
| Cropping +Other | 4 | 199 | 0.26 | 195 | 0.25 | 235 | 0.29 | | |
| Pig + Other | 7 | 149 | 0.19 | 124 | 0.16 | 128 | 0.16 | | |
| Stud Horse Brd. | 7 | 1258 | 1.64 | 1432 | 1.82 | 1340 | 1.68 | 1466 | 1.81 |
| Deer | 7 | 642 | 0.84 | 857 | 1.09 | 1020 | 1.28 | 1088 | 1.35 |
| Goat | 7 | 305 | 0.40 | 470 | 0.60 | 773 | 0.97 | 974 | 1.21 |
| Sml.Animal Brd. | 7 | 37 | 0.05 | 64 | 0.08 | 58 | 0.07 | 41 | 0.05 |
| Mixed Livestock | 3 | 2745 | 3.58 | 3043 | 3.86 | 2708 | 3.39 | 3114 | 3.85 |
| Gen.Mixd.Fming. | 7 | | | | | | | | |
| Broiler Chicken | 5 | 85 | 0.11 | 97 | 0.12 | 109 | 0.14 | | |
| Poultry (Other) | 5 | 331 | 0.43 | 313 | 0.40 | 317 | 0.40 | | |
| Vegs.inc.Tomato | 5 | 1665 | 2.17 | 1722 | 2.19 | 1821 | 2.28 | 1860 | 2.30 |
| Mushroom | 5 | 12 | 0.02 | 11 | 0.01 | 12 | 0.02 | 11 | 0.01 |
| Pipfruit Orch. | 5 | 761 | 0.99 | 770 | 0.98 | 821 | 1.03 | 877 | 1.09 |
| Citrus Orchard | 5 | 295 | 0.38 | 275 | 0.35 | 286 | 0.36 | 291 | 0.36 |
| Stonefruit | 5 | 287 | 0.37 | 304 | 0.39 | 317 | 0.40 | 317 | 0.39 |
| Kiwifruit Orch. | 5 | 1958 | 2.56 | 2081 | 2.64 | 2392 | 3.00 | 2662 | 3.29 |
| Grape Growing | 5 | 366 | 0.48 | 377 | 0.48 | 357 | 0.45 | 334 | 0.41 |
| Berryfruit | 5 | 375 | 0.49 | 406 | 0.52 | 402 | 0.50 | 379 | 0.47 |
| Other Fruit | 5 | 628 | 0.82 | 721 | 0.91 | 647 | 0.81 | 715 | 0.88 |
| Tobacco & Hop | 5 | 116 | 0.15 | 107 | 0.14 | 94 | 0.12 | 85 | 0.11 |
| Flower Growing | 5 | 240 | 0.31 | 276 | 0.35 | 288 | 0.36 | 343 | 0.42 |
| Plant Nurseries | 5 | 438 | 0.57 | 425 | 0.54 | 410 | 0.51 | 391 | 0.48 |
| Beekeeping | 5 | 49 | 0.06 | 63 | 0.08 | 58 | 0.07 | 55 | 0.07 |
| Plantations | 6 | 758 | 0.99 | 994 | 1.26 | 1090 | 1.37 | 1106 | 1.37 |
| Other Farming | 6 | 1804 | 2.35 | 1348 | 1.71 | 1324 | 1.66 | 1667 | 2.06 |
| Idle Land &Con. | 6 | 6538 | 8.53 | 7577 | 9.61 | 7589 | 9.51 | 8176 | 0.12 |
| TOTAL | | 76633 | 100 | 78808 | 100 | 79824 | 100 | 80796 | 100 |

## Appendix 4-4 (Continued)

## Enterprise Weightings to Determine $R_m$ for N.Z.Agriculture

### A. Groupings (Percent of New Zealand Agriculture):

| Year : | 1. Dairy T.S. | 2. Dairy+ Others | 3.Sheep+ Beef+ others +mixed L/stck | 4. Crop + Others | 5.Orch.+ Pltry+ Veges+ Flwrs+ +etc | 6.Idle+ Rsch.+ Educ.+ Plntn. +etc | 7. OTHERS | 8. TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1970/71 | 1.750 | 28.981 | 54.639 | 2.008 | 6.278 | 2.061 | 4.283 | 100.0 |
| 1971/72 | 1.750 | 28.981 | 54.639 | 2.008 | 6.278 | 2.061 | 4.283 | 100.0 |
| 1972/73 | 1.750 | 26.958 | 55.541 | 1.851 | 7.247 | 3.048 | 3.605 | 100.0 |
| 1973/74 | 1.750 | 23.616 | 51.891 | 2.435 | 7.351 | 8.980 | 3.978 | 100.0 |
| 1974/75 | 1.750 | 23.616 | 51.891 | 2.435 | 7.351 | 8.980 | 3.978 | 100.0 |
| 1975/76 | 1.750 | 23.616 | 51.891 | 2.435 | 7.351 | 8.980 | 3.978 | 100.0 |
| 1976/77 | 1.750 | 22.676 | 51.843 | 2.450 | 7.353 | 9.662 | 4.267 | 100.0 |
| 1977/78 | 1.750 | 21.966 | 52.158 | 2.333 | 7.369 | 10.418 | 4.007 | 100.0 |
| 1978/79 | 1.750 | 21.077 | 52.722 | 2.297 | 7.314 | 11.043 | 3.797 | 100.0 |
| 1979/80 | 1.768 | 20.076 | 53.782 | 1.966 | 7.303 | 11.694 | 3.411 | 100.0 |
| 1980/81 | 1.925 | 19.192 | 58.085 | 1.835 | 8.062 | 8.660 | 2.241 | 100.0 |
| 1981/82 | 1.871 | 18.903 | 53.615 | 2.005 | 6.178 | 15.555 | 1.874 | 100.0 |
| 1982/83 | 1.612 | 19.130 | 52.084 | 1.974 | 7.571 | 15.163 | 2.466 | 100.0 |
| 1983/84 | 1.489 | 19.304 | 51.664 | 2.096 | 9.925 | 11.875 | 3.647 | 100.0 |
| 1984/85 | 1.414 | 18.861 | 50.702 | 2.087 | 10.085 | 12.586 | 4.265 | 100.0 |
| 1985/86 | 1.285 | 18.783 | 50.197 | 2.133 | 10.437 | 12.531 | 4.634 | 100.0 |
| 1986/87 | 1.750 | 17.580 | 49.345 | 2.437 | 10.298 | 13.551 | 5.039 | 100.0 |

**B. WEIGHTS:**

| Year | 1. Dairy T.S. | 2. Dairy F.S. | 3.Shp., Beef& Mx.Stk | TOTAL |
|---|---|---|---|---|
| 1970/71 | 2.05 | 33.95 | 64.00 | 100.0 |
| 1971/72 | 2.05 | 33.95 | 64.00 | 100.0 |
| 1972/73 | 2.08 | 32.00 | 65.93 | 100.0 |
| 1973/74 | 2.27 | 30.57 | 67.17 | 100.0 |
| 1974/75 | 2.27 | 30.57 | 67.17 | 100.0 |
| 1975/76 | 2.27 | 30.57 | 67.17 | 100.0 |
| 1976/77 | 2.29 | 29.73 | 67.97 | 100.0 |
| 1977/78 | 2.31 | 28.95 | 68.74 | 100.0 |
| 1978/79 | 2.32 | 27.90 | 69.79 | 100.0 |
| 1979/80 | 2.34 | 26.55 | 71.12 | 100.0 |
| 1980/81 | 2.43 | 24.23 | 73.34 | 100.0 |
| 1981/82 | 2.51 | 25.41 | 72.07 | 100.0 |
| 1982/83 | 2.21 | 26.27 | 71.52 | 100.0 |
| 1983/84 | 2.05 | 26.64 | 71.30 | 100.0 |
| 1984/85 | 1.99 | 26.57 | 71.43 | 100.0 |
| 1985/86 | 1.83 | 26.73 | 71.44 | 100.0 |
| 1986/87 | 2.55 | 25.60 | 71.85 | 100.0 |

**C. The Index as a % of the Total New Zealand Agriculture**

| Year | 1+2+3 | 1+2+3+6 | 1+..+4+6[1] |
|---|---|---|---|
| 1970/71 | 85.37 | 87.43 | 89.44 |
| 1971/72 | 85.37 | 87.43 | 89.44 |
| 1972/73 | 84.25 | 87.30 | 89.15 |
| 1973/74 | 77.26 | 86.24 | 88.67 |
| 1974/75 | 77.26 | 86.24 | 88.67 |
| 1975/76 | 77.26 | 86.24 | 88.67 |
| 1976/77 | 76.27 | 85.93 | 88.38 |
| 1977/78 | 75.87 | 86.29 | 88.62 |
| 1978/79 | 75.55 | 86.59 | 88.89 |
| 1979/80 | 75.63 | 87.32 | 89.29 |
| 1980/81 | 79.20 | 87.86 | 89.70 |
| 1981/82 | 74.39 | 89.94 | 91.95 |
| 1982/83 | 72.83 | 87.99 | 89.96 |
| 1983/84 | 72.46 | 84.33 | 86.43 |
| 1984/85 | 70.98 | 83.56 | 85.65 |
| 1985/86 | 70.26 | 82.80 | 84.93 |
| 1986/87 | 68.68 | 82.23 | 84.66 |

Note: 1. See Table A, above.

## Appendix 4-5

### A. N.Z. FACTORY MILK SUPPLY DAIRY FARM RETURNS

| YEAR end 30/6 | AREA ha. | GROSS REV. $/ha | WKING. EXPN. $/ha | GROSS MARGIN $/ha | YEAR end 30/6 | AREA ha. | GROSS REV. $/ha | WKING. EXPN. $/ha | GROSS MARGIN $/ha |
|---|---|---|---|---|---|---|---|---|---|
| 70/71 | 64 | 217.80 | 94.61 | 123.19 | 79/80 | 66 | 681.02 | 295.50 | 385.52 |
| 71/72 | 67 | 278.84 | 112.55 | 166.29 | 80/81 | 63 | 852.79 | 376.92 | 475.87 |
| 72/73 | 70 | 304.04 | 121.63 | 182.41 | 81/82 | 64 | 1043.00 | 464.56 | 578.44 |
| 73/74 | 70 | 326.47 | 135.34 | 191.13 | 82/83 | 64 | 1187.13 | 517.72 | 669.41 |
| 74/75 | 72 | 339.86 | 141.68 | 198.18 | 83/84 | 64 | 1334.72 | 583.86 | 750.86 |
| 75/76 | 73 | 368.23 | 139.32 | 228.91 | 84/85 | 67 | 1538.58 | 654.48 | 884.10 |
| 76/77 | 70 | 437.40 | 177.73 | 259.67 | 85/86 | 67 | 1497.27 | 659.64 | 837.63 |
| 77/78 | 69 | 438.20 | 188.23 | 249.97 | 86/87 | 67 | 1497.27 | 659.64 | 837.63 |
| 78/79 | 67 | 557.97 | 220.94 | 337.03 | | | | | |

**Notes:**

1. Reference: New Zealand Dairy Board. Economic Survey of Factory Supply Dairy Farms. New Zealand : N.Z. Dairy Board. [Published Annually].
2. The last set of published data available at the time of this research was for the 1985/86 season. The 1986/87 season was assumed to be the same as for 1985/86 season.

## Appendix 4-5 (Continued)

### B. N.Z. TOWN MILK SUPPLY DAIRY RETURNS

| YEAR end 30/6 | AREA ha. | GROSS REV. $/ha | WKING. EXPN. $/ha | GROSS MARGIN $/ha | YEAR end 30/6 | AREA ha. | GROSS REV. $/ha | WKING. EXPN. $/ha | GROSS MARGIN $/ha |
|---|---|---|---|---|---|---|---|---|---|
| 70/71 | 62.4 | 327.42 | 145.29 | 182.13 | 79/80 | 82.7 | 847.90 | 397.81 | 450.09 |
| 71/72 | 64.9 | 397.37 | 162.54 | 234.83 | 80/81 | 83.7 | 1028.15 | 469.04 | 559.11 |
| 72/73 | 73.6 | 432.07 | 179.33 | 252.74 | 81/82 | 86.6 | 1189.88 | 531.02 | 658.86 |
| 73/74 | 73.8 | 486.11 | 212.99 | 273.12 | 82/83 | 87.9 | 1393.41 | 649.87 | 743.54 |
| 74/75 | 74.7 | 513.09 | 205.60 | 307.49 | 83/84 | 83.6 | 1488.73 | 691.47 | 797.26 |
| 75/76 | 75.2 | 512.14 | 204.16 | 307.98 | 84/85 | 84.8 | 1686.75 | 755.28 | 931.47 |
| 76/77 | 79.4 | 591.37 | 248.30 | 343.07 | 85/86 | 81.0 | 1826.10 | 811.31 | 1014.8 |
| 77/78 | 80.9 | 638.32 | 265.55 | 372.77 | 86/87 | 81.0 | 1826.10 | 811.31 | 1014.8 |
| 78/79 | 76.2 | 784.06 | 313.67 | 470.39 | | | | | |

**Notes:**

1. Reference: Moffit, R.G. An Economic Survey of N.Z. Town Milk Producers. (Agribusiness and Economics Research Unit. Research Report. Lincoln College). [Published Annually].
2. The last set of published data available at the time of this research was for the 1985/86 season. The 1986/87 season was assumed to be the same as for the 1985/86 season.

## Appendix 4-6

## N.Z. MEAT & WOOL BOARDS' ECONOMIC SERVICE FARM CLASS 8 RETURNS

| YEAR end 30/6 | AREA ha. | GROSS REV. $/ha | WKING. EXPN. $/ha | GROSS MARGIN $/ha | YEAR end 30/6 | AREA ha. | GROSS REV. $/ha | WKING. EXPN. $/ha | GROSS MARGIN $/ha |
|---|---|---|---|---|---|---|---|---|---|
| 70/71 | 212 | 114.17 | 52.15 | 62.02 | 79/80 | 229 | 326.98 | 145.37 | 181.62 |
| 71/72 | 216 | 116.27 | 55.84 | 60.43 | 80/81 | 228 | 437.94 | 189.90 | 248.04 |
| 72/73 | 212 | 169.81 | 72.35 | 97.45 | 81/82 | 231 | 471.86 | 224.11 | 247.75 |
| 73/74 | 229 | 177.21 | 83.83 | 93.38 | 82/83 | 248 | 578.73 | 316.10 | 262.63 |
| 74/75 | 227 | 146.47 | 88.63 | 57.84 | 83/84 | 266 | 617.14 | 347.52 | 269.63 |
| 75/76 | 222 | 238.99 | 94.81 | 144.18 | 84/85 | 268 | 720.18 | 378.53 | 341.65 |
| 76/77 | 232 | 260.95 | 110.08 | 150.87 | 85/86 | 264 | 598.14 | 403.31 | 194.83 |
| 77/78 | 235 | 262.54 | 114.73 | 147.81 | 86/87 | 261 | 595.20 | 337.32 | 257.88 |
| 78/79 | 213 | 301.77 | 131.44 | 170.33 | | | | | |

**Notes:**

1. Reference: New Zealand Meat and Wool Boards' Economic Service. The New Zealand Sheep and Beef Farm Survey. Wellington : Government Printer. [Published Annually].
2. The last set of published data available at the time of this research was for the 1986/87 season.

## Appendix 4-7

### NEW ZEALAND GROSS AGRICULTURAL PRODUCTION

| YEAR | GROSS AGRIC PRODN $mill | TOTAL AREA OF FARMS '000 ha | GROSS AGRIC. PRODN/ha $/ha | YEAR | GROSS AGRIC PRODN $mill | TOTAL AREA OF FARMS '000 ha | GROSS AGRIC. PRODN/ha $/ha |
|---|---|---|---|---|---|---|---|
| 1970/71 | 1000 | 17422.8 | 57.40 | 1979/80 | 4520 | 21237.3 | 212.83 |
| 1971/72 | 1247 | 19030.4 | 65.53 | 1980/81 | 4549 | 21249.6 | 214.07 |
| 1972/73 | 1668 | 20667.4 | 80.71 | 1981/82 | 5000 | 21263.6 | 235.14 |
| 1973/74 | 1714 | 20772.0 | 82.51 | 1982/83 | 5092 | 21266.1 | 239.44 |
| 1974/75 | 1394 | 20937.8 | 66.58 | 1983/84 | 5900 | 21224.3 | 277.98 |
| 1975/76 | 1913 | 21223.7 | 90.14 | 1984/85 | 7579 | 21376.8 | 354.54 |
| 1976/77 | 2775 | 21225.5 | 130.74 | 1985/86 | 6900 | 21331.0 | 323.47 |
| 1977/78 | 2768 | 21254.4 | 130.23 | 1986/87 | 6979 | 17795.0 | 392.19 |
| 1978/79 | 3470 | 21231.3 | 163.44 | | | | |

**Reference :** New Zealand Dept. of Statistics. Agricultural Statistics. Wellington : Government Printer. [Published Annually].

# Appendix 5-1

## Alternative Farm Sector Capital Asset Pricing Models for the Lincoln University Mixed Cropping Farm

**Model = Non - deflated, Gross Revenue, $R_m$ = Unweighted Index, $R_f$ = $170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ $/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Non-syst. Risk $\sigma_i(1-r_{im})$ $/ha | Systmat. Risk $r_{im}\sigma_i$ $/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 0.949 | 687.46 | 0.962 | 839.62 | 152.16 | 417.87 | 15.75 | 402.12 |
| F.Barley | 0.430 | 410.60 | 0.899 | 473.54 | 62.95 | 202.67 | 20.39 | 182.28 |
| Fld.Peas | 0.725 | 615.29 | 0.846 | 681.47 | 66.18 | 362.85 | 55.70 | 307.15 |
| Frz.Peas | 0.976 | 773.99 | 0.912 | 858.68 | 84.69 | 453.48 | 39.91 | 413.56 |
| Frz.Bean | 2.455 | 1572.23 | 0.950 | 1902.22 | 329.99 | 1094.62 | 54.38 | 1040.23 |
| P.Potato | 2.142 | 2297.19 | 0.735 | 1681.33 | -615.86 | 1235.55 | 327.96 | 907.58 |
| Ryegrass | 0.842 | 641.42 | 0.875 | 764.37 | 122.95 | 407.98 | 51.05 | 356.93 |
| W.Clover | 0.399 | 617.97 | 0.638 | 451.70 | -166.27 | 265.33 | 96.16 | 169.17 |
| Rgrs/Clv | 1.242 | 1259.38 | 0.894 | 1046.08 | -213.30 | 588.74 | 62.63 | 526.10 |
| SheepBOR | 0.332 | 308.34 | 0.949 | 404.38 | 96.04 | 148.27 | 7.52 | 140.75 |
| SheepPR | 0.508 | 448.36 | 0.939 | 528.82 | 80.46 | 229.59 | 14.12 | 215.48 |

**Model = Non - deflated, Gross Revenue, $R_m$ = Farm Class 8, $R_f$ = $170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ $/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ $/ha | Systemt. Risk $r_{im}\sigma_i$ $/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.031 | 687.46 | 0.949 | 557.64 | -129.82 | 417.87 | 21.38 | 396.49 |
| F.Barley | 0.944 | 410.60 | 0.909 | 350.17 | -60.43 | 202.67 | 18.39 | 184.29 |
| Fld.Peas | 1.608 | 615.29 | 0.865 | 476.94 | -138.36 | 362.85 | 48.90 | 313.95 |
| Frz.Peas | 2.091 | 773.99 | 0.900 | 569.04 | -204.95 | 453.48 | 45.32 | 408.16 |
| Frz.Bean | 4.891 | 1572.23 | 0.872 | 1103.43 | -468.80 | 1094.62 | 139.87 | 954.75 |
| P.Potato | 4.188 | 2297.19 | 0.662 | 969.31 | -1327.88 | 1235.55 | 417.98 | 817.57 |
| Ryegrass | 1.689 | 641.42 | 0.808 | 492.35 | -149.07 | 407.98 | 78.27 | 329.72 |
| W.Clover | 0.828 | 617.97 | 0.609 | 327.98 | -289.99 | 265.33 | 103.74 | 161.59 |
| Rgrs/Clv | 2.517 | 1259.38 | 0.835 | 650.33 | -609.05 | 588.74 | 97.43 | 491.31 |
| SheepBOR | 0.735 | 308.34 | 0.968 | 310.30 | 1.96 | 148.27 | 4.76 | 143.50 |
| SheepPR | 1.142 | 448.36 | 0.971 | 387.91 | -60.44 | 229.59 | 6.70 | 222.89 |

KEY: F. Barley = Feed Barley; Frz. Bean = Frozen Bean
Fld. Peas = Field Peas; P.Potato = Process Potato
Frz. Peas = Frozen Peas; W.Clover = White Clover
SheepBOR = Sheep (Corriedales, breeding own ewe replacements)
SheepPR = Sheep (Corriedales, purchasing 5 year old ewe replacements)

## Appendix 5-1 (Continued)

**Model = Non - deflated, Gross Revenue, $R_m$ = N.Z.Agriculture, $R_f$ = $170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ $/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ $/ha | Systemt. Risk $r_{im}\sigma_i$ $/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.256 | 687.46 | 0.958 | 508.15 | -179.30 | 417.87 | 17.67 | 400.21 |
| F.Barley | 1.057 | 410.60 | 0.925 | 328.40 | -82.20 | 202.67 | 15.21 | 187.46 |
| Fld.Peas | 1.810 | 615.29 | 0.885 | 441.21 | -174.08 | 362.85 | 41.87 | 320.98 |
| Frz.Peas | 2.355 | 773.99 | 0.921 | 522.95 | -251.03 | 453.48 | 35.76 | 417.72 |
| Frz.Bean | 5.623 | 1572.23 | 0.911 | 1012.78 | -559.45 | 1094.62 | 97.18 | 997.43 |
| P.Potato | 4.489 | 2297.19 | 0.644 | 842.81 | -1454.38 | 1235.55 | 439.28 | 796.27 |
| Ryegrass | 1.958 | 641.42 | 0.851 | 463.47 | -177.94 | 407.98 | 60.66 | 347.33 |
| W.Clover | 0.866 | 617.97 | 0.579 | 299.86 | -318.11 | 265.33 | 111.64 | 153.69 |
| Rgrs/Clv | 2.824 | 1259.38 | 0.851 | 593.33 | -666.05 | 588.74 | 87.72 | 501.01 |
| SheepBOR | 0.804 | 308.34 | 0.962 | 290.55 | -17.79 | 148.27 | 5.60 | 142.67 |
| SheepPR | 1.251 | 448.36 | 0.966 | 357.48 | -90.87 | 229.59 | 7.71 | 221.89 |

**Model = Non - deflated, Gross Revenue, $R_m$ = N.Z. Grs.Ag.Prdn., $R_f$ = $170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ $/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ $/ha | Systemt. Risk $r_{im}\sigma_i$ $/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 3.790 | 687.46 | 0.954 | 220.60 | -466.86 | 417.87 | 19.40 | 398.47 |
| F.Barley | 1.784 | 410.60 | 0.926 | 193.82 | -216.78 | 202.67 | 15.10 | 187.58 |
| Fld.Peas | 2.954 | 615.29 | 0.856 | 209.43 | -405.86 | 362.85 | 52.33 | 310.52 |
| Frz.Peas | 3.988 | 773.99 | 0.925 | 223.24 | -550.75 | 453.48 | 34.23 | 419.25 |
| Frz.Bean | 9.403 | 1572.23 | 0.903 | 295.53 | -1276.69 | 1094.62 | 106.01 | 988.61 |
| P.Potato | 7.522 | 2297.19 | 0.640 | 270.41 | -2026.77 | 1235.55 | 444.77 | 790.78 |
| Ryegrass | 3.475 | 641.42 | 0.895 | 216.39 | -425.03 | 407.98 | 42.64 | 365.34 |
| W.Clover | 1.497 | 617.97 | 0.593 | 189.99 | -427.98 | 265.33 | 107.91 | 157.42 |
| Rgrs/Clv | 4.972 | 1259.38 | 0.888 | 236.38 | -1023.00 | 588.74 | 65.98 | 522.76 |
| SheepBOR | 1.367 | 308.34 | 0.969 | 188.25 | -120.09 | 148.27 | 4.58 | 143.69 |
| SheepPR | 2.095 | 448.36 | 0.959 | 197.96 | -250.39 | 229.59 | 9.38 | 220.22 |

**Model = Non - deflated, Gross Margin, $R_m$ = Unweighted Index, $R_f$ = $170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ $/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ $/ha | Systemt. Risk $r_{im}\sigma_i$ $/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 1.090 | 456.34 | 0.907 | 534.92 | 78.58 | 268.17 | 24.86 | 243.32 |
| F.Barley | 0.218 | 207.36 | 0.601 | 243.03 | 35.66 | 81.05 | 32.36 | 48.69 |
| Fld.Peas | 0.704 | 377.92 | 0.688 | 405.62 | 27.70 | 228.22 | 71.12 | 157.10 |
| Frz.Peas | 1.346 | 608.99 | 0.809 | 620.67 | 11.69 | 371.48 | 70.99 | 300.49 |
| Frz.Bean | 4.119 | 1303.88 | 0.934 | 1549.02 | 245.15 | 984.40 | 64.91 | 919.49 |
| P.Potato | 0.068 | 607.43 | 0.021 | 192.81 | -414.62 | 712.58 | 697.37 | 15.21 |
| Ryegrass | 0.769 | 311.09 | 0.687 | 427.61 | 116.51 | 250.06 | 78.30 | 171.76 |
| W.Clover | 0.146 | 365.73 | 0.170 | 218.73 | -147.00 | 190.84 | 158.34 | 32.49 |
| Rgrs/Clv | 1.279 | 775.70 | 0.782 | 598.01 | -177.69 | 365.04 | 79.66 | 285.38 |
| SheepBOR | 0.515 | 265.37 | 0.909 | 342.38 | 77.01 | 126.43 | 11.50 | 114.93 |
| SheepPR | 0.746 | 272.63 | 0.878 | 419.68 | 147.04 | 189.63 | 23.15 | 166.48 |

## Appendix 5-1 (Continued)

**Model = Non - deflated, Gross Margin, $R_m$ = Farm Class 8, $R_f$ = \$170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ \$/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systemt. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.728 | 456.34 | 0.844 | 185.77 | -270.58 | 268.17 | 41.95 | 226.22 |
| F.Barley | 0.682 | 207.36 | 0.697 | 173.94 | -33.42 | 81.05 | 24.52 | 56.53 |
| Fld.Peas | 1.831 | 377.92 | 0.665 | 180.58 | -197.34 | 228.22 | 76.38 | 151.85 |
| Frz.Peas | 3.533 | 608.99 | 0.789 | 190.42 | -418.57 | 371.48 | 78.52 | 292.96 |
| Frz.Bean | 8.492 | 1303.88 | 0.715 | 219.08 | -1084.79 | 984.40 | 280.15 | 704.24 |
| P.Potato | -1.635 | 607.43 | 0.190 | 160.55 | -446.88 | 712.58 | 576.95 | 135.63 |
| Ryegrass | 1.297 | 311.09 | 0.430 | 177.50 | -133.59 | 250.06 | 142.47 | 107.59 |
| W.Clover | 0.486 | 365.73 | 0.211 | 172.81 | -192.92 | 190.84 | 150.52 | 40.31 |
| Rgrs/Clv | 2.699 | 775.70 | 0.613 | 185.60 | -590.10 | 365.04 | 141.20 | 223.85 |
| SheepBOR | 1.448 | 265.37 | 0.950 | 178.37 | -87.00 | 126.43 | 6.36 | 120.07 |
| SheepPR | 2.070 | 272.63 | 0.905 | 181.96 | -90.67 | 189.63 | 17.99 | 171.64 |

**Model = Non - deflated, Gross Margin, $R_m$ = N.Z.Agriculture, $R_f$ = \$170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ \$/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systemt. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.685 | 456.34 | 0.942 | 186.49 | -269.86 | 268.17 | 15.51 | 252.66 |
| F.Barley | 0.580 | 207.36 | 0.673 | 173.56 | -33.80 | 81.05 | 26.48 | 54.57 |
| Fld.Peas | 1.830 | 377.92 | 0.754 | 181.24 | -196.68 | 228.22 | 56.05 | 172.17 |
| Frz.Peas | 3.462 | 608.99 | 0.877 | 191.26 | -417.73 | 371.48 | 45.73 | 325.75 |
| Frz.Bean | 9.366 | 1303.88 | 0.895 | 227.51 | -1076.37 | 984.40 | 103.22 | 881.18 |
| P.Potato | -1.349 | 607.43 | 0.178 | 161.72 | -445.71 | 712.58 | 585.67 | 126.90 |
| Ryegrass | 1.535 | 311.09 | 0.578 | 179.43 | -131.67 | 250.06 | 105.64 | 144.43 |
| W.Clover | 0.091 | 365.73 | 0.045 | 170.56 | -195.17 | 190.84 | 182.26 | 8.57 |
| Rgrs/Clv | 2.552 | 775.70 | 0.658 | 185.67 | -590.03 | 365.04 | 124.95 | 240.09 |
| SheepBOR | 1.277 | 265.37 | 0.950 | 177.84 | -87.53 | 126.43 | 6.27 | 120.16 |
| SheepPR | 1.932 | 272.63 | 0.959 | 181.87 | -90.77 | 189.63 | 7.82 | 181.81 |

**Model = Non - deflated, Gross Margin, $R_m$ = N.Z.Grs.Agr.Prdn., $R_f$ = \$170/ha**

| Asset i | Beta $B_i$ | Historic Mean $R_i$ \$/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systemt. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.380 | 456.34 | 0.933 | 201.77 | -254.58 | 268.17 | 18.00 | 250.17 |
| F.Barley | 0.501 | 207.36 | 0.650 | 176.69 | -30.68 | 81.05 | 28.40 | 52.65 |
| Fld.Peas | 1.555 | 377.92 | 0.650 | 190.75 | -187.17 | 228.22 | 79.96 | 148.26 |
| Frz.Peas | 3.140 | 608.99 | 0.889 | 211.91 | -397.07 | 371.48 | 41.40 | 330.08 |
| Frz.Bean | 8.290 | 1303.88 | 0.885 | 280.67 | -1023.21 | 984.40 | 112.87 | 871.53 |
| P.Potato | -1.240 | 607.43 | 0.183 | 153.44 | -453.99 | 712.58 | 582.16 | 130.42 |
| Ryegrass | 1.534 | 311.09 | 0.645 | 190.48 | -120.61 | 250.06 | 88.81 | 161.26 |
| W.Clover | 0.142 | 365.73 | 0.078 | 171.89 | -193.83 | 190.84 | 175.92 | 14.92 |
| Rgrs/Clv | 2.504 | 775.70 | 0.721 | 203.43 | -572.27 | 365.04 | 101.76 | 263.28 |
| SheepBOR | 1.151 | 265.37 | 0.957 | 185.36 | -80.01 | 126.43 | 5.44 | 120.99 |
| SheepPR | 1.666 | 272.63 | 0.924 | 192.24 | -80.39 | 189.63 | 14.45 | 175.18 |

# Appendix 5-1 (Continued)

**Model = Deflated, Gross Revenue, $R_m$ = Unweighted Index, $R_f$ = \$170/ha**

| Asset<br>i | Beta<br>$B_i$ | Historic Mean<br>$R_i$<br>\$/ha | Correln. Coeffnt.<br>$r_{im}$ | Expected Return<br>$E(R_i)$<br>\$/ha | Error<br>$E(R_i)-R_i$<br>\$/ha | Total Risk<br>$\sigma_i$<br>\$/ha | Nonsyst. Risk<br>$\sigma_i(1-r_{im})$<br>\$/ha | Systemt. Risk<br>$r_{im}\sigma_i$<br>\$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 0.112 | 1163.74 | 0.112 | 330.77 | -832.96 | 289.30 | 256.90 | 32.41 |
| F.Barley | 0.293 | 748.70 | 0.404 | 589.35 | -159.35 | 209.20 | 124.67 | 84.53 |
| Fld.Peas | 0.593 | 1108.81 | 0.397 | 1019.70 | -89.10 | 431.68 | 260.41 | 171.27 |
| Frz.Peas | -0.077 | 1319.70 | 0.065 | 60.00 | -1259.70 | 339.41 | 317.24 | 22.17 |
| Frz.Bean | 2.070 | 2642.52 | 0.616 | 3135.56 | 493.05 | 969.91 | 372.14 | 597.77 |
| P.Potato | 4.347 | 4636.71 | 0.640 | 6398.92 | 1762.21 | 1960.79 | 705.23 | 1255.56 |
| Ryegrass | 0.643 | 1114.27 | 0.406 | 1091.45 | -22.81 | 457.46 | 271.72 | 185.74 |
| W.Clover | 1.040 | 1213.77 | 0.666 | 1659.73 | 445.96 | 450.78 | 150.49 | 300.28 |
| Rgrs/Clv | 1.683 | 2328.03 | 0.662 | 2581.23 | 253.20 | 734.74 | 248.71 | 486.03 |
| SheepBOR | 0.113 | 553.28 | 0.410 | 332.54 | -220.73 | 79.99 | 47.22 | 32.76 |
| SheepPR | 0.183 | 801.93 | 0.481 | 432.20 | -369.73 | 109.89 | 57.04 | 52.85 |

**Model = Deflated, Gross Revenue, $R_m$ = Farm Class 8, $R_f$ = \$170/ha**

| Asset<br>i | Beta<br>$B_i$ | Historic Mean<br>$R_i$<br>\$/ha | Correln. Coeffnt.<br>$r_{im}$ | Expected Return<br>$E(R_i)$<br>\$/ha | Error<br>$E(R_i)-R_i$<br>\$/ha | Total Risk<br>$\sigma_i$<br>\$/ha | Nonsyst. Risk<br>$\sigma_i(1-r_{im})$<br>\$/ha | Systemt. Risk<br>$r_{im}\sigma_i$<br>\$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 3.040 | 1163.74 | 0.678 | 1566.28 | 402.54 | 289.30 | 93.27 | 196.03 |
| F.Barley | 1.208 | 748.70 | 0.372 | 724.66 | -24.04 | 209.20 | 131.33 | 77.87 |
| Fld.Peas | 0.267 | 1108.81 | 0.040 | 292.57 | -816.24 | 431.68 | 414.48 | 17.21 |
| Frz.Peas | 1.403 | 1319.70 | 0.267 | 814.29 | -505.41 | 339.41 | 248.95 | 90.45 |
| Frz.Bean | 1.750 | 2642.52 | 0.116 | 973.46 | -1669.06 | 969.91 | 857.11 | 112.80 |
| P.Potato | -0.670 | 4636.71 | 0.022 | -137.90 | -4774.61 | 1960.79 | 1917.57 | 43.23 |
| Ryegrass | -0.438 | 1114.27 | 0.062 | -31.25 | -1145.52 | 457.46 | 429.21 | 28.25 |
| W.Clover | 0.085 | 1213.77 | 0.012 | 208.91 | -1004.86 | 450.78 | 445.31 | 5.46 |
| Rgrs/Clv | -0.353 | 2328.03 | 0.031 | 7.69 | -2320.34 | 734.74 | 711.95 | 22.79 |
| SheepBOR | 0.270 | 553.28 | 0.218 | 294.21 | -259.07 | 79.99 | 62.55 | 17.44 |
| SheepPR | 0.686 | 801.93 | 0.402 | 484.87 | -317.06 | 109.89 | 65.68 | 44.21 |

**Model = Deflated, Gross Revenue, $R_m$ = N.Z.Agriculture, $R_f$ = \$170/ha**

| Asset<br>i | Beta<br>$B_i$ | Histrc. Mean<br>$R_i$<br>\$/ha | Correln. Coeffnt.<br>$r_{im}$ | Expected Return<br>$E(R_i)$<br>\$/ha | Error<br>$E(R_i)-R_i$<br>\$/ha | Total Risk<br>$\sigma_i$<br>\$/ha | Nonsyst. Risk<br>$\sigma_i(1-r_{im})$<br>\$/ha | Systemt. Risk<br>$r_{im}\sigma_i$<br>\$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.16 | 1163.74 | 0.399 | 1008.30 | -155.44 | 289.30 | 173.97 | 115.34 |
| F.Barley | 1.47 | 748.70 | 0.377 | 742.96 | -5.74 | 209.20 | 130.37 | 78.83 |
| Fld.Peas | 3.18 | 1108.81 | 0.395 | 1408.10 | 299.29 | 431.68 | 261.34 | 170.35 |
| Frz.Peas | 2.17 | 1319.70 | 0.342 | 1012.99 | -306.71 | 339.41 | 223.43 | 115.98 |
| Frz.Bean | 7.98 | 2642.52 | 0.440 | 3274.20 | 631.68 | 969.91 | 542.81 | 427.10 |
| P.Potato | 0.57 | 4636.71 | 0.016 | 392.73 | -4243.99 | 1960.79 | 1930.15 | 30.64 |
| Ryegrass | -0.80 | 1114.27 | 0.093 | -140.40 | -1254.66 | 457.46 | 414.75 | 42.71 |
| W.Clover | -2.90 | 1213.77 | 0.344 | -956.65 | -2170.42 | 450.78 | 295.76 | 155.01 |
| Rgrs/Clv | -3.69 | 2328.03 | 0.269 | -1267.02 | -3595.05 | 734.74 | 537.02 | 197.71 |
| SheepBOR | -0.40 | 553.28 | 0.269 | 13.49 | -539.79 | 79.99 | 58.45 | 21.53 |
| SheepPR | 0.20 | 801.93 | 0.097 | 247.20 | -554.73 | 109.89 | 99.27 | 10.62 |

# Appendix 5-1 (Continued)

**Model = Deflated, Gross Revenue, $R_m$ = N.Z. Grs. Agr. Prodn., $R_f$ = \$170/ha**

| Asset i | Beta $B_i$ | Histrc. Mean $R_i$ \$/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systemt. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 3.94 | 1163.74 | 0.487 | 739.08 | -424.66 | 289.30 | 148.50 | 140.80 |
| F.Barley | 0.96 | 748.70 | 0.164 | 308.64 | -440.07 | 209.20 | 174.90 | 34.30 |
| Fld.Peas | -2.23 | 1108.81 | 0.185 | -152.60 | -1261.40 | 431.68 | 351.87 | 79.82 |
| Frz.Peas | 4.70 | 1319.70 | 0.495 | 849.47 | -470.23 | 339.41 | 171.30 | 168.11 |
| Frz.Bean | 9.96 | 2642.52 | 0.367 | 1609.82 | -1032.70 | 969.91 | 613.67 | 356.24 |
| P.Potato | -9.50 | 4636.71 | 0.173 | -1203.76 | -5840.47 | 1960.79 | 1620.90 | 339.89 |
| Ryegrass | 3.47 | 1114.27 | 0.272 | 672.35 | -441.91 | 457.46 | 333.17 | 124.29 |
| W.Clover | -3.16 | 1213.77 | 0.251 | -287.51 | -1501.28 | 450.78 | 337.58 | 113.20 |
| Rgrs/Clv | 0.31 | 2328.03 | 0.015 | 214.83 | -2113.20 | 734.74 | 723.64 | 11.09 |
| SheepBOR | 0.09 | 553.28 | 0.038 | 182.38 | -370.90 | 79.99 | 76.93 | 3.06 |
| SheepPR | 0.16 | 801.93 | 0.052 | 192.93 | -609.00 | 109.89 | 104.21 | 5.67 |

**Model = Deflated, Gross Margin, $R_m$ = Unweighted Index, $R_f$ = \$170/ha**

| Asset i | Beta $B_i$ | Histrc. Mean $R_i$ \$/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systemt. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 0.06 | 751.37 | 0.072 | 214.63 | -536.74 | 226.74 | 210.38 | 16.35 |
| F.Barley | 0.33 | 388.19 | 0.448 | 408.45 | 20.26 | 194.96 | 107.60 | 87.36 |
| Fld.Peas | 0.72 | 678.33 | 0.483 | 689.77 | 11.44 | 394.30 | 203.86 | 190.44 |
| Frz.Peas | -0.24 | 991.25 | 0.178 | -6.69 | -997.94 | 363.70 | 298.96 | 64.74 |
| Frz.Bean | 2.22 | 2086.75 | 0.589 | 1773.04 | -313.71 | 996.63 | 409.29 | 587.34 |
| P.Potato | 3.96 | 1387.22 | 0.623 | 3030.98 | 1643.76 | 1681.86 | 633.62 | 1048.24 |
| Ryegrass | 0.85 | 517.30 | 0.506 | 784.70 | 267.40 | 445.22 | 219.99 | 225.22 |
| W.Clover | 1.12 | 744.08 | 0.684 | 982.50 | 238.42 | 435.40 | 137.70 | 297.69 |
| Rgrs/Clv | 1.84 | 1407.19 | 0.701 | 1502.63 | 95.44 | 696.84 | 208.57 | 488.27 |
| SheepBOR | 0.12 | 469.22 | 0.389 | 254.88 | -214.34 | 79.96 | 48.86 | 31.10 |
| SheepPR | 0.02 | 399.55 | 0.037 | 185.59 | -213.96 | 152.99 | 147.28 | 5.71 |

**Model = Deflated, Gross Margin, $R_m$ = Farm Class 8, $R_f$ = \$170/ha**

| Asset i | Beta $B_i$ | Histrc. Mean $R_i$ \$/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ \$/ha | Error $E(R_i)-R_i$ \$/ha | Total Risk $\sigma_i$ \$/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ \$/ha | Systemt. Risk $r_{im}\sigma_i$ \$/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.26 | 751.37 | 0.585 | 435.80 | -315.57 | 226.74 | 94.10 | 132.63 |
| F.Barley | 1.31 | 388.19 | 0.392 | 323.35 | -64.84 | 194.96 | 118.44 | 76.52 |
| Fld.Peas | -1.44 | 678.33 | 0.214 | 1.20 | -677.12 | 394.30 | 310.07 | 84.23 |
| Frz.Peas | 1.73 | 991.25 | 0.279 | 373.52 | -617.73 | 363.70 | 262.14 | 101.56 |
| Frz.Bean | -1.68 | 2086.75 | 0.099 | -27.57 | -2114.32 | 996.63 | 898.04 | 98.59 |
| P.Potato | 0.79 | 1387.22 | 0.028 | 262.71 | -1124.51 | 1681.86 | 1635.60 | 46.26 |
| Ryegrass | -1.52 | 517.30 | 0.200 | -8.40 | -525.70 | 445.22 | 356.19 | 89.02 |
| W.Clover | 1.53 | 744.08 | 0.206 | 349.67 | -394.41 | 435.40 | 345.74 | 89.65 |
| Rgrs/Clv | 0.03 | 1407.19 | 0.002 | 173.35 | -1233.85 | 696.84 | 695.17 | 1.67 |
| SheepBOR | 0.40 | 469.22 | 0.293 | 216.88 | -252.34 | 79.96 | 56.57 | 23.39 |
| SheepPR | 0.92 | 399.55 | 0.350 | 277.46 | -122.09 | 152.99 | 99.37 | 53.62 |

# Appendix 5-1 (Continued)

**Model = Deflated, Gross Margin, $R_m$ = N.Z.Agriculture, $R_f$ = $170/ha**

| Asset i | Beta $B_i$ | Histrc. Mean $R_i$ $/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ $/ha | Systemt. Risk $r_{im}\sigma_i$ $/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.71 | 751.37 | 0.590 | 483.59 | -267.78 | 226.74 | 92.88 | 133.86 |
| F.Barley | 1.79 | 388.19 | 0.453 | 376.82 | -11.37 | 194.96 | 106.68 | 88.28 |
| Fld.Peas | 2.46 | 678.33 | 0.308 | 454.72 | -223.61 | 394.30 | 272.77 | 121.53 |
| Frz.Peas | 3.51 | 991.25 | 0.476 | 575.59 | -415.66 | 363.70 | 190.57 | 173.12 |
| Frz.Bean | 9.15 | 2086.75 | 0.453 | 1227.08 | -859.67 | 996.63 | 545.43 | 451.21 |
| P.Potato | -0.37 | 1387.22 | 0.011 | 127.01 | -1260.21 | 1681.86 | 1663.51 | 18.35 |
| Ryegrass | -1.70 | 517.30 | 0.188 | -25.85 | -543.15 | 445.22 | 361.62 | 83.60 |
| W.Clover | -2.46 | 744.08 | 0.278 | -114.05 | -858.14 | 435.40 | 314.15 | 121.25 |
| Rgrs/Clv | -3.76 | 1407.19 | 0.266 | -264.11 | -1671.30 | 696.84 | 511.54 | 185.30 |
| SheepBOR | -0.39 | 469.22 | 0.239 | 125.31 | -343.90 | 79.96 | 60.89 | 19.07 |
| SheepPR | 1.94 | 399.55 | 0.626 | 394.36 | -5.18 | 152.99 | 57.22 | 95.77 |

**Model = Deflated, Gross Margin, $R_m$ = N.Z. Grs. Agr. Prodn., $R_f$ = $170/ha**

| Asset i | Beta $B_i$ | Histrc. Mean $R_i$ $/ha | Correln. Coeffnt. $r_{im}$ | Expected Return $E(R_i)$ $/ha | Error $E(R_i)-R_i$ $/ha | Total Risk $\sigma_i$ $/ha | Nonsyst. Risk $\sigma_i(1-r_{im})$ $/ha | Systemt. Risk $r_{im}\sigma_i$ $/ha |
|---|---|---|---|---|---|---|---|---|
| Wheat | 2.70 | 751.37 | 0.427 | 560.88 | -190.48 | 226.74 | 130.02 | 96.71 |
| F.Barley | -0.72 | 388.19 | 0.133 | 65.30 | -322.89 | 194.96 | 169.06 | 25.90 |
| Fld.Peas | -2.74 | 678.33 | 0.249 | -226.16 | -904.49 | 394.30 | 296.28 | 98.02 |
| Frz.Peas | 4.81 | 991.25 | 0.473 | 865.71 | -125.54 | 363.70 | 191.56 | 172.13 |
| Frz.Bean | 10.82 | 2086.75 | 0.389 | 1735.26 | -351.49 | 996.63 | 609.36 | 387.27 |
| P.Potato | -7.59 | 1387.22 | 0.161 | -927.46 | -2314.68 | 1681.86 | 1410.33 | 271.53 |
| Ryegrass | 2.27 | 517.30 | 0.182 | 498.15 | -19.15 | 445.22 | 364.03 | 81.19 |
| W.Clover | -3.74 | 744.08 | 0.307 | -370.65 | -1114.73 | 435.40 | 301.63 | 133.77 |
| Rgrs/Clv | -0.06 | 1407.19 | 0.003 | 161.68 | -1245.51 | 696.84 | 694.78 | 2.06 |
| SheepBOR | 0.19 | 469.22 | 0.083 | 196.69 | -272.53 | 79.96 | 73.36 | 6.60 |
| SheepPR | 1.58 | 399.55 | 0.369 | 398.03 | -1.52 | 152.99 | 96.57 | 56.42 |

# APPENDIX 5-2

## Alpha and Beta Coefficients and Their Standard Error Estimates, for the Lincoln University Mixed Cropping Farm Activities; $R_f$= $170/ha.

### A. Gross Revenue, Non - deflated Models

| Activity | Unwgt. | Std.Er Estim. | Farm Class8 | Std.Er Estim. | N.Z. Agric. | Std.Er Estim. | N.Z. G.A.P. | Std.Er Estim. | Beta/ Alpha |
|---|---|---|---|---|---|---|---|---|---|
| Wheat | 0.95*1 | 0.07 | 2.03* | 0.18 | 2.26* | 0.18 | 3.79* | 0.31 | Beta |
| | -143 | 120 | -46 | 141 | -34 | 128 | -8 | 134 | Alpha |
| F.Barley | 0.43* | 0.05 | 0.94* | 0.11 | 1.06* | 0.11 | 1.78* | 0.19 | Beta |
| | 34 | 94 | 70 | 90 | 73 | 82 | 84 | 82 | Alpha |
| Field Peas | 0.73* | 0.12 | 1.61* | 0.24 | 1.81* | 0.25 | 2.95* | 0.46 | Beta |
| | -19 | 206 | 35 | 194 | 37 | 180 | 74 | 200 | Alpha |
| Frozen Peas | 0.98* | 0.11 | 2.09* | 0.26 | 2.36* | 0.26 | 3.99* | 0.43 | Beta |
| | -81 | 198 | 20 | 210 | 21 | 188 | 43 | 184 | Alpha |
| Frozen Bean | 2.46* | 0.21 | 4.89* | 0.71 | 5.62* | 0.66 | 9.40* | 1.15 | Beta |
| | -577 | 363 | -193 | 570 | -226 | 480 | -152 | 500 | Alpha |
| Potatoes | 2.14* | 0.51 | 4.19* | 1.23 | 4.49* | 1.36 | 7.52* | 2.33 | Beta |
| | 422 | 893 | 786 | 986 | 861 | 1006 | 918 | 1011 | Alpha |
| Ryegrass | 0.84* | 0.12 | 1.69* | 0.32 | 1.96* | 0.31 | 3.48* | 0.45 | Beta |
| | -96 | 210 | 32 | 256 | 15 | 228 | 4 | 193 | Alpha |
| Wht.Clover | 0.40* | 0.13 | 0.83* | 0.28 | 0.87* | 0.32 | 1.50* | 0.53 | Beta |
| | 268 | 217 | 319 | 224 | 341 | 230 | 343 | 227 | Alpha |
| Grass/Clovr | 1.24* | 0.16 | 2.52* | 0.43 | 2.82* | 0.45 | 4.97* | 0.67 | Beta |
| | 172 | 281 | 351 | 345 | 356 | 329 | 348 | 228 | Alpha |
| Sheep BOR | 0.33* | 0.03 | 0.74* | 0.05 | 0.80* | 0.06 | 1.37* | 0.09 | Beta |
| | 18 | 50 | 43 | 40 | 51 | 43 | 58 | 39 | Alpha |
| Sheep PR | 0.51* | 0.05 | 1.14* | 0.14 | 1.25* | 0.09 | 2.10* | 0.16 | Beta |
| | 3 | 84 | 36 | 59 | 48 | 63 | 64 | 69 | Alpha |

1. A * indicates the estimate is statistically significant at the 5 percent level of significance.

## Appendix 5-2 (Continued)

### B. Gross Margin, Non - deflated Models

| | Unwght. | Std.Er Estim. | Farm Class8 | Std.Er Estim. | N.Z. Agric. | Std.Er Estim. | N.Z. G.A.P. | Std.Er Estim. | Beta/ Alpha |
|---|---|---|---|---|---|---|---|---|---|
| Wheat | 1.09* | 0.13 | 2.73* | 0.45 | 2.69* | 0.25 | 2.38* | 0.24 | Beta |
| | -94 | 120 | -23 | 153 | -17 | 96 | 20 | 103 | Alpha |
| F.Barley | 0.22* | 0.08 | 0.68* | 0.18 | 0.58* | 0.17 | 0.50* | 0.15 | Beta |
| | 97 | 69 | 88 | 62 | 105 | 64 | 116 | 66 | Alpha |
| Field Peas | 0.70* | 0.19 | 1.83* | 0.53 | 1.83* | 0.41 | 1.56* | 0.39 | Beta |
| | 23 | 176 | 56 | 181 | 56 | 160 | 93 | 170 | Alpha |
| Frozen Peas | 1.35* | 0.25 | 3.53* | 0.71 | 3.46* | 0.49 | 3.14* | 0.42 | Beta |
| | -71 | 233 | -12 | 243 | -1 | 190 | 33 | 181 | Alpha |
| Frozen Bean | 4.12* | 0.41 | 8.49* | 2.14 | 9.37* | 1.20 | 8.29* | 1.12 | Beta |
| | -775 | 374 | -189 | 732 | -346 | 467 | -216 | 487 | Alpha |
| Potatoes | 0.07 | 0.82 | -1.64 | 2.18 | -1.35 | 1.92 | -1.24 | 1.72 | Beta |
| | 573 | 758 | 895 | 745 | 845 | 747 | 835 | 746 | Alpha |
| Ryegrass | 0.77* | 0.21 | 1.30 | 0.70 | 1.54* | 0.56 | 1.53* | 0.47 | Beta |
| | -77 | 194 | 83 | 240 | 41 | 217 | 30 | 204 | Alpha |
| Wht.Clover | 0.15 | 0.22 | 0.49 | 0.58 | 0.09 | 0.52 | 0.14 | 0.47 | Beta |
| | 292 | 200 | 280 | 199 | 350 | 203 | 340 | 203 | Alpha |
| Grass/Clovr | 1.28* | 0.26 | 2.70* | 0.90 | 2.55* | 0.76 | 2.50* | 0.62 | Beta |
| | 130 | 242 | 301 | 307 | 326 | 293 | 317 | 269 | Alpha |
| Sheep BOR | 0.52* | 0.06 | 1.45* | 0.12 | 1.28* | 0.11 | 1.15* | 0.09 | Beta |
| | 6 | 56 | 11 | 42 | 40 | 42 | 54 | 39 | Alpha |
| Sheep PR | 0.75* | 0.11 | 2.07* | 0.25 | 1.93* | 0.15 | 1.67* | 0.18 | Beta |
| | -104 | 97 | -91 | 86 | -68 | 57 | -33 | 77 | Alpha |

## APPENDIX 5-2 (Continued)

## C. Gross Revenue, Deflated Models

| | Unwght. | Std.Er Estim. | Farm Class8 | Std.Er Estim. | N.Z. Agric. | Std.Er Estim. | N.Z. G.A.P. | Std.Er Estim. | Beta/ Alpha |
|---|---|---|---|---|---|---|---|---|---|
| Wheat | 0.11 | 0.26 | 3.04* | 0.85 | 2.16 | 1.28 | 3.94* | 1.82 | Beta |
| | 984*1 | 306 | -749 | 227 | -41 | 283 | -74 | 269 | Alpha |
| F.Barley | 0.29 | 0.17 | 1.21 | 0.78 | 1.47 | 0.93 | 0.96 | 1.49 | Beta |
| | 280 | 204 | -11 | 207 | -75 | 206 | 447* | 220 | Alpha |
| Field Peas | 0.59 | 0.35 | 0.27 | 1.73 | 3.18 | 1.91 | -2.23 | 3.06 | Beta |
| | 158 | 422 | 941* | 459 | -670 | 422 | 1811* | 452 | Alpha |
| Frozen Peas | -0.08 | 0.30 | 1.40 | 1.31 | 2.17 | 1.54 | 4.70* | 2.13 | Beta |
| | 1442* | 360 | 437 | 348 | 108 | 340 | -158 | 314 | Alpha |
| Frozen Bean | 2.07 | 0.68 | 1.75 | 3.86 | 7.98 | 4.20 | 9.96 | 6.51 | Beta |
| | -675 | 813 | 1542 | 1026 | -1818 | 927 | -490 | 960 | Alpha |
| Potatoes | 4.35* | 1.35 | -0.67 | 7.85 | 0.57 | 9.46 | -9.50 | 13.93 | Beta |
| | -2331 | 1603 | 5059* | 2087 | 4317* | 2087 | 7625* | 2056 | Alpha |
| Ryegrass | 0.64 | 0.37 | -0.44 | 1.83 | -0.80 | 2.20 | 3.47 | 3.18 | Beta |
| | 84 | 445 | 1390* | 486 | 1560* | 489 | 21 | 469 | Alpha |
| Wht.Clover | 1.04* | 0.30 | 0.09 | 1.81 | -2.90 | 2.04 | -3.16 | 3.15 | Beta |
| | -453 | 358 | 1161* | 480 | 2833* | 451 | 2209* | 465 | Alpha |
| Grass/Clovr | 1.68* | 0.49 | -0.35 | 2.94 | -3.69 | 3.41 | 0.31 | 5.30 | Beta |
| | -369 | 587 | 2550* | 782 | 4393* | 753 | 2231* | 782 | Alpha |
| Sheep BOR | 0.11 | 0.07 | 0.27 | 0.31 | -0.40 | 0.37 | 0.09 | 0.58 | Beta |
| | 372* | 78 | 383* | 83 | 778* | 82 | 526* | 85 | Alpha |
| Sheep PR | 0.18* | 0.09 | 0.69 | 0.40 | 0.20 | 0.53 | 0.16 | 0.79 | Beta |
| | 509* | 103 | 371* | 107 | 691* | 116 | 752* | 117 | Alpha |

1. A * indicates that the estimate is statistically significant at the 5 percent level of significance.

## Appendix 5-2 (Continued)

### D. Gross Margin, Deflated Models

| Activity | Unwght. | Std.Er Estim. | Farm Class8 | Std.Er Estim. | N.Z. Agric. | Std.Er Estim. | N.Z. G.A.P. | Std.Er Estim. | Beta/ Alpha |
|---|---|---|---|---|---|---|---|---|---|
| Wheat | 0.06 | 0.22 | 2.26* | 0.81 | 2.71* | 0.96 | 2.70 | 1.48 | Beta |
| | 696*1 | 241 | 101 | 196 | -24 | 195 | -99 | 218 | Alpha |
| F.Barley | 0.33 | 0.17 | 1.31 | 0.79 | 1.79 | 0.91 | -0.72 | 1.39 | Beta |
| | 94 | 186 | 13 | 191 | -123 | 185 | 616* | 206 | Alpha |
| Field Peas | 0.72* | 0.34 | -1.44 | 1.70 | 2.46 | 1.96 | -2.74 | 2.76 | Beta |
| | 36 | 368 | 1091* | 410 | -25 | 399 | 1540* | 407 | Alpha |
| Frozen Peas | -0.24 | 0.35 | 1.73 | 1.54 | 3.51* | 1.67 | 4.81 | 2.31 | Beta |
| | 1210* | 381 | 493 | 372 | -11 | 341 | -522 | 341 | Alpha |
| Frozen Bean | 2.22* | 0.79 | -1.68 | 4.37 | 9.15 | 4.65 | 10.82 | 6.63 | Beta |
| | 107 | 857 | 2570* | 1056 | -526 | 946 | 1318 | 978 | Alpha |
| Potatoes | 3.96* | 1.28 | 0.79 | 7.41 | -0.37 | 8.81 | -7.59 | 11.98 | Beta |
| | -2147 | 1400 | 1160 | 1790 | 1494 | 1790 | 3775* | 1767 | Alpha |
| Ryegrass | 0.85* | 0.37 | -1.52 | 1.92 | -1.70 | 2.29 | 2.27 | 3.16 | Beta |
| | -242 | 409 | 954* | 464 | 1001* | 466 | -197 | 446 | Alpha |
| Wht.Clover | 1.12* | 0.31 | 1.52 | 1.88 | -2.46 | 2.19 | -3.74 | 2.99 | Beta |
| | -260 | 338 | 304 | 454 | 1446* | 445 | 1920* | 441 | Alpha |
| Grass/Clovr | 1.84* | 0.49 | 0.03 | 3.07 | -3.76 | 3.52 | -0.06 | 5.03 | Beta |
| | -239 | 529 | 1399 | 742 | 2480* | 715 | 1425 | 742 | Alpha |
| Sheep BOR | 0.12 | 0.07 | 0.40 | 0.34 | -0.39 | 0.41 | 0.19 | 0.58 | Beta |
| | 364* | 78 | 355* | 81 | 580* | 83 | 411* | 85 | Alpha |
| Sheep PR | 0.02 | 0.15 | 0.92 | 0.63 | 1.94* | 0.63 | 1.58 | 1.03 | Beta |
| | 380* | 163 | 137 | 153 | -155 | 127 | -97* | 151 | Alpha |

1. A * indicates that the estimate is statistically significant at the 5 percent level of significance.

# APPENDIX 5-3

## GOLDFELD & QUANDT HETEROSCEDASTICITY TESTS

| Activity | Farm Sector Portfolio (Non - deflated Models) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Gross Revenue | | | | Gross Margin | | | |
| | Unwgt. Index | Farm Cls.8 | N.Z. Agric. | Gross Ag.P. | Unwgt. Index | Farm Cls. 8 | N.Z. Agric. | Gross Ag.P. |
| Wheat | 0.42 | 9.43* | 2.73 | 3.29 | 0.32 | 6.67* | 2.20 | 3.13 |
| F.Barley | 0.80 | 0.77 | 0.67 | 0.26 | 90.4# | 0.61 | 0.12 | 0.13 |
| Field Peas | 4.16 | 1.59 | 1.80 | 1.41 | 3.58 | 1.29 | 1.34 | 1.31 |
| Frozen Peas | 4.85 | 6.93* | 7.36* | 5.50 | 6.30 | 1.65 | 4.72 | 4.33 |
| Frozen Bean | 3.39 | 4.71 | 3.14 | 2.94 | 4.31 | 2.13 | 2.76 | 2.63 |
| Potatoes | 0.20 | 7.04* | 6.85* | 20.1# | 7.24* | 4.00 | 5.31 | 10.0* |
| Ryegrass | 5.86 | 2.67 | 1.40 | 0.42 | 5.63 | 2.55 | 0.89 | 0.30 |
| Wht.Clover | 11.2* | 0.64 | 0.96 | 1.69 | 10.9* | 0.91 | 0.66 | 9.15* |
| Grass/Clover | 4.78 | 1.09 | 0.95 | 0.81 | 6.35 | 0.65 | 0.66 | 0.63 |
| Sheep BOR | 2.20 | 2.21 | 1.60 | 3.80 | 2.20 | 1.72 | 1.68 | 3.96 |
| Sheep PR | 6.02 | 5.73 | 5.05 | 10.6* | 8.26* | 4.93 | 8.54* | 12.1* |

F (table) at 5% level of significance = 6.39 ( * )
F (table) at 1% level of significance =16.00 ( # )
If F (cacl.) > F (table) = Heteroscedasticity

## Appendix 5-3 (Continued)

**GOLDFELD & QUANDT HETEROSCEDASTICITY TESTS (Continued)**

| Deflated Models | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Activity | Farm Sector Portfolio | | | | | | | |
| | Gross Revenue | | | | Gross Margin | | | |
| | Equal Wght. | Farm Class 8 | N.Z. Agric. | Gross Agric Prodn | Equal Wght. | Farm Class 8 | N.Z. Agric. | Gross Agric. Prodn. |
| Wheat | 4.77 | 0.28 | 0.47 | 0.26 | 1.24 | 0.66 | 0.75 | 0.26 |
| F.Barley | 1.72 | 1.39 | 1.44 | 0.32 | 6.59* | 0.42 | 9.05* | 0.25 |
| Field Peas | 5.89 | 0.68 | 1.00 | 0.06 | 11.4* | 0.09 | 0.66 | 0.05 |
| Frozen Peas | 1.68 | 0.49 | 0.58 | 0.46 | 0.82 | 0.36 | 0.09 | 0.37 |
| Frozen Bean | 1.21 | 0.47 | 0.26 | 0.52 | 0.69 | 0.73 | 0.27 | 0.56 |
| Potatoes | 1.37 | 0.93 | 1.82 | 0.67 | 1.70 | 6.05 | 0.71 | 1.40 |
| Ryegrass | 1.81 | 0.47 | 0.12 | 0.09 | 5.39 | 0.42 | 0.21 | 0.08 |
| Wht.Clover | 2.28 | 0.81 | 0.20 | 0.70 | 0.88 | 0.08 | 0.23 | 0.61 |
| Grass/Clover | 2.72 | 0.37 | 0.07 | 0.15 | 7.07* | 0.09 | 0.12 | 0.10 |
| Sheep BOR | 5.27 | 0.91 | 0.84 | 0.00 | 3.18 | 0.76 | 0.45 | 0.98 |
| Sheep PR | 1.16 | 1.30 | 26.7# | 1.04 | 0.99 | 0.51 | 12.4* | 2.13 |

F (table) at 5% level of significance = 6.39 ( * )
F (table) at 1% level of significance =16.00 ( # )
If F (cacl.) > F (table) = Heteroscedasticity

# APPENDIX 5-4

## DURBAN-WATSON AUTOCORRELATION TESTS

Non-deflated Models

| Activity | Farm Sector Portfolio | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Gross Revenue | | | | Gross Margin | | | |
| | Equal Wght. | Farm Class 8 | N.Z. Agric. | Gross Agric Prodn | Equal Wght. | Farm Class 8 | N.Z. Agric. | Gross Agric. Prodn. |
| Wheat | 0.00* | 0.05* | 0.05* | 0.05* | 0.04* | 0.07* | 0.07* | 0.06* |
| F.Barley | 0.06* | 0.01* | 0.00* | 0.03* | 0.36* | 0.44* | 0.58* | 0.68* |
| Field Peas | 0.08* | 0.08* | 0.09* | 0.09* | 0.25* | 0.14* | 0.14* | 0.10* |
| Frozen Peas | 0.00* | 0.05* | 0.05* | 0.05* | 0.14* | 0.08* | 0.08* | 0.08* |
| Frozen Bean | 0.17* | 0.12* | 0.12* | 0.12* | 0.20* | 0.16* | 0.16* | 0.16* |
| Potatoes | 0.20* | 0.22* | 0.22* | 0.23* | 1.39@ | 1.22@ | 1.24@ | 1.26@ |
| Ryegrass | 0.06* | 0.15* | 0.16* | 0.17* | 0.18* | 0.21* | 0.40* | 0.43* |
| Wht.Clover | 0.89# ~ | 0.06* | 0.02* | 0.05* | 2.07@ | 1.11@~ | 2.08@ | 2.05@ |
| Grass/Clover | 0.04* | 0.07* | 0.08* | 0.09* | 0.10* | 0.16* | 0.15* | 0.15* |
| Sheep BOR | 0.06* | 0.13* | 0.23* | 0.02* | 0.07* | 0.05* | 0.03* | 0.01* |
| Sheep PR | 0.07* | 0.03* | 0.04* | 0.06* | 0.03* | 0.20* | 0.19* | 0.17* |

| KEY: | | Durban-Watson Table |
|---|---|---|
| | * : +ve autocorrelation at 1 %<br>@ : no autocorrelation at 1 %<br># : test inconclusive at 1 %<br>~ : +ve autocorrelation at 5 % | 5% : dl =1.13, du =1.38<br><br>1% : dl =0.87, du =1.10 |

## Appendix 5-4 (Continued)

## DURBAN-WATSON AUTOCORRELATION TESTS (Continued)

| Deflated Models | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Activity | Farm Sector Portfolio | | | | | | | |
| | Gross Revenue | | | | Gross Margin | | | |
| | Equal Wght. | Farm Class 8 | N.Z. Agric. | Gross Agric Prodn | Equal Wght. | Farm Class 8 | N.Z. Agric. | Gross Agric. Prodn. |
| Wheat | 1.10@ ~ | 0.13* | 0.07* | 0.07* | 1.23@ | 0.09* | 0.11* | 0.12* |
| F.Barley | 1.49@ | 0.13* | 0.17* | 0.00* | 0.51* | 0.22* | 0.55* | 1.30@ |
| Field Peas | 1.36@ | 1.16@ | 0.31* | 0.53* | 0.46* | 0.99#~ | 0.35* | 0.92# ~ |
| Frozen Peas | 1.82@ | 0.04* | 0.10* | 0.12* | 1.79@ | 0.08* | 0.22* | 0.28* |
| Frozen Bean | 0.02* | 0.09* | 0.29* | 0.25* | 0.33* | 0.83* | 0.37* | 0.39* |
| Potatoes | 0.15* | 0.65* | 0.16* | 0.22* | 0.63* | 0.10* | 0.70* | 0.55* |
| Ryegrass | 0.49* | 2.17@ | 1.84@ | 0.34* | 0.10* | 2.17@ | 2.15@ | 1.44@ |
| Wht.Clover | 0.15* | 1.98@ | 0.93#~ | 0.62* | 0.17* | 0.17* | 1.17@ | 1.14@ |
| Grass/Clover | 0.22* | 1.86@ | 0.54* | 0.75* | 0.69* | 2.49@ | 0.95# ~ | 2.50@ |
| Sheep BOR | 0.60* | 1.59@ | 1.79@ | 1.65@ | 1.20@ | 0.55* | 1.27@ | 1.50@ |
| Sheep PR | 1.0#~ | 0.15* | 1.57@ | 1.14@ | 0.74* | 0.01* | 0.22* | 0.22* |

| KEY: | | Durban-Watson Table |
|---|---|---|
| | * : +ve autocorrelation at 1% | 5% : dl =1.13, du =1.38 |
| | @ : no autocorrelation at 1% | |
| | # : test inconclusive at 1% | |
| | ~ : +ve autocorrelation at 5% | 1% : dl =0.87, du =1.10 |

## Appendix 5-5

**A Comparison of Beta Coefficients and Percent Systematic Risk with Alternative Farm Sector Portfolios; Gross Margin, Deflated Models, $R_f$= $170/ha**

| Activity | Unweighted Index | | | N.Z. Farm Class 8 | | | N.Z. Agriculture | | | N.Z. Gross Agr.Production | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beta $B_i$ | Beta Rank | Sys. Risk % | Beta $B_i$ | Beta Rank | Sys. Risk % | Beta $B_i$ | Beta Rank | Sys. Risk % | Beta $B_i$ | Beta Rank | Sys. Risk % |
| Fzn.Bean | 2.22* | 2[1] | 58.9 | -1.7 | 11 | 9.9 | 9.15 | 1 | 45.3 | 10.8 | 1 | 38.4 |
| Fzn.Peas | -0.2 | 11 | 17.8 | 1.73 | 2 | 27.9 | 3.51* | 2 | 47.6 | 4.81 | 2 | 47.3 |
| Grs/Clv. | 1.84* | 3 | 69.1 | 0.03 | 8 | 0.2 | -3.8 | 11 | 26.6 | -0.1 | 7 | 0.3 |
| Wheat | 0.06 | 9 | 7.2 | 2.26* | 1 | 58.5 | 2.71* | 3 | 59.0 | 2.70 | 3 | 42.7 |
| Ryegrs. | 0.85* | 5 | 50.6 | -1.5 | 10 | 20.0 | -1.7 | 9 | 18.8 | 2.27 | 4 | 18.2 |
| Sheep PR | 0.02 | 10 | 3.7 | 0.92 | 5 | 35.0 | 1.94* | 5 | 62.6 | 1.58 | 5 | 36.9 |
| Fld.Peas | 0.72* | 6 | 48.3 | -1.4 | 9 | 21.4 | 2.46 | 4 | 30.8 | -2.7 | 9 | 24.9 |
| SheepBOR | 0.12 | 8 | 38.9 | 0.40 | 7 | 29.2 | -0.4 | 8 | 23.8 | 0.19 | 6 | 8.2 |
| Barley | 0.33 | 7 | 44.8 | 1.31 | 4 | 39.2 | 1.79 | 6 | 45.3 | -0.7 | 8 | 13.3 |
| Wht.Clv. | 1.12* | 4 | 68.4 | 1.53 | 3 | 20.6 | -2.5 | 10 | 27.3 | -3.7 | 10 | 30.7 |
| P.Potato | 3.96* | 1 | 62.3 | 0.79 | 6 | 2.7 | -0.4 | 7 | 1.1 | -7.6 | 11 | 16.1 |

1. Activities ranked from highest Beta coefficients to lowest.
A * indicates the estimates are statistically significant.

# Appendix 5-6

**Data for Farm Sector Security Market Lines : A Comparison of the four Farm Sector Portfolios.**

Non-deflated, Gross Margin Models.

| Unweighted | | N.Z.Farm Class 8 | | N.Z.Agriculture | | N.Z.Grs.Agr.Prod. | |
|---|---|---|---|---|---|---|---|
| Beta | $E(R_i)$ Grs.Mgn. $/ha | Beta | $E(R_i)$ Grs.Mgn. $/ha | Beta | $E(R_i)$ Grs.Mgn. $/ha | Beta | $E(R_i)$ Grs.Mgn. $/ha |
| 0.068 PP | 192.81 | -1.635 PP | 160.55 | -1.349 PP | 161.72 | -1.240 PP | 153.44 |
| 0.146 WC | 218.73 | 0.486 WC | 172.81 | 0.091 WC | 170.56 | 0.142 WC | 171.89 |
| 0.218 FB | 243.03 | 0.682 FB | 173.94 | 0.580 FB | 173.56 | 0.501 FB | 176.69 |
| 0.515 BOR | 342.38 | 1.297 RG | 177.50 | 1.277 BOR | 177.84 | 1.151 BOR | 185.36 |
| 0.704 FDP | 405.62 | 1.448 BOR | 178.37 | 1.535 RG | 179.43 | 1.534 RG | 190.48 |
| 0.746 PR | 419.68 | 1.831 FDP | 180.58 | 1.830 FDP | 181.24 | 1.555 FDP | 190.75 |
| 0.769 RG | 427.61 | 2.070 PR | 181.96 | 1.932 PR | 181.87 | 1.666 PR | 192.24 |
| 1.090 W | 534.92 | 2.699 R/C | 185.60 | 2.552 R/C | 185.67 | 2.380 W | 201.77 |
| 1.279 R/C | 598.01 | 2.728 W | 185.77 | 2.685 W | 186.49 | 2.504 R/C | 203.43 |
| 1.346 FZP | 620.67 | 3.533 FZP | 190.42 | 3.462 FZP | 191.26 | 3.140 FZP | 211.91 |
| 4.119 FZB | 1549.02 | 8.492 FZB | 219.08 | 9.366 FZB | 227.51 | 8.290 FZB | 280.67 |

Note:

PP = P.Potato FDP = Field Pea R/C = Grs/Clover FZP = Frozen Peas
WC = W.Clover RG = Ryegrass FZB = Frozen Beans
FB = F.Barley W = Wheat BOR = Sheep (Breeding own replc.)
PR = Sheep (Purchasing replacement ewes)

## Appendix 5-7

## The Unweighted Index - Undercompensation or Not?[1]

This Appendix examines why the error terms sum to zero when an unweighted index is used.

The returns on each activity i, where i = 1, 2, ....., n contained in a market portfolio, M, consists of both a systematic and a non - systematic component. The portion of i's risk that is systematic corresponds to the degree to which $R_{it}$, the return on i, is correlated with $R_{mt}$, the return on the market portfolio, M, over the time horizon t = 1, 2 ,......, T.

This relationship can be captured by the OLS regression of $R_{it}$ on $R_{mt}$,

$$R_{it} = a_i + B_i R_{mt} + e_{it} \quad \text{............. Equation 1}$$

Now the expected return for each activity which is being fully compensated for systematic risk, over the time period, $E(R_i)$ is given by

$$E(R_i) = R_f + B_i (R_m - R_f) \quad \text{............. Equation 2}$$

where $B_i$ is the Beta risk coefficient for activity i;

$R_m$ is the mean return / ha. on the farm sector portfolio; and

$R_f$ is a constant which represents the risk - free rate. Now the actual mean return on each activity over the time period, $R_i$, is given by

$$R_i = \frac{1}{T} \sum_{t=1}^{T} R_i t \quad \text{.................... Equation 3}$$

1. This mathematical proof was developed with the assistance of Dr Neal Watson of the University of Canterbury and Dr Sandra Martin of Lincoln University.

Lets take a closer look at how the portfolio is constructed

The mean return on the farm sector portfolio in any one year, t, $R_{mt}$, is given by

$$R_{mt} = \frac{1}{n} \sum_{i=1}^{n} R_{it} \quad \text{.......................... Equation 4}$$

The mean return on the farm sector portfolio over the whole time period, $R_m$, is given by

$$R_m = \frac{1}{T} \sum_{t=1}^{T} R_{mt} \quad \text{..................... Equation 5}$$

Let's observe the $B_i$'s more closely. Bi is estimated by OLS regression (Equation 1). From the normal equations, this implies that

$$B_i = \frac{\sum_{t=i}^{T} (R_{mt}-\overline{R_{mt}})(R_{it}-\overline{R_{it}})}{\sum_{T=i}^{T} (R_{mt}-\overline{R_{mt}})^2} \quad \text{........... Equation 6}$$

It is required to evaluate the expression $\sum_{i=1}^{n} (E(R_i) - R_i)$.

The problem becomes much more transparent when the variables are displayed in matrix form and some of the terms are redefined using less confusing notation.

That is

$$A' = \begin{bmatrix} R_{11} & R_{21} & \cdots & R_{n1} & M_1 \\ R_{12} & R_{22} & \cdots & R_{n2} & M_2 \\ \cdot & \cdot & \cdots & \cdot & \cdot \\ \cdot & \cdot & \cdots & \cdot & \cdot \\ \cdot & \cdot & \cdots & \cdot & \cdot \\ R_{1t} & R_{2t} & \cdots & R_{nT} & M_T \\ N_1 & N_2 & \cdots & N_n & S \end{bmatrix} \quad \text{...... Equation 7}$$

where $< M_1 \quad M_2 \ \ldots\ldots \ M_T >$ is a column vector

$$M_t = \frac{1}{n} \sum_{i=1}^{n} R_{it} = R_{mt} \quad \text{............... Equation 8}$$

and $[N_1\ N_2 \ldots\ldots N_n]$ is a row vector

where $N_i = \frac{1}{T} \sum_{i=1}^{T} R_{it} = R_i$ ................ Equation 9

and $S = \frac{1}{T} \sum_{i=1}^{T} M_t = \frac{1}{n} \sum_{i=1}^{n} N_i = R_m$ ..... Equation 10

Note that

$$\overline{R_{it}} = \frac{1}{T} \sum_{t=1}^{T} R_{it} = R_i = N_i \text{ ........ Equation 11}$$

and $$\overline{R_{mt}} = \frac{1}{T} \sum_{t=1}^{T} R_{mt} = \frac{1}{T} \sum_{t=1}^{T} M_t = R_m \text{ .. Equation 12}$$

Also, let

$$R_f = C \text{ .............................. Equation 13}$$

Substituting the appropriate terms into Equation 6 gives

$$B_i = \frac{\sum_{t=1}^{T} (M_t - S)(R_{it} - N_i)}{\sum_{t=1}^{T} (M_t - S)^2} \text{ ........ Equation 14}$$

and Equation 2 becomes

$$E(R_i) = C + B_i (S - C) \text{ ................. Equation 15}$$

and $\sum_{i=1}^{n} [E(R_i) - R_i]$ becomes

$$\sum_{i=1}^{n} [\, E(R_i) - R_i \,] = \sum_{i=1}^{n} [\, C + B_i \, (S - C) - N_i \,]$$

$$= \sum_{i=1}^{n} \left[ C + (S-C) \left( \frac{\sum_{t=1}^{T} (M_t - S)(R_{it} - N_i)}{\sum_{t=1}^{T} (M_t - S)^2} \right) - N_i \right]$$

$$= \frac{1}{\sum_{t=1}^{T} (M_t - S)^2} \left[ C \sum_{i=1}^{n} \sum_{t=1}^{T} (M_t - S)^2 \right.$$

$$\left. + (S-C) \sum_{i=1}^{n} \sum_{t=1}^{T} (M_t - S)(R_{it} - N_i) - \sum_{i=1}^{n} N_i \sum_{t=1}^{T} (M_t - S)^2 \right]$$

$$= \frac{1}{\sum_{t=1}^{T} (M_t - S)^2} \left[ \sum_{t=1}^{T} \sum_{i=1}^{n} \Big( C \, (M_t - S)^2 \right.$$

$$\left. + (S-C)\,(M_t - S)\,(R_{it} - N_i) - N_i (M_t - S)^2 \Big) \right]$$

$$= \frac{1}{\sum_{t=1}^{T} (M_t - S)^2} \left[ \sum_{t=1}^{T} \sum_{i=1}^{n} (M_t - S) \, (CM_t - CS + SR_{it} \right.$$

$$\left. + SN_i - CR_{it} + CN_i - N_i M_t + N_i S) \right]$$

$$= \frac{1}{\sum_{t=1}^{T} (M_t - S)^2} \left[ \sum_{t=1}^{T} (M_t - S) \left( C_n M_t - C_n S + S_n M_t - C_n M_t + C_n S - nSM_t \right) \right]$$

i.e $$\sum_{i=1}^{n} [ E(R_i) - R_i ] = 0$$

Hence, it follows that when an unweighted index is used, the sum of the error terms for the undercompensated activities must always equal the sum of the error terms of the overcompensated activities. This implies that if a very few activities are highly overcompensated for systematic risk and this is not counterbalanced by a very few activities which are massively undercompensated for systematic risk, then you will invariably arrive at the conclusion that most activities are not being compensated for systematic risk.

## Appendix 5-8

**Sensitivity of FSCAPM to Alternative Values of Risk - Free Asset (Deflated, Gross Margin Models)**

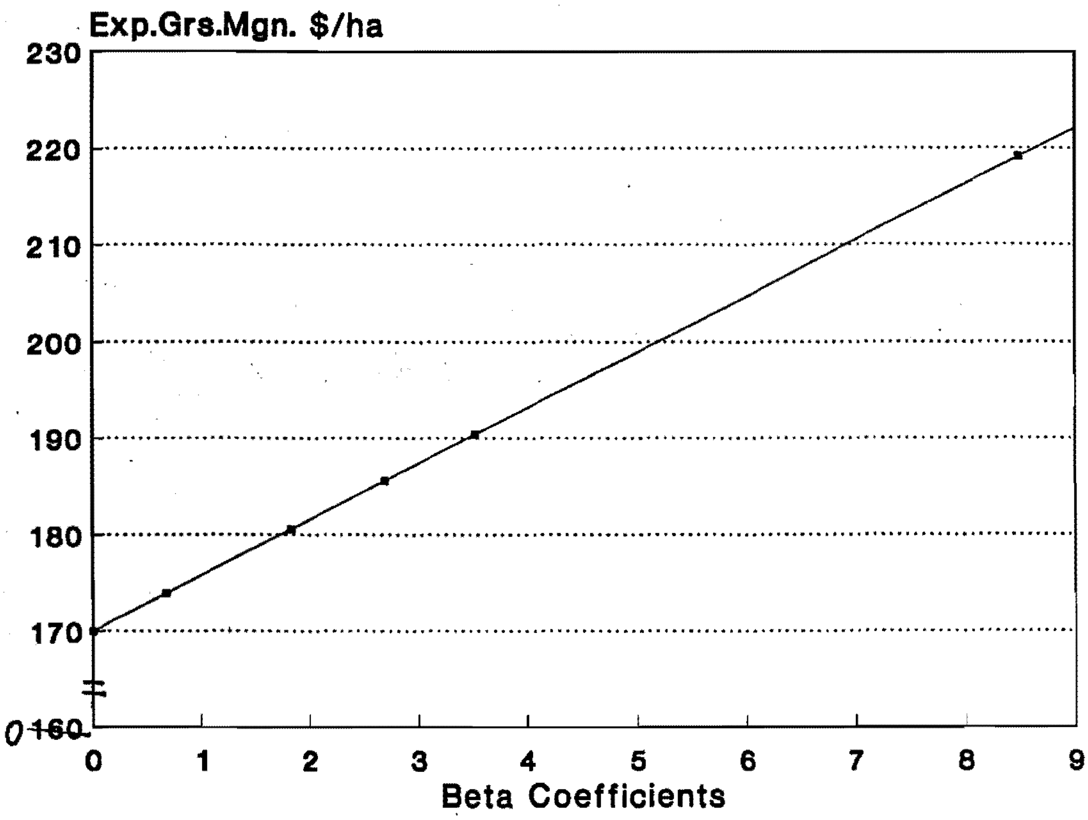
| Activity | $R_m$ = Unweighted Index | | | | $R_m$ = N.Z. Farm Class 8 | | | |
|---|---|---|---|---|---|---|---|---|
| | Beta | Expected Returns Gross Margin $/ha | | | Beta | Expected Returns Gross Margin $/ha | | |
| $R_f$, $/ha | | 150 | 170 | 190 | | 150 | 170 | 190 |
| Wheat | 0.06 | 195 | 215 | 233 | 2.26* | 461 | 436 | 411 |
| Barley | 0.33 | 395 | 408 | 422 | 1.31 | 329 | 323 | 317 |
| Fld.Peas | 0.72* | 685 | 690 | 695 | -1.44 | -48 | 1 | 50 |
| Fzn.Peas | -0.24 | -28 | -7 | 18 | 1.73 | 388 | 374 | 359 |
| Fzn.Bean | 2.22* | 1799 | 1773 | 1749 | 1.68 | -81 | -28 | 26 |
| Potato | 3.96* | 3091 | 3031 | 2972 | 0.79 | 259 | 263 | 267 |
| Ryegras. | 0.85* | 781 | 785 | 788 | -1.52 | -59 | -8 | 42 |
| Wh.Clov. | 1.12 | 982 | 983 | 980 | 1.52 | 360 | 350 | 339 |
| Grs/Clv. | 1.84* | 1517 | 1503 | 1486 | 0.03 | 154 | 173 | 193 |
| SheepBOR | 0.12 | 239 | 255 | 273 | 0.40 | 205 | 217 | 229 |
| SheepPR | 0.02 | 165 | 186 | 205 | 0.92 | 276 | 277 | 279 |

A * indicates the estimate is statistically significant at the five percent level of significance.

### Appendix 5-9

**Farm - Sector Security Market Line for the Lincoln University Mixed Cropping Farm ($R_m$ = Farm Class 8, Non - deflated Models)**

Note: This graph includes the non - significant activities as well.



# Appendix 5-10

## Compensation for Systematic Risk for the Lincoln University Mixed Cropping Farm Activities

### A. Gross Margin, Deflated Models

| Activ-ity | Histo-ric Mean $/ha | Expected Return E(Ri) $/ha | | | | Error E(Ri) - Ri $/ha | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Unwght. | F.C.8 | N.Z.A. | G.A.P. | Unwght. | F.C.8 | N.Z.A. | G.A.P. |
| Wheat | 751.37 | 213.37 | 435.51 | 483.09 | 560.47 | -538.00 | -315.86 | -268.28 | -190.90 |
| Barl. | 388.19 | 408.51 | 323.90 | 376.80 | 65.87 | 20.32 | -64.29 | -11.39 | -322.32 |
| Fld.P. | 678.33 | 690.39 | 0.83 | 454.20 | -226.26 | 12.06 | -677.50 | -224.13 | -904.59 |
| Fzn.P. | 991.25 | -3.47 | 373.24 | 575.51 | 865.62 | -994.72 | -618.01 | -415.74 | -125.63 |
| Fzn.B. | 2086.75 | 1774.55 | -27.37 | 1227.10 | 1734.79 | -312.20 | -2114.1 | -859.65 | -351.96 |
| Potato | 1387.22 | 3032.17 | 262.81 | 127.25 | -927.67 | 1644.95 | -1124.4 | -1260.0 | -2314.9 |
| R/gras | 517.30 | 784.36 | -8.57 | -26.40 | 498.29 | 267.06 | -525.87 | -543.70 | -19.01 |
| W.Clov | 744.08 | 979.50 | 348.57 | -114.20 | -370.88 | 235.42 | -395.51 | -858.28 | -1114.9 |
| Gr/Clv | 1407.19 | 1499.90 | 173.52 | -264.39 | 161.32 | 92.71 | -1233.7 | -1671.6 | -1245.9 |
| Sh/BOR | 469.22 | 256.73 | 216.99 | 124.94 | 197.48 | -212.49 | -252.23 | -344.28 | -272.74 |
| Sh/PR | 399.55 | 184.46 | 278.08 | 394.13 | 398.50 | -215.09 | -121.47 | -5.42 | -1.05 |

## Appendix 5-10 (Continued)

### B. Gross Revenue Models, Non - deflated Models

| Activ-ity | Histo-ric Mean $/ha | Expected Return E(Ri) $/ha | | | | Error E(Ri) - Ri $/ha | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Unwght. | F.C.8 | N.Z.A. | G.A.P. | Unwght. | F.C.8 | N.Z.A. | G.A.P. |
| Wheat | 687.46 | 839.62 | 557.64 | 508.15 | 220.60 | 152.16 | -129.82 | -179.31 | -466.86 |
| Barl. | 410.60 | 473.54 | 350.17 | 328.40 | 193.82 | 62.94 | -60.43 | -82.20 | -216.78 |
| Fld.P. | 615.29 | 681.47 | 476.94 | 441.21 | 209.43 | 66.18 | -138.35 | -174.08 | -405.86 |
| Fzn.P. | 773.99 | 858.68 | 569.04 | 522.95 | 223.24 | 84.69 | -204.95 | -251.04 | -550.75 |
| Fzn.B. | 1572.23 | 1902.22 | 1103.43 | 1012.78 | 295.53 | 329.99 | -468.80 | -559.45 | -1276.7 |
| Potato | 2279.19 | 1681.33 | 969.31 | 842.81 | 270.41 | -597.86 | -1309.8 | -1436.4 | -2008.8 |
| R/gras | 641.42 | 764.37 | 492.35 | 463.47 | 216.39 | 122.95 | -149.07 | -177.95 | -425.03 |
| W.Clov | 617.97 | 451.70 | 327.98 | 299.86 | 189.99 | -166.27 | -289.99 | -318.11 | -427.98 |
| Gr/Clv | 1259.38 | 1046.08 | 650.33 | 593.33 | 236.38 | -213.30 | -609.05 | -666.05 | -1023.0 |
| Sh/BOR | 308.34 | 404.38 | 310.30 | 290.55 | 188.25 | 96.04 | 1.96 | -17.79 | -120.09 |
| Sh/PR | 448.36 | 528.82 | 387.91 | 357.48 | 197.96 | 80.46 | -60.45 | -90.88 | -250.40 |

## Appendix 5-10 (Continued)

### C. Gross Revenue, Deflated Models

| Activ-ity | Histo-ric Mean $/ha | Expected Return E(Ri) $/ha | | | | Error E(Ri) - Ri $/ha | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Unwght. | F.C.8 | N.Z.A. | G.A.P. | Unwght. | F.C.8 | N.Z.A. | G.A.P. |
| Wheat | 1163.74 | 327.62 | 1566.06 | 1012.36 | 739.80 | -836.12 | 402.32 | -151.38 | -423.94 |
| Barl. | 748.70 | 585.53 | 725.67 | 743.27 | 308.84 | -163.17 | -23.03 | -5.43 | -439.86 |
| Fld.P. | 1108.81 | 1015.39 | 293.99 | 1410.14 | -152.50 | -93.42 | -814.82 | 301.33 | -1261.3 |
| Fzn.P. | 1319.70 | 55.37 | 812.92 | 1016.26 | 849.71 | -1264.3 | -506.78 | -303.44 | -469.99 |
| Fzn.B. | 2642.52 | 3136.02 | 973.65 | 3282.04 | 1610.42 | 493.50 | -1668.9 | 639.52 | -1032.1 |
| Potato | 4636.71 | 6402.94 | -137.68 | 392.29 | -1203.9 | 1766.23 | -4774.4 | -4244.4 | -5840.6 |
| R/gras | 1114.27 | 1087.03 | -32.06 | -141.98 | 671.83 | -27.24 | -1146.3 | -1256.3 | -442.44 |
| W.Clov | 1213.77 | 1660.17 | 211.33 | -960.94 | -287.00 | 446.40 | -1002.4 | -2174.7 | -1500.8 |
| Gr/Clv | 2328.03 | 2577.21 | 9.27 | -1269.0 | 214.83 | 249.18 | -2318.8 | -3597.1 | -2113.2 |
| Sh/BOR | 553.28 | 327.62 | 293.99 | 14.01 | 183.02 | -225.66 | -259.29 | -539.27 | -370.26 |
| Sh/PR | 801.93 | 427.92 | 486.87 | 248.00 | 193.14 | -374.01 | -315.06 | -553.93 | -608.79 |